DLC pro

Digital Laser Controller

Manual

Manual: M-063 Version 20
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Dear Customer,

Welcome to the TOPTICA community!

We have designed this product to be easy to use and reliable so that you can focus on your work. If you have questions or need advice on how to integrate it into your setup, please contact us immediately so we can walk you through the process. We will provide you with quick and competent help through our service staff and product managers.

You can always contact TOPTICA service on the Internet by

- Email: service@toptica.com
- Web form: service.toptica.com

The service department at our headquarters in Munich can be reached by phone

- Tel: +49 89 85837150

For up-to-date phone numbers and addresses of our regional offices please refer to our web site: www.toptica.com/contact-us/

Please have your product ID and serial number ready when contacting us, so we can quickly retrieve all relevant information.

As we are constantly improving our products, we greatly value all customer feedback. We encourage you to tell us what you like about our products as well as any suggestions for improvement.

Best regards,

Harald Ellmann

Director Service
TOPTICA Photonics AG

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1 The Digital Laser Controller DLC pro

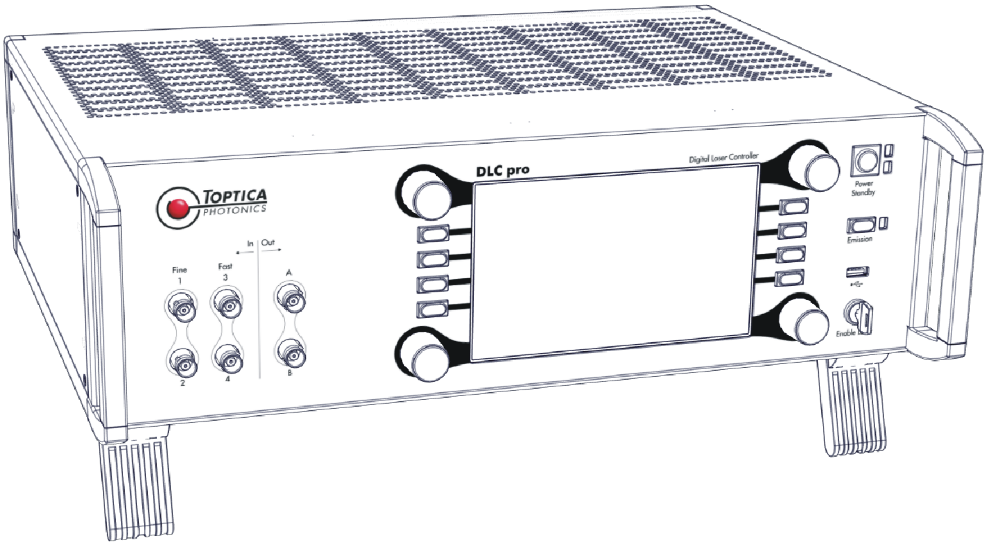


Figure 1 The Digital Laser Controller DLC pro

TOPTICA´s DLC pro is a revolutionary diode laser controller that is completely digital and therefore flexible and easy to use. Its digital nature makes life easier. Settings can be remembered and stored and new features can be realized in firmware and software which does not require additional hardware, soldering or sending modules back and forth.

The digital nature also makes this technology better: Digital signals have no drift and provide exceptional noise performance of current and voltage outputs when combined with highly-optimized D/A converters and driving stages.

1.1 Highlights of the Digital World

The DLC pro is a digital laser controller. Here, we would like to give you a taste of the new features that become available in the digital world and complement the laser performance improvements.

- The provided **TOPAS DLC pro PC-GUI control software** allows easy remote operation of the connected laser heads. It includes long-term plots and recordings of various parameters. TOPAS DLC pro is provided on the USB flash drive – that comes together with the DLC pro laser system - and is part of each new software release, too. Currently, its OS requirements are Windows 8 or newer. See section 6.

- **Network connections** to the DLC pro can be made either through a direct link to a PC or through a network (see section 5.2.4). When connected to a network, a single DLC pro may be monitored and controlled from several PCs simultaneously. Vice versa, it is also possible to control several DLC pro controllers from a single PC.

- Especially in combination with a remote desktop connection, these features improve support and service. The **service report** allows generating an overview of controller and laser head parameters, e.g., for trouble shooting. See section 6.11.

- Remote operation of the DLC pro, e.g., by an experimental control program, may also be performed with a simple **command language**. The Remote Command Reference for TCP/IP and USB lists and documents the available commands and parameters, as well as the language syntax. The reference is provided on the USB flash drive.
  See sections 5.12 and 6.24 for accessing parameters.

- For remote control of the DLC pro from **Python** programs, we provide an easy-to-use software development kit (SDK). See www.toptica.com/laser-sdk for more information of the TOPTICA Python Laser SDK, which is available for **pip install**.

- **Labview** example VIs for remote operation are available for download on our DLC pro website and also included on the USB flash drive. These examples use the command language mentioned above.

- **DLC pro Lock** is a software license key that enables access to additional features. If not purchased already with the system, a license key for a 30-day-trial is available on the USB flash drive. See section 10.19. With additional Dual-Laser-Operation upgrade, DLC pro lock is valid for both lasers.

- **Updates** are available for download in the DLC pro section of the TOPTICA webpage. For each new release, we include a list of changes of the command language and release notes in the documentation folder. The latest version of the DLC pro manual and the Remote Command Reference for TCP/IP and USB are included as PDF files, too. See section 10.18.

- Subscribe to receive **email notifications** for such updates by sending an email with subject „subscribe“ to DLCpro@toptica.com. See section 10.17.

- The **status of frequency locks** is not only indicated by the TOPAS DLC pro PC-GUI and the touchscreen user interface, but also available in real-time via the digital I/O ports of the MC+ module. **Trigger signals** synchronized with the **scans** are provided, too. See section 9.2.3.

- TOPTICA's laser heads feature a non-volatile memory with all relevant laser parameters, allowing for an **easy exchange of laser heads**. Furthermore, your operational parameters will be saved to the DLC pro memory.

- **Screen shots** of the touchscreen user interface can easily be taken with a connected USB flash drive and by pressing the save button for a few seconds. See section 10.12.

- Features only available with the digital controller DLC pro include the **fast Fourier transformation** of signals (see section 5.3.2), **air pressure compensation** (see section 10.11), and **active power stabilization** (see section 5.3.6), to name just a few.

1.2 Design of the Digital Laser Controller DLC pro

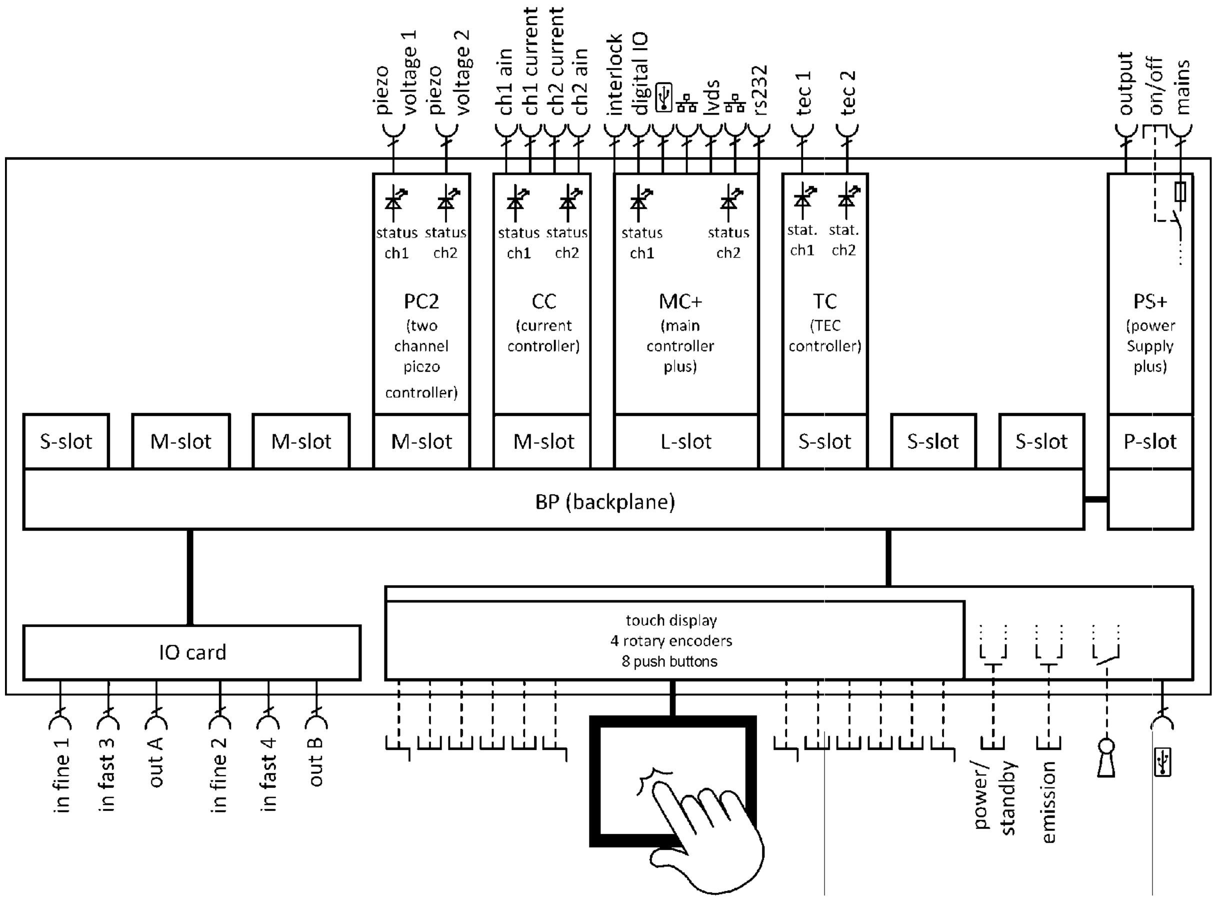


Figure 2 Block diagram of the DLC pro (example)

PS+	Power Supply Module	**S-slot**	(Small slot)
TC	Temperature Control Module	**M-slot**	(Medium slot)
MC+	Main Controller	**L-slot**	(Large slot)
CC	Current Controller	**P-slot**	(Power slot)
PC2	Piezo Controller		

The Digital Laser Controller DLC pro is a complete solution for running, controlling, and stabilizing tunable diode lasers. It consists of a housing with slots on the rear panel, where various plug-in modules can be integrated, depending on the type of laser head being controlled. The user interface and a number of BNC inputs and outputs (I/O board) for connection to the user's experiment or apparatus are located on the DLC pro front panel.

A tunable External Cavity Diode Laser (ECDL) works with a DLC pro comprising a current controller (e.g., CC-500) to provide the laser diode current, a temperature controller (TC) for temperature control and stabilization, a piezo controller (PC2/PC) for high-voltage generation to drive a piezo-electric element, and a main controller (MC+) that contains central computing, interfaces, and signal-processing hardware.

The MC+ module generates scans for tuning the laser and processes input signals to comfortably stabilize the laser with multiple PIDs and modulation/demodulation if required. The MC+ module also contains digital inputs and outputs as well as interfaces for communication. A power supply module (PS+) provides the required power. The DLC pro hardware is described in detail in section 9.

The user interface consists of a touchscreen with four digital rotary/push knobs and eight push buttons arranged around the display. Sections 4 and 5 describe how to control the laser with this user interface.

Beside the touchscreen, the DLC pro can also be controlled via TCP/IP or USB by a computer. A comfortable graphical user interface (TOPAS DLC pro, please refer to section 6) for Windows® is supplied. Moreover, the DLC pro may also be remotely controlled by other software and by hardware sending control commands (please refer to section 10.13).

1.3 Upgrade for Control of a 2nd Laser (Dual-Laser-Operation)

NOTE !	To use the DLC pro for control of two lasers (Dual-Laser-Operation), an Upgrade for Control of a 2nd laser is required. When the Dual-Laser-Operation upgrade is acquired, TOPTICA provides a license key via e-mail or USB flash drive and additional hardware, such as modules and cables. Please refer to section 10.2 for a step-by-step description on how to upgrade your DLC pro. The license is unlimited in time but linked to the individual hardware of the DLC pro and cannot be used for other devices. If purchased along with the DLC pro, the licence and the hardware will already be installed.

The Digital Laser Controller DLC pro is capable of controlling two laser systems of the type DL pro, DFB pro, TA pro, BoosTA pro or two modules in the TA pro AL (MTA pro) laser head. In this manual, mainly the operation of one laser is described, the second laser is operated in the same way. After pressing the **Laser 1/2** buttons on the DLC pro front panel or tapping the symbols aside (see sections 5.8 and 5.9), you can control the laser which is connected to the DLC pro as laser 1/2. The front panel controls change accordingly. Additional information on the connection and operation of two lasers is noted in this manual where necessary. With a single Lock option installed (see section 10.19), in combination with the Dual-Laser-Operation upgrade, frequency locking of both lasers is possible.

1.4 PDH Module for Pound-Drever-Hall Locking

NOTE !	When the PDH module is acquired, TOPTICA also provides relevant software to update your DLC pro. Please refer to section 10.3 for a step-by-step description on how to install a PDH module. If purchased along with the DLC pro, the PDH module and the software is already installed.

2 Safety Instructions and Warnings

Before using the DLC pro, please read and follow the Safety Instructions and Warnings.

TOPTICA laser systems with DLC pro are manufactured according to the International Laser Safety Standard IEC 60825-1:2014 and comply with US laws 21 CFR §1040.10 and §1040.11.

The following safety terms are used in this manual:

The **DANGER !** heading in this manual explains danger that could result in personal injury or death.
The **CAUTION !** heading in this manual explains hazards that could damage the instrument.
In addition, a **NOTE !** heading provides information to the user that may be beneficial in the use of the instrument.

CAUTION ! Before connecting the cables to the laser head, the DLC pro must be switched off and disconnected from the mains supply. This complete power down is required for exchange of laser heads, too.

2.1 General Safety Terms

DANGER !
CAUTION ! Before operating the Digital Laser Controller DLC pro, please read this manual carefully to prevent personal injury and damage to the electronics and connected diode lasers. The following safety instructions must be followed at all times.

DANGER !
CAUTION ! **Possibility of electrical shock !** Wherever this symbol is attached, the possibility of an electrical shock may appear. Use only equipment and accessories supplied by TOPTICA.

Caution ! Wherever this symbol is attached read and understand the manual before operating the device. The manual must be consulted in order to find out the nature of the potential HAZARDS and any actions which have to be taken to avoid them.

DANGER ! During installation, maintenance, and service, all persons in the room must wear appropriate laser safety goggles while the laser is in operation. The recommended protection stage is dependent on the laser system. For details, please refer to the laser head manual.

DANGER ! Laser safety goggles selected for adjustment purposes do not protect against an intentionally focused direct beam which will increase the optical power densities by a few orders of magnitude.

DANGER ! Regular functional checks and performance inspections at the supplier are recommended for all laser safety goggles.

DANGER !
CAUTION ! The DLC pro and the laser head are both equipped with LEDs that indicate laser emission. (Please refer to the laser head manual and to section 4.1 in this manual for detailed information). Be aware of laser emission when at least one of these LEDs lights up.

DANGER !
CAUTION ! Before **connecting/disconnecting any cables** at the DLC pro or the connected laser device, **switch off the DLC pro and disconnect it from the mains supply**.
This complete power down is required for exchange of laser heads, too.

DANGER ! Do not position the equipment so that it is difficult to operate the disconnecting device.

DANGER ! Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

DANGER ! If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

DANGER ! For safe operation and for proper grounding, please use the supplied mains cable only. Improper or missing grounding can lead to serious injury.

DANGER ! Operation of this electrical equipment in outdoor areas, wet or dirty atmospheres, potentially explosive atmosphere, corrosive atmosphere, and other environments that deviate from normal environmental conditions (IEC 61010-1 clause 1.4.1) is not allowed.

DANGER ! Plug-in modules should only be opened by trained personnel. Before exchanging and opening any module, the Digital Laser Controller DLC pro must be switched off and disconnected from the mains supply.

DANGER ! Always switch off the PC2/PC Piezo Control module(s) and **disconnect the piezo supply cable** at the PC2/PC module panel when opening the housing of the connected laser device, e.g., for internal adjustments. **Dangerous voltages** can be present inside the connected laser device.

DANGER ! Do not look into the laser beam as the output can exceed the limits for class 1 specified by US laws 21 CFR 1040.10 and 2 CFR 1040.11 and the Laser Safety Standard EN 60825-1:2014. Take precautions to eliminate exposure to a direct or reflected beam.

DANGER ! The Digital Laser Controller DLC pro can operate very powerful lasers (up to class 4). Therefore, it is imperative to take great care and observe the statutory warning labels on the unit. To set up an external interlock, the MC+ module of the Digital Laser Controller DLC pro is equipped with an external interlock connector. By using an appropriate door switch, laser emission of the laser heads connected to the DLC pro can be switched off.

DANGER ! Do not open the Digital Laser Controller DLC pro during operation. Only authorized and specially-trained service personnel should perform internal tuning and replacement of components. Be aware that under certain circumstances, parts of the equipment may remain under high voltage conditions (e.g., piezo-electric elements) even when the device is disconnected from the mains supply.

CAUTION ! Check the adjusted parameters of the Digital Laser Controller DLC pro before switching on the connected laser, e.g. if exchanging laser heads ! In particular, pay attention to the I_{max} and U_{max} limitations and the correct setting of the laser diode polarity (please refer to section 4.5.4). As long as the laser emission is switched off by the Emission push button on the DLC pro front panel, the laser diode is short-circuited and therefore protected by the relay integrated in the TOPTICA diode laser head.

CAUTION ! Special precautions are necessary if the Digital Laser Controller DLC pro is to be operated in surroundings of high electro-magnetic radiation such as close to a plasma discharge. Please contact TOPTICA for technical support.

CAUTION ! Please assure with particular care that the electrical safety conditions are met especially concerning the high-voltage outputs. Also carefully read the operating instructions for the Digital Laser Controller DLC pro before starting the device.

2.2 Service Operations

For certain installation or alignment procedures, the exchange of components or internal electronics settings, tools are required to perform the respective procedure at the DLC pro.
All operations, which require tools to be used, are declared as service operations. Service operations require additional knowledge and may only be carried out by specially trained personnel.

DANGER ! **CAUTION !**	**Before carrying out service operations, switch off the DLC pro and disconnect it from the mains supply.**

2.3 Safety Features

2.3.1 External Interlock Connector

The DLC pro provides an external interlock connector located at the MC+ module (see Figure 136). The external interlock is equal to the function of the key switch on the front panel of the DLC pro (see section 4.1). All lasers connected to the DLC pro are disabled when the external interlock circuit is open.

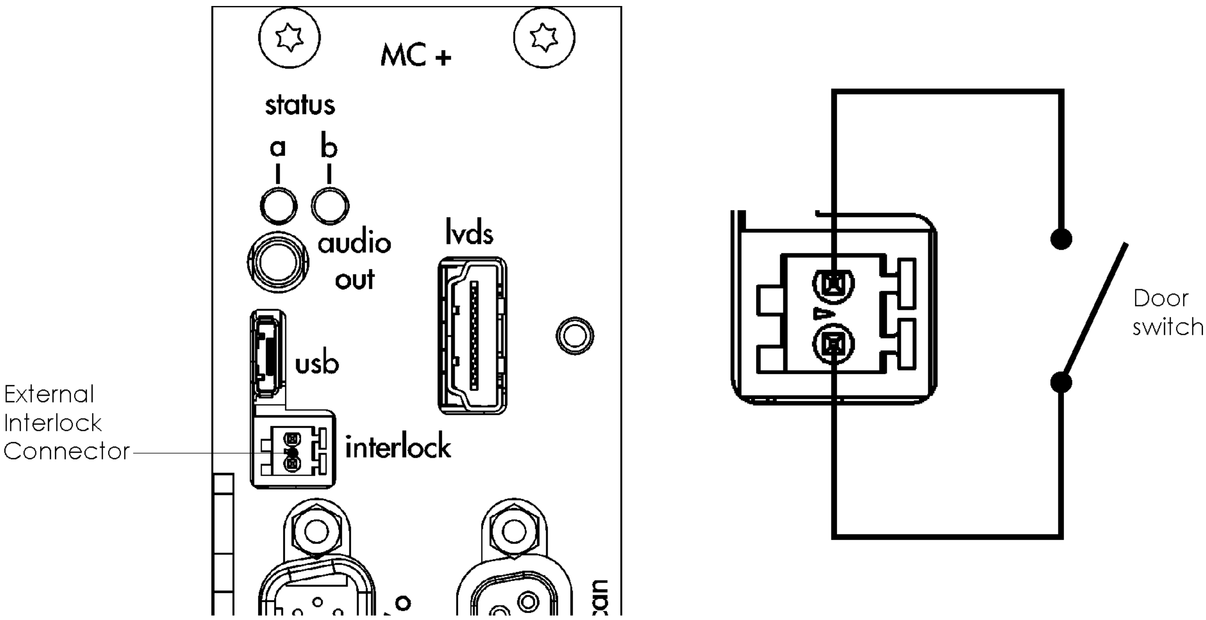


Figure 3 External interlock connector (Phoenix MC 0.5/2-G-2.5)

NOTE !	We recommend setting up an external interlock circuit with a door switch. When the interlock circuit shown in Figure 3 is opened, the connected laser is switched off and cannot be switched on. After closing the interlock circuit, the **Emission** push button on the DLC pro front panel must be pressed to switch ON the connected laser. The interlock plug supplied with the DLC pro should only be used for first adjustment purposes. For safe operation, the circuit shown in Figure 3 must be installed. Always follow the required safety measures applicable to the working environment.

2.3.2 AC Mains Voltage and Fuse DLC pro with PS+ Module

The DLC pro with PS+ module (see section 9.2.1) works with a wide range of input voltages.

CAUTION !	The mains voltage input of the DLC pro with PS+ module is a wide-range input for input voltages of 100 .. 240 V~, 50/60 Hz.

The mains supply is protected by a 250 V~, 4 A T (slow blow) fuse 5 x 20 mm, which is accessible at the PS+ module at the rear of the DLC pro next to the mains plug. For exchanging the fuse, please refer to section 10.7.1.

DANGER !	Before exchanging the fuse, make sure to switch off and disconnect the DLC pro from the mains supply !

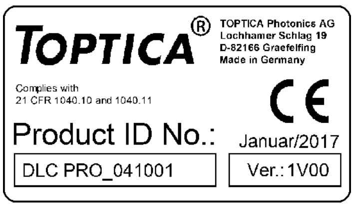
2.3.3 AC Mains Voltage and Fuse DLC pro with PS HP Module

The external power adaptor of a DLC pro with PS HP module (see section 9.2.2) works with a wide range of input voltages.

CAUTION !	The PS HP module is delivered together with an external power adaptor. The mains voltage input of this external power adaptor is a wide-range input for input voltages of 100 .. 240 V~, 50/60 Hz. Do not use other equipment than the external power adaptor delivered by TOPTICA.

2.4 Identification of Manufacturer

Manufacturer (name and address), product ID number, and compliance with CE standards are noted on the identification label.



Size:	60 mm x 34 mm
Color:	Silver/black
Location:	Bottom side of the DLC pro

3 Installation

3.1 Inspection after Delivery

The DLC pro is packaged in a carton designed to give maximum protection during shipment. If the outside of the shipping carton is damaged, notify your shipping department immediately. The shipping agent may wish to notify the carrier at this point.

If the shipping carton is not damaged externally, remove the DLC pro from the carton. If any damage is visually evident, notify TOPTICA and your shipping agent. We recommend saving the carton for future storage or transportation.

After unpacking, please check the package contents. If any item is missing, please contact TOPTICA (for contact details, please refer to section 10.35).

Package Contents:

1. DLC pro Laser Control Electronics
2. Keys for the Key Switch on the DLC pro front panel
3. Interlock plug
4. Mains cable (DLC pro with PS+ power supply module)
   Mains cable, external power adaptor, connection cable (DLC pro with PS HP power supply module)
5. USB flash drive

3.2 Installation Instructions

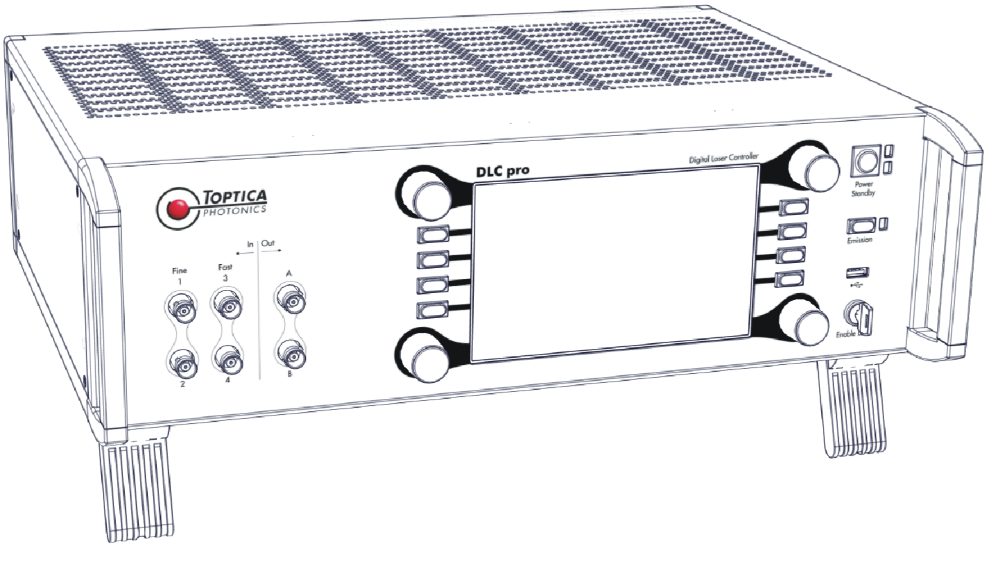


Figure 4 DLC pro Laser Control Electronics

Follow these instructions when installing the DLC pro Laser Control Electronics:

- For general and environmental specifications, please refer to section 10.1.1.
- Do not block the ventilation grilles of the DLC pro.
- Do not place more than 4 DLC pro units on top of each other.
- Always tighten the cable connector screws.
- Install the DLC pro only in an area free of vibrations.

4 Operation

4.1 DLC pro Front Panel

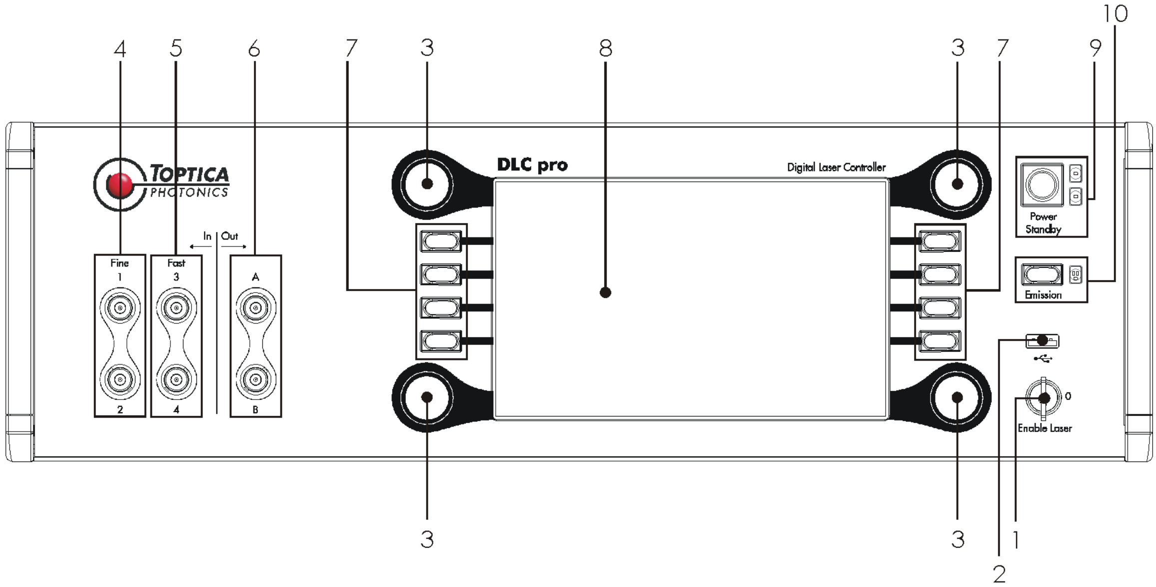


Figure 5 DLC pro front panel

- **1** Key Switch
- **2** USB Connector
- **3** Rotary Knob
- **4** Input Connectors - Fine
- **5** Input Connectors - Fast
- **6** Output Connectors
- **7** Push Buttons
- **8** Touchscreen
- **9** Power/Standby Push Button and LED
- **10** Emission Push Button and Laser Radiation Emission LED

The user interface and the I/O board are located on the front panel of the DLC pro. The user interface operator controls are described in this section, while the I/O board is described in the hardware section 9.1.1.

4.2 DLC pro Rear Panel

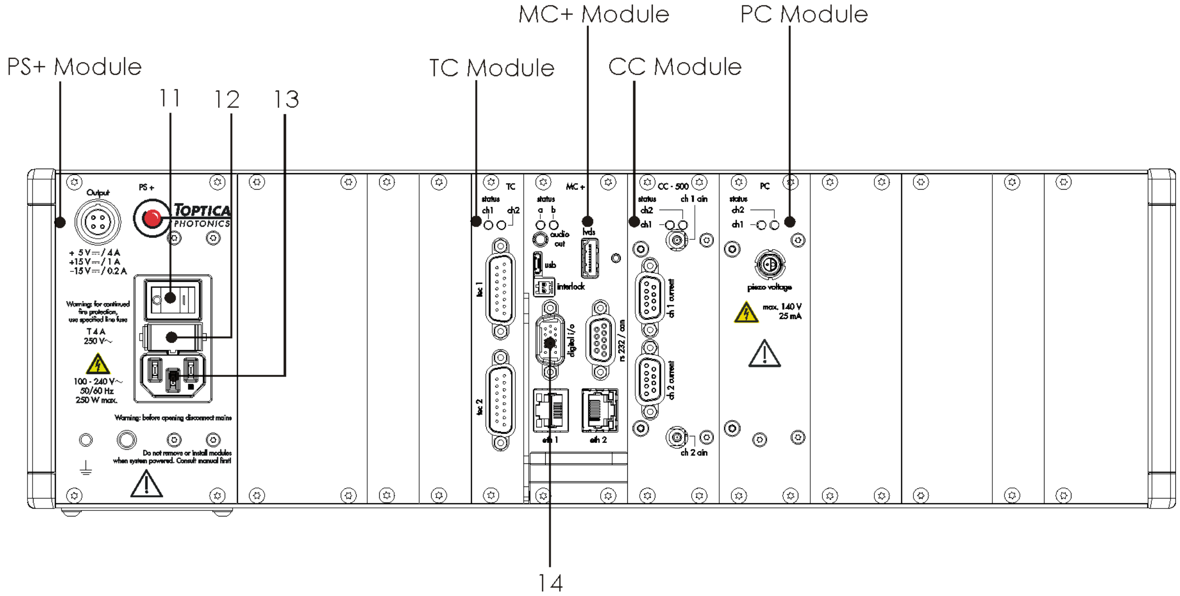


Figure 6 DLC pro rear panel (example DLC DL pro)

11 ON/OFF Switch

12 Fuse Cartridge

13 Mains Connector

14 Scan Trigger and Lock Status Digital Signals

The DLC pro accepts numerous modules for various laser configurations on the rear panel. The different modules are described in detail in section 9.2. Please refer to section 10.5 for the mounting positions of the modules.

4.3 Description of Operator Controls

1 Key Switch	The Key Switch must be set to position Enable Laser before laser emission of all connected lasers can be switched on by pressing the **Emission** push button. **Key Switch in Position 0:** No laser emission possible. **Key Switch in Position Enable Laser:** Laser emission possible.
2 USB Connector	The USB 2.0 host connector can be used, e.g., to load/save configuration data on a USB flash drive, or to perform a software/firmware update (please refer to sections 10.16 and 10.17). **NOTE !** This USB connector cannot be used for remote control of the DLC pro. Please use the USB or Ethernet connector on the MC+ module (rear panel of the DLC pro) for remote control.
3 Rotary Knob	The rotary knob changes the respective operating parameters. Please refer to section 4.4.1 for detailed information.
4 Input Connectors - Fine • BNC-connectors	Input connectors for analog voltages that are internally converted by a 24-bit A/D converter into digital signals. The use of the connectors can be configured via touchscreen or TOPAS DLC pro PC-GUI. **Fine 1 and 2** Input Resistance: 10 kΩ Input Voltage: - 4 V .. + 4 V Sample Rate: 675 kHz
5 Input Connectors - Fast • BNC-connectors	Input connectors for analog voltages that are internally converted by a 16-bit A/D converter into digital signals. The use of the connectors can be configured via touchscreen or TOPAS DLC pro PC-GUI. **Fast 3 and 4** Input Resistance: 10 kΩ Input Voltage: - 4 V .. + 4 V Sample Rate: 200 kHz
6 Output Connectors • BNC-connectors	Output connectors for analog voltages that are internally converted by a 16-bit D/A converter from digital signals. The use of the connectors can be configured via touchscreen or TOPAS DLC pro PC-GUI. The outputs are enabled/disabled in the Misc tab (see section 6.23) where the applied signals can be further customized. **A and B** Output Voltage: - 4 V .. + 4 V at ≥ 100 kΩ load Sample Rate: 2.7 MHz **CAUTION !** During power up (boot procedure) of the DLC pro, the voltage level at the two output connectors starts with -4 V before they get reset by the software to the stored value.
7 Push Buttons	Push buttons for selecting the touchscreen operation modes and to perform frequent tasks. Please refer to section 5 for detailed information.
8 Touchscreen	Please refer to sections 4.4 and 5 for detailed description on operating the touchscreen.

9 Power/Standby Push Button and LEDs	Push button for toggling between power and standby mode of the DLC pro. A green LED indicates that the DLC pro is on, a red LED indicates standby mode. The standby function of the push button can be configured in the parameter menu (please refer to section 5.12) or in the Params tab of the TOPAS DLC pro PC-GUI (please refer to section 6.24). **Standby** Touchscreen switches off. The standby status of the PC2/PC, CC, and TC modules is as configured. **Power** The operating parameters resume as they were set before switching to standby. **NOTE !** **If a power down is required, e.g. for exchanging laser heads,** using the Power/Standby Push Button is not sufficient. Please use the ON/OFF Switch on the DLC pro rear panel instead and disconnect the DLC pro from mains.
10 Emission Push Button and Laser Radiation Emission Warning LED	The Emission push button switches on/off (toggle function) one or more CC modules and thus laser emission for all laser channels is activated. After pressing the Emission push button, the LED lights up white when laser emission is enabled and thus at least one of the connected lasers emits laser light. The LED lights up red when the connected laser head(s) are disabled (**Laser 1**/**Laser 2** buttons, see sections 5.8 and 5.9), or when a laser safety-related issue leads to a condition in which the laser cannot be switched on or has been switched off automatically. In this case, check the system messages (please refer to section 10.15). To switch on the laser again, press the push button twice to actively switch off/on the laser. **DANGER !** When the Laser Radiation Emission Warning LED lights up white, be aware that there is laser emission. **NOTE !** Laser emission can only be switched on with the Emission push button if: • Laser 1 or laser 2 is enabled by the corresponding push buttons (see sections 5.8 and 5.9). • the external interlock circuit is closed (see section 2.3.1). • the key switch is in the Enable Laser position. • the CC modules are activated in the parameter menu (please refer to section 5.12) or in the Params tab of the TOPAS DLC pro PC-GUI (please refer to section 6.24). **NOTE !** During the boot procedure, the white Laser Radiation Emission Warning LED lights up for a short time as a function test. **NOTE !** If laser emission is switched on by the Emission push button, the short circuit relay inside the laser head, which secures the laser diode, is opened.
11 ON/OFF Switch	ON/OFF switch for DLC pro laser driver electronics. For detailed description, please refer to sections 9.2.1 and 9.2.2. **NOTE !** After switching off, please wait for at least 10 seconds before switching the DLC pro on again.

12 Fuse Cartridge	The mains supply is protected by a 250 V~, 4 A T (slow blow) fuse 5 x 20 mm, which is accessible after removing the fuse cartridge. For exchanging the fuse, please refer to section 10.7.1. **DANGER !** Before exchanging the fuse, make sure to switch off and disconnect the device from the mains supply ! **NOTE !** Only DLC pro with PS or PS+ Power Supply Module.
13 Mains Connector	Connector for the supplied mains cable. **NOTE !** Only DLC pro with PS or PS+ Power Supply Module: For description of the PS HP power supply module, please refer to section 9.2.2.
14 Digital I/O Connector	Connector for multi-purpose digital inputs and outputs, e.g., scan trigger and lock status digital signals are available. Please refer to section 9.2.3.

4.4 Rotary Knob and Touchscreen Operation

4.4.1 Rotary Knob

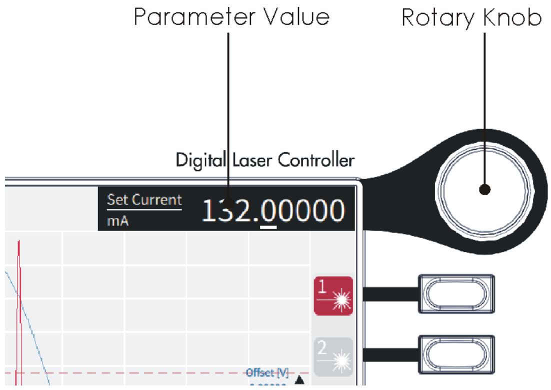


Figure 7 Rotary knob and corresponding parameter value

The user can select the digit and set the value of the parameter to be changed using the rotary knob.

Changing a Parameter Value

- Press the rotary knob once to change between selecting or setting a digit. The background color is white for selecting digits and black for setting values.
- Background color white: Turn the rotary knob to move the cursor below the numbers and select the digit to be changed.
- Background color black: Turn the rotary knob to increase/decrease the value of the selected digit (cursor). All digits left of the one selected change accordingly.

NOTE !	In order to ensure a fluent user interface, not every single tick of a dial is communicated immediately, but several ticks might be collected before doing so. Due to this please rotate the knob slow enough in order to avoid jumps across narrow features due to this accumulation of ticks.

NOTE !	Depending on the operation mode of the DLC pro, the rotary knobs are assigned to certain control parameters. In some operation modes, the assignment of a rotary knob (corner parameter) can be selected in a drop-down menu which is available after tapping the parameter name corresponding to the rotary knob (see section 4.4.2).

4.4.2 Selecting a Corner Parameter

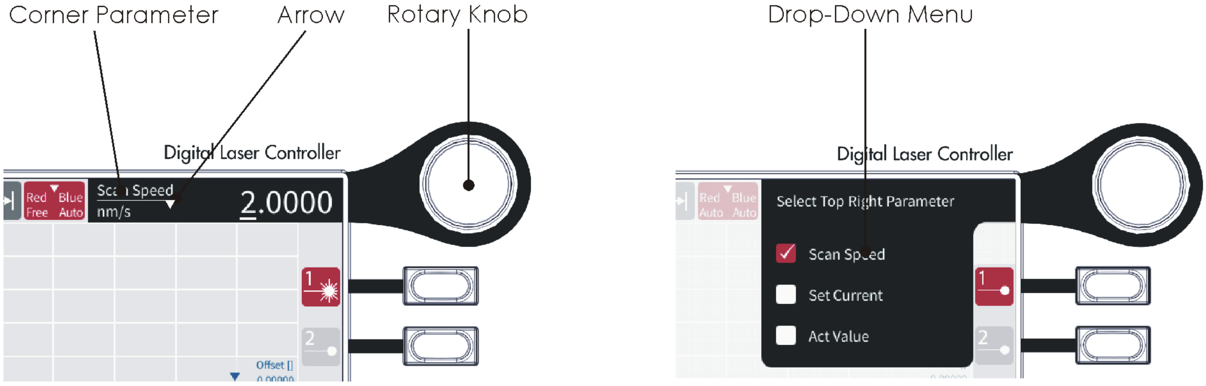


Figure 8 Corner Parameter (example top-right) and Drop-Down Menu

In some screens the displayed corner parameter and thus the rotary knob assignment can be selected. The little white arrow near the corner parameter indicates that there are further options available that can be selected in a drop-down menu which appears after tapping on the corner parameter.

4.4.3 Touchscreen

4.4.3.1 Gestures

Use the following gestures to operate the DLC pro via touchscreen.

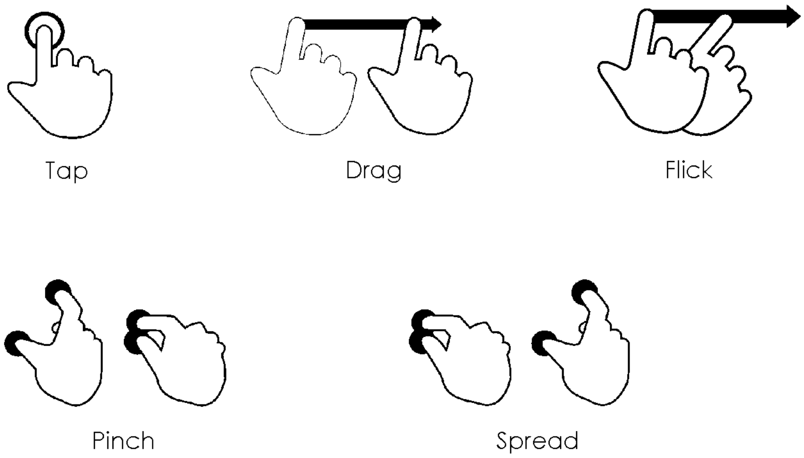


Figure 9 Gestures for touchscreen operation

Tap	Briefly touch surface with fingertip.	Selects, for example, a parameter value, opens the numerical editor or selects a candidate in Scan/Lock mode.
Drag	Move fingertip over surface without losing contact.	Moves a displayed graph or element left/right or up/down.
Flick	Quickly brush surface with fingertip.	Used, for example, to scroll in the parameter menu.
Pinch	Touch surface with two fingers and bring them closer together.	Zooms out of the displayed graph.
Spread	Touch surface with two fingers and move them apart.	Zooms into the displayed graph.

4.4.3.2 Numerical Editor

The user can change a parameter value via a touchscreen keypad (numerical editor).

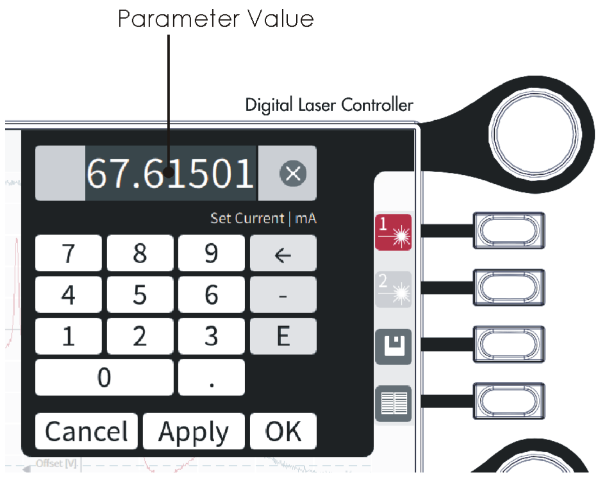


Figure 10 Parameter value and touchscreen keypad

Changing a Parameter Value

- To open the numerical editor, tap the parameter value to be changed. A keypad is displayed on the touchscreen.
- Use the touch keys to enter/change the parameter value.

⊗ **Key**	Deletes the parameter value.
← **Key**	Deletes the number to the left of the cursor position.
- / + Key	Toggles between a negative or positive sign being added to the parameter value or an exponent at the position of the cursor.
E Key	E represents "times ten raised to the power of" and is followed by the exponent.
Cancel	The new parameter value is ignored. The numerical editor returns to the value that was active before the editor was opened.
Apply	The new parameter value is applied, and the numerical editor remains opened.
OK	The new parameter value is applied, and the numerical editor is closed.

4.4.4 Touchscreen Display Settings

General touchscreen settings are configured in the parameter menu with the Home screen selected. When auto-dark is enabled (parameter: **display > auto-dark**), the touchscreen is switched dark after the time set in **display > idle-timeout** (minimum time is 2 seconds). When tapping on the touchscreen, it is switched on for the **idle-timeout** set.

The parameter **display > brightness** (range 0 (dark) .. 100 (max. brightness)) determines the brightness of the touchscreen when switched on. Parameter **display > state** shows the state of the touchscreen. Press the **Load/Save** button or tap the corresponding symbol twice to store the settings to the flash memory of the DLC pro.

4.5 DLC pro Set Up and Initial Power Up

The following sections describe the basic setup and operation of a DL pro laser system controlled by the DLC pro. Please refer to sections 4.1 and 4.2 for location of the operator controls.
Please follow the instructions provided in sections 4.5.2 to 4.5.5 in the given order.

NOTE !	For detailed information on the setup and operation of your laser system, please refer to the respective laser head manual.

NOTE !	The DLC pro laser driver electronics, that are shipped together with laser systems containing a frequency-conversion stage, such as a DL-/TA-SHG/FHG pro, are pre-configured by TOPTICA especially for use with their particular laser head. Any connection of a different type of laser head with such a DLC pro may lead to unwanted results.

4.5.1 Control of the DLC pro

The DLC pro can be operated in three different ways:

- Using the rotary knobs, push buttons, and the touchscreen on the DLC pro front panel. This way of operation is possible without any additional software installation and is the preferred way for quick-start and for interacting with the laser while making adjustments at the optical table. Please refer to sections 4.4.1 and 4.4.3 for basic rotary knob and touchscreen operation.
- Using TOPAS DLC pro software (PC-GUI) installed on a PC. This way of operation requires software installation on a control computer (Please refer to section 6 for detailed information on the software and installation). The PC-GUI offers complete access to all parameters and is especially useful for controlling and monitoring the laser from your desk.
- Using software commands to remotely control the DLC pro via USB or Ethernet. The software commands may also be integrated in user-specific software. For a detailed description of the software commands, please refer to the Remote Command Reference for TCP/IP and USB. This document is available as a pdf file in the Documentations folder on the software USB flash drive supplied with the DLC pro. Labview VIs and an example using these VIs are provided on this drive as well as on the DLC pro product page at www.toptica.com.

NOTE !	We recommend operating the DLC pro via Ethernet over using a USB connection due to the higher communication bandwidth. Using a USB to Ethernet adapter on the PC side allows fast communication while having a point-to-point connection between PC and DLC pro – without connecting the DLC pro to the local network or disconnecting the PC from it.

4.5.2 Mains Supply DLC pro

4.5.2.1 DLC pro with PS+ Power Supply Module

Connect the DLC pro to mains via the supplied mains cable. The DLC pro works with a wide range of input voltages.

CAUTION !	The mains voltage input of the DLC pro is a wide-range input for input voltages of 100 .. 240 V~, 50/60 Hz.

4.5.2.2 DLC pro with PS HP Power Supply Module

Connect the PS HP module to the DLC pro, and the PS HP external power adaptor to mains via the supplied cables as described in section 9.2.2. The PS HP external power adaptor works with a wide range of input voltages.

CAUTION !	The PS HP module is delivered together with an external power adaptor. The mains voltage input of this external power adaptor is a wide-range input for input voltages of 100 .. 240 V~, 50/60 Hz. Do not use other equipment than the external power adaptor delivered by TOPTICA.

4.5.3 Cable Connections

CAUTION !	Before connecting the cables to the laser head, the DLC pro must be switched off and disconnected from the mains supply.

NOTE !	For detailed information on the cable connections of your laser system, please refer to the respective laser head manual.

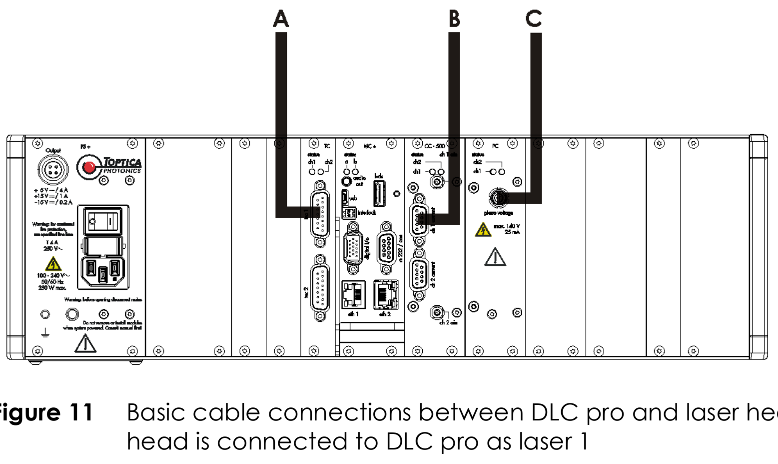


Figure 11 Basic cable connections between DLC pro and laser head (example DLC DL pro). The laser head is connected to DLC pro as laser 1

Basic Connections for laser 1:

A Temperature control connection to laser head 1
B Current control connection to laser head 1
C Piezo control connection to laser head 1

NOTE !	**Dual-Laser-Operation**: For examples and general rules on TC, CC, and PC module connection, please refer to section 10.2.1.

4.5.4 Laser Configuration for DL pro Laser Heads with EEPROM

NOTE !	All TOPTICA DL pro and TA pro laser heads with serial number 20000 and higher are equipped with an EEPROM. For detailed information on the configuration of your laser system, please refer to the respective laser head manual.

Laser heads equipped with an EEPROM have the operating parameters stored on this EEPROM and they are read out during the boot procedure of the DLC pro with the laser head connected.

CAUTION !	Before interchanging laser heads, the DLC pro must be switched off and disconnected from the mains supply. When the DLC pro is switched on at the ON/OFF switch at on the rear panel, the EEPROM of the new laser head is read out during the boot procedure and settings, such as current limits are set accordingly.

CAUTION !	As long as the laser emission is switched off by the **Emission** push button on the DLC pro front panel, the laser diode is short-circuited and therefore protected by the relay integrated in the TOPTICA diode laser head.

Switch on the ON/OFF switch on the DLC pro rear panel and wait for the DLC pro to start. The boot procedure takes approximately 30 to 60 seconds and is finished when an acoustic signal is played and the Home screen (see Figure 13) is displayed on the touchscreen.
Please note that you may need to enable the CC, TC or PC modules in the parameter menu.

4.5.5 Switching on the Laser

DANGER !	For your safety, we recommended that you set up an **external interlock circuit**. If no interlock circuit is connected, please use the supplied interlock plug to close the external interlock circuit. For detailed information, please refer to section 2.3.1.

DANGER !	Do not look into the laser beam of the connected laser as the output can exceed the limits for class 1 specified by US laws 21 CFR 1040.10 and 2 CFR 1040.11 and the Laser Safety Standard EN 60825-1:2014. Take precautions to eliminate exposure to a direct or reflected beam. Always wear appropriate laser safety goggles.

NOTE !	For detailed information on operating your laser system, please refer to the respective laser head manual.

1. Close the external interlock circuit.

2. Set the key switch on the DLC pro front panel to the Enable Laser position.

3. Select the Scan/Lock mode by pressing the **Scan/Lock Mode** button or tapping the corresponding symbol and select the Scan sub-screen by tapping the **Scan** function mode field at the bottom of the touchscreen. Adjust the desired set current with the top-right rotary knob, or enter it in the Laser tab of the PC-GUI.

4. Enable the desired laser for laser emission by pressing the **Laser 1**/**Laser 2** buttons on the DLC pro front panel (see sections 5.8 and 5.9 for details). Press the **Emission** push button on the DLC pro front panel. The enabled laser is switched on and the white Laser Radiation Emission Warning LED lights up and indicates laser emission.

5. If necessary, coarsely adjust the wavelength of the connected laser. Please refer to the laser head manual.

6. In the Scan sub-screen of the Scan/Lock mode, optimize the mode hop-free tuning as described in the laser head manual by adjusting the available parameters with the rotary knobs. If necessary, assign the top-left rotary knob to adjust Feed Forward or T_{set} (for assignment, please refer to section 4.4.2).

NOTE !	Feed Forward adjustment is normally not necessary unless the Set Current I_{set} or the Scan Frequency is changed considerably.

7. Store the settings by pressing the **Load/Save** button on the DLC pro front panel twice or via **Menu > Save Configuration** in the PC-GUI.

4.6 Power Down

NOTE !	For detailed information on operating your laser system, please refer to the respective laser head manual.

1. Press the **Emission** push button on the DLC pro front panel. All connected lasers are switched off and the Laser Radiation Emission Warning LED turns off.
In case of a DLC pro for Dual-Laser-Operation, please refer to section 5.8 and 5.9 for switching off only one laser by disabling it with the **Laser 1**/**Laser 2** buttons on the DLC pro front panel.

2. Press the **Power/Standby** push button to set the system into standby mode. The factory settings for the standby mode are such that every module but the TC module is switched off.
During longer breaks, switch off the key switch on the DLC pro front panel (for laser safety reasons) and switch off the DLC pro with the ON/OFF switch on the rear panel.

4.7 Normal Power Up

NOTE !	For detailed information on operating your laser system, please refer to the respective laser head manual.

1. Depending on the status, switch on the DLC pro by the ON/OFF switch on the rear panel (wait for boot procedure to be completed) or press the **Power/Standby** push button.

2. Press the **Emission** push button on the DLC pro front panel. The enabled lasers are switched on and the white Laser Radiation Emission Warning LED indicates laser emission.

3. Switch to the Scan sub-screen of the Scan/Lock mode (for touchscreen operation see section 5.3, for PC-GUI operation see section 6.15) and optimize the scan by tuning I_{set} and T_{set}. Changing the Feed Forward is usually not required.

4.8 Seed Laser + BoosTA pro Combination

In addition to a DL pro, DFB pro or CTL as seed laser head, a BoosTA pro tapered amplifier can be connected to the DLC pro, if at least one CC-5000 module is installed in the DLC pro laser driver electronics. The operation and control of the respective seed laser head is unchanged, and controls for the BoosTA pro are added in the user interfaces: In the touchscreen user interface, the top-left parameter of the Scan/Lock screen can be changed to display/control the amplifier actual and set current (see section 5.3.7.1). The TOPAS DLC pro PC-GUI shows additional fields for the amplifier current and temperature in the Laser tab (see section 6.14.9).

Please refer to the BoosTA pro manual for details about how to connect and power up/down the laser heads correctly.

4.9 User Levels

One feature of the DLC pro is the option to restrict or allow reading and/or changing parameters according to the expert knowledge of the user. Five user levels are available:

READ-ONLY: Parameters can be read but their values cannot be changed.

USER: User level for daily operation of the laser. **The DLC pro touchscreen interface is acting in this user level.**
To operate the laser remotely via network access, we recommend introducing a password for the USER level (please refer to section 4.9.1). Please note that now operation of the laser directly via the operator controls at the DLC pro is still possible.
For locking the touchscreen and the operator controls at the DLC pro by a pincode, please refer to section 4.9.2.

MAINTENANCE: User level for operations needed to maintain the laser (according to the laser safety standard).

SERVICE: User level for operations that may change the laser safety classification such as changing the maximum operating current of the laser (service operation according to the laser safety standard).

INTERNAL: For internal TOPTICA use only.

DANGER !	The user levels MAINTENANCE and SERVICE may only be accessed by authorized and specially-trained service personnel.

The passwords for the user levels MAINTENANCE and SERVICE are noted in the Electronics/Software section of the Production and Quality Control Data Sheet. Maintenance and service operations need to be performed by using the TOPAS DLC pro PC-GUI as for the touchscreen interface the USER level is fixed.

For changing the user level, click **Menu > Device Configuration** and select the **Userlevel section** (please refer to section 6.11).

NOTE ! The user level required for changing a certain parameter is noted in the parameter description in the Remote Command Reference for TCP/IP and USB. This document is available as a pdf file in the Documentations folder on the software USB flash drive supplied with the DLC pro.
The user level nomenclatures in the Remote Command Reference and in this manual correspond as follows:
4 > READ-ONLY
3 > USER
2 > MAINTENANCE
1 > SERVICE
0 > INTERNAL

4.9.1 Introducing a Password for the USER Level

NOTE !	When a password for the USER level is introduced, only DLC pro remote control operation by TOPAS DLC pro, or by sending control commands is affected: Parameter values cannot be changed anymore (read-only) unless the password is entered. Operation of the laser directly via the operator controls at the DLC pro is still possible. For locking the touchscreen and the operator controls at the DLC pro by a pincode, please refer to section 4.9.2.

Please proceed as described below to introduce a password for the USER level:

1. Select **Menu > Device Configuration > Userlevel section** and change to the SERVICE level.

2. Select **change-password** in the Params tab of the TOPAS DLC pro PC-GUI and click on its right so that **Execute** appears. Click **Execute** to open a dialog window.

3. Enter the desired password in the input field and click **Execute** to set the password.

4. Select **Menu > Device Configuration > Userlevel section** and change to the USER level.

5. Switch the DLC pro off and on at the ON/OFF switch on the rear panel to reboot.

NOTE !	After switching off, please wait for at least 10 seconds before switching the DLC pro on again.

NOTE !	If a password for the USER level is introduced, this password plus the MAINTENANCE password must be entered as a combined but single password for changing to the MAINTENANCE level. The SERVICE password remains unchanged.

4.9.2 Locking Touchscreen and Operator Controls at the DLC pro via a Pin-code

NOTE !	When the touchscreen and the operator controls at the DLC pro are locked by a pin-code, operation of the **Emission** and **Power/Standby** push buttons is still possible.

Please proceed as described below to introduce a pincode for locking the touchscreen and the operator controls at the DLC pro:

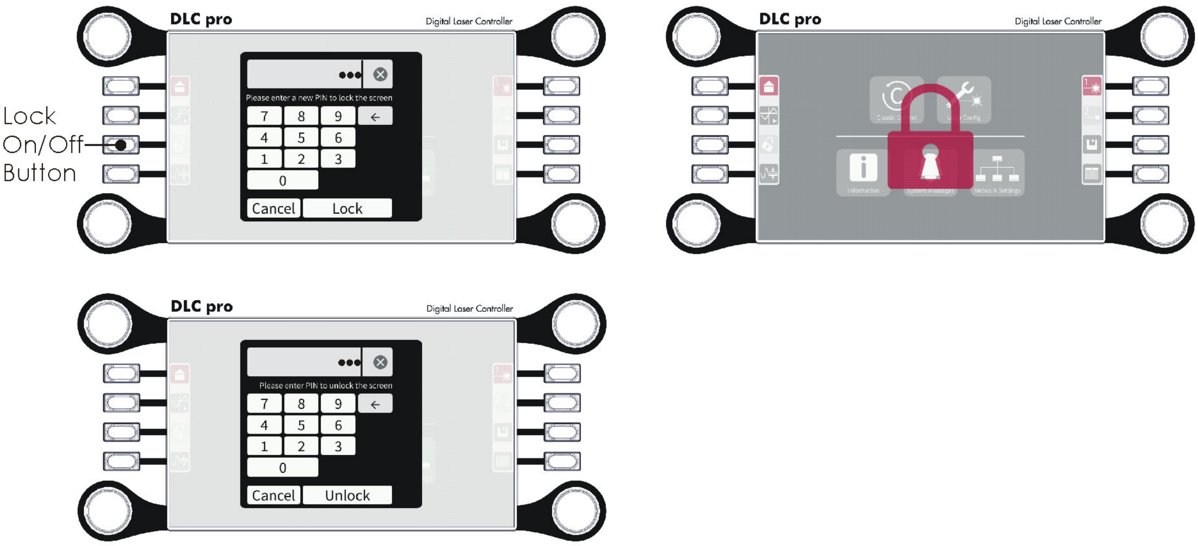


Figure 12 Locking the touchscreen and the operator controls at the DLC pro

1. Press the **Lock On/Off** button for longer than 4 seconds until a numerical editor appears.
2. Enter a pincode and tap **Lock**. The touchscreen and the operator controls at the DLC pro are locked. This is indicated by a red lock symbol and a transparent touchscreen appearance.
3. To unlock the touchscreen and the operator controls, again press the **Lock On/Off** button for longer than 4 seconds. Enter the previously entered (see 2.) pincode and tap **Unlock**. The touch-screen and the operator controls at the DLC pro are unlocked.

NOTE !	In case the pincode is lost, a Master PIN to unlock the touchscreen is noted in the Electronics/Software section of the Production and Quality Control Data Sheet. For a DLC pro delivered with firmware lower than 2.0.0 please contact TOPTICA Service (see section 10.35) to obtain the Master PIN.

4.10 Laser Current Settings and Clips

A number of laser current related parameters ensure that the laser is operated in a safe way. The order is as follows (assuming positive current values):

0 ≤ current-set, current-act ≤ current-clip ≤ current-clip-limit ≤ maximal current of supply

The maximal current of supply depends on the CC module(s) of the DLC pro and their operating mode (CC-500: two channel or one channel) and their setting.

current-set	**Set Current** is the operating current to which the output of the CC module is regulated when the laser is switched on.
current-act	**Actual Current** is the current as measured internally.
current-clip	Named **Maximum Current** in the various menus and tabs on the touchscreen and the TOPAS DLC pro PC-GUI. Current-clip may be changed in the USER level and is intended to limit the operating current of the laser to a certain range, e.g., a level needed to reach the desired power level for the experiment.
current-clip-limit	May be changed in the Params tab of the TOPAS DLC pro PC-GUI. The SERVICE level is required to change the value as in some cases the laser class may be affected or at least the power level may be changed. Current-clip-limit may be used to limit the power of the laser to fulfill safety regulations. The laser is classified with the power emitted at this current.

4.11 Loading/Saving of Device Parameter Configurations

DANGER !	Always switch off the laser emission of the connected laser heads when handling configurations !

The DLC pro allows to save and load several device parameter configurations, which include laser head operation parameters as well as not laser head specific settings of the DLC pro, e.g., display settings. A configuration file contains the laser head type and its serial number and can only be loaded if this data matches the selected laser head. Please refer to sections 5.11.1 and 6.11 for detailed information on how to load/save device parameter configurations via the DLC pro touchscreen or the TOPAS DLC pro PC-GUI.

4.12 Loading the Factory Settings

DANGER !	Always switch off the laser emission of the connected laser heads when handling factory settings !

NOTE !	Factory settings are certain laser head specific operation parameters, such as laser diode maximum voltages and currents, laser diode polarity, photo diode calibration data and other mostly laser safety related settings. For additional information please refer to section 10.14. **Please note that the factory settings may have been changed formerly by the user**, e.g. after an exchange of the laser diode.

In general, the operation parameters for the connected laser head are saved by pressing the **Load/Save** button on the DLC pro front panel twice or via **Menu > Save Configuration** in the PC-GUI. During the boot procedure of the DLC pro, these operation parameters are loaded again.
To load and use the parameter values in the factory settings, you have the following options:

DLC pro Touchscreen

Please use the Factory Settings section in the Configuration Manger (see section 5.11.1).

TOPAS DLC pro PC-GUI Configuration Manager

Run the TOPAS DLC pro PC-GUI on the control computer and connect to the laser head (please refer to section 6). Please use the Configuration Manger which is available in the menu (see section 6.11).

TOPAS DLC pro PC-GUI Params Tab

1. Run the TOPAS DLC pro PC-GUI on the control computer and connect to the laser head (please refer to section 6).

2. In the Params tab of the TOPAS DLC pro PC-GUI (see section 6.24), look for the factory settings and click **apply** to load.

NOTE !	In case of an amplified or frequency converted laser system, the factory settings of the Master Oscillator (dl), the Amplifier (amp), the SHG stage (nlo > shg), and fhg stage (nlo fhg) are treated separately. For a CTL laser system, please load the factory settings for (dl) and (ctl) separately.

3. If these settings should be used after the next DLC pro boot procedure, please click **Menu > Save Configuration**.

5 Touchscreen User Interface

For operation of the DLC pro via the touchscreen user interface, use the touchscreen as well as the rotary knobs and the push buttons. For basic rotary knob and touchscreen operation, please refer to section 4.4.

NOTE !	The screenshot function (please refer to section 10.12) allows for storing screenshots of the actual touchscreen display on a USB flash drive.

5.1 Upgrade for Control of a 2nd Laser (Dual-Laser-Operation)

NOTE !	To use the DLC pro for control of two lasers (Dual-Laser-Operation), an Upgrade for Control of a 2nd laser is required. When the Dual-Laser-Operation upgrade is acquired, TOPTICA provides a license key via e-mail or USB flash drive and additional hardware, such as modules and cables. For installation of the modules, please refer to sections 10.4 and 10.5. The license key must be activated via the TOPAS DLC pro PC-GUI (please refer to section 10.19). If purchased along with the DLC pro, the licence and the hardware will already be installed.

The Digital Laser Controller DLC pro is capable of controlling two laser systems of the type DL pro, DFB pro, TA pro, BoosTA pro or two modules in the TA pro AL (MTA pro) laser head. In this manual, mainly the operation of one laser is described, the second laser is operated in the same way. After pressing the **Laser 1/2** buttons on the DLC pro front panel or tapping the symbols aside (see sections 5.8 and 5.9), you can control the laser which is connected to the DLC pro as laser 1/2. The front panel controls change accordingly. Additional information on the connection and operation of two lasers is noted in this manual where necessary. With a single Lock option installed (see section 10.19), in combination with the Dual-Laser-Operation upgrade, frequency locking of both lasers is possible.

5.2 Home Screen

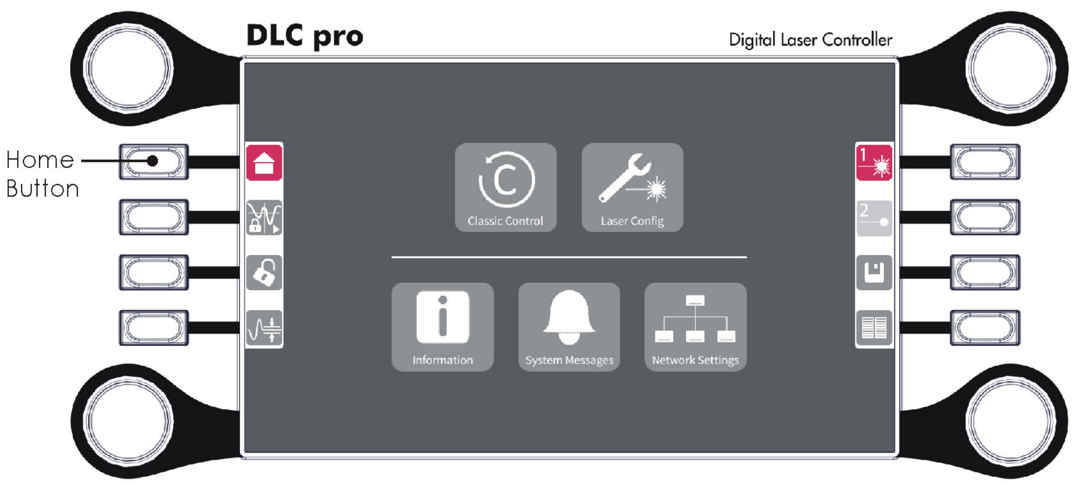


Figure 13 Home screen (example DLC DL pro)

Pressing the **Home** button or tapping the corresponding symbol allows to access the Home screen. Depending on the type of the connected laser head, it offers various sub menus which are described in the following sections.

5.2.1 Classic Control

Tap **Classic Control** to operate the DLC pro in a way similar to the front panel operation of the plug-in modules of the DC 110 Laser Driver Electronics. Please note that the **Classic Control** is not available for the operation of all types of laser heads.

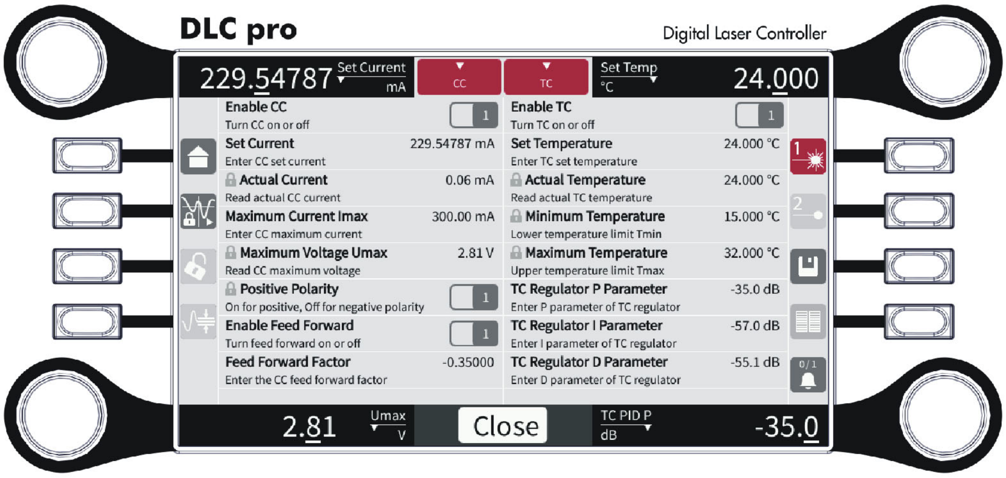


Figure 14 Classic Control showing operating parameters for CC module and TC module (example)

The display shows two columns with the most important operating parameters of two selectable modules which can be directly adjusted without entering the parameter menu. Tap the top or bottom Right/Left Parameter to assign the rotary knobs to various functions (see section 4.4.2). The operating parameters displayed for each module are a selection from the complete parameter menu (please refer to section 5.12).

To select the modules to be displayed, tap the red fields at the top of the touchscreen and choose the desired modules. Press the **Load/Save** button or tap the corresponding symbol twice to store the settings to the flash memory of the DLC pro. Tap **Close** to return to the Home screen.

NOTE !	**DLC TA pro and DLC TA pro AL:** For certain alignment procedures, it is necessary to operate Master Oscillator and Tapered Amplifier independently from one another. Please use the Classic Control for this purpose.

5.2.2 Information

Tap **Information** on the **Main** screen to display various details of your DLC pro on the touchscreen, including serial numbers, version number of the installed firmware and system software, and time of operation of the laser head.

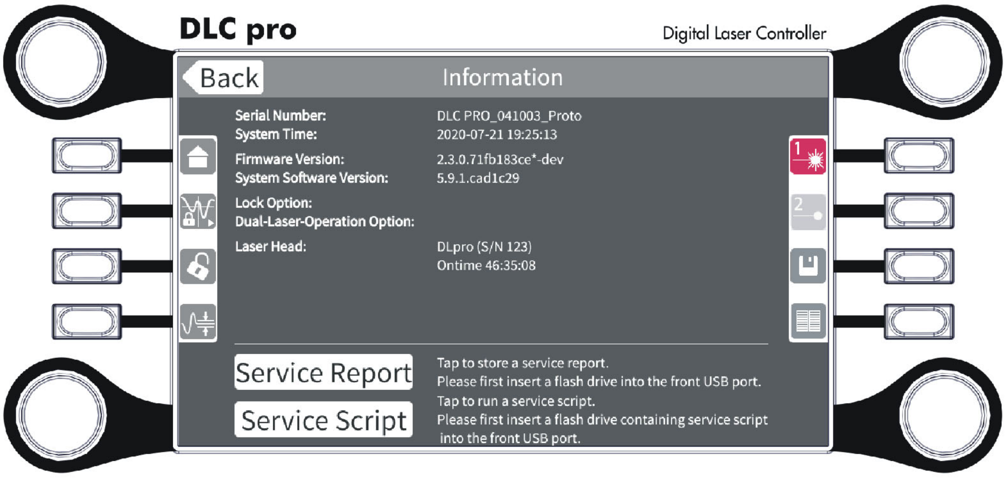


Figure 15 Information screen

You can scroll the lower section of the screen to get access to all functions of the Information screen:

System Info	Shows a detailed system summary.
Legal Info	This product incorporates certain third party software. The license and copyright information associated with this software is available after tapping **Legal Info**.
Service Report	Store a service report to a USB flash drive which first must be inserted at the USB connector on the DLC pro front panel (see section 4.1).
Service Script	Functionality to run a service script provided by TOPTICA: Create a directory \toptica on a FAT formatted USB flash drive. Copy the service script to the \toptica directory on the USB flash drive. Plug the USB flash drive into the USB connector on the DLC pro front panel (please refer to section 4.1).

5.2.3 System Messages

Tap **System Messages** to display current messages on the touchscreen.

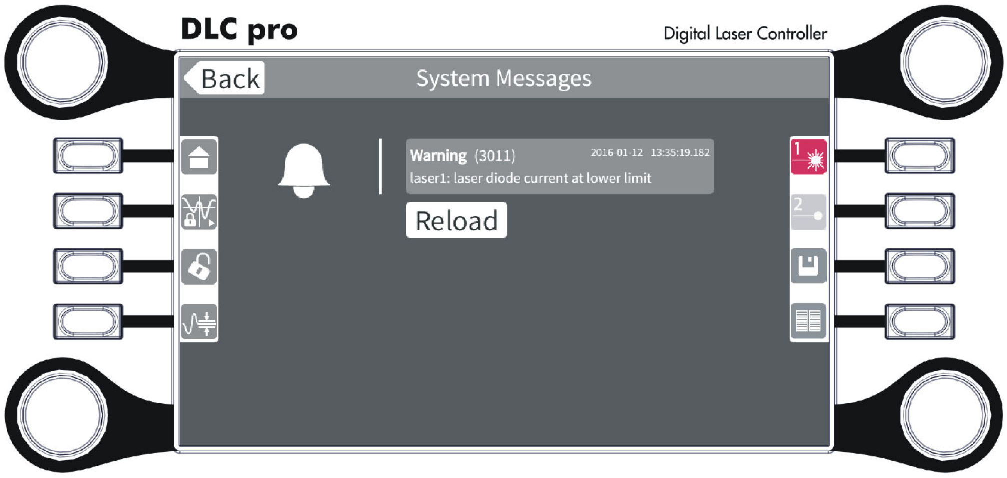


Figure 16 System Messages

The system messages are displayed together with the date and the time of the occurrence. If there is a current message, the total number of current system messages is displayed in the bottom right area of the touchscreen next to the small bell symbol (e.g., 0/1 means: 0 messages not confirmed so far, 1 current message total). The description of the warnings and errors is displayed along with the time at which they occurred (see also section 10.15). Tap **Reload** to refresh the displayed messages. Tap **Back** to return to the Home screen.

NOTE !	A system message is only deleted, if the cause of the malfunction is resolved.

NOTE !	Only current system messages are displayed on the touchscreen. For checking all system messages since the last boot procedure of the DLC pro, you need to use the TOPAS DLC pro PC-GUI. Click on the red **Error** indicator in its header (please refer to section 6.5) to open the System Messages window (please refer to section 6.10) and select **Message Log**.

5.2.4 Network Settings

Tap **Network Settings** to enter the menu for network configuration.

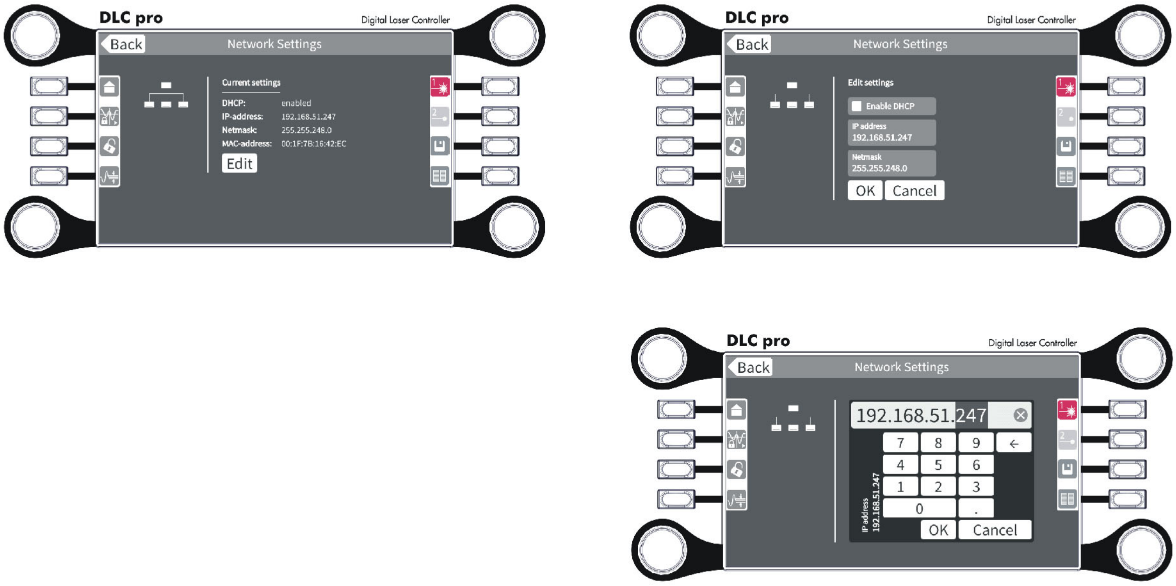


Figure 17 Network Settings

In the first window (Figure 17 top left), the current network settings (DHCP status, IP-Address, Netmask, and MAC-Address) are displayed. Please ask your network administrator for information on how to configure the network interface.

NOTE !	To connect the DLC pro directly to a computer, disable DHCP on both devices and set the same subnet mask (e.g., 255.255.255.0) and different IP addresses (e.g., 192.168.1.200 and 192.168.1.201).

Back Tap to close the window and return to the Home screen.

Edit Tap to open a window (Edit Settings, Figure 17 top right) for changing the network settings.

Edit Settings Window Tap the setting to be changed. A numerical editor (Figure 17 bottom right) opens to change the value. Tap **OK** to use the new setting or **Cancel** to discard the change.

Enable DHCP **When selected**, the device's network adapter configuration is set for automatic setup by a DHCP server. In order to use the DHCP mechanism, tap **OK**.
When not selected, the device's network adapter configuration is set to a static IP configuration. The desired IP address and netmask have to be provided in the **IP-address** and **Netmask** field, respectively. In order to use the new static address, click **OK**.

IP-Address Tap to open a numerical editor for setting up a fixed IP address. Enter a valid IPv4 address in the format "xxx.xxx.xxx.xxx". (e.g., "192.168.51.247"). Tap **OK** to use the new setting or **Cancel** to discard the change.

Netmask Tap to open a numerical editor for setting up a fixed subnet mask. Enter a valid IPv4 netmask in the format "xxx.xxx.xxx.xxx". (e.g., "255.255.255.0"). Tap **OK** to use the new setting or **Cancel** to discard the change.

OK Tap **OK** to apply the new settings.

Cancel Tap to discard the new setting.

5.2.5 Laser Config

Tap **Laser Config** to display a menu for basic laser head parameters on the touchscreen. Please note that the **Laser Config** menu is not available for all types of laser heads.

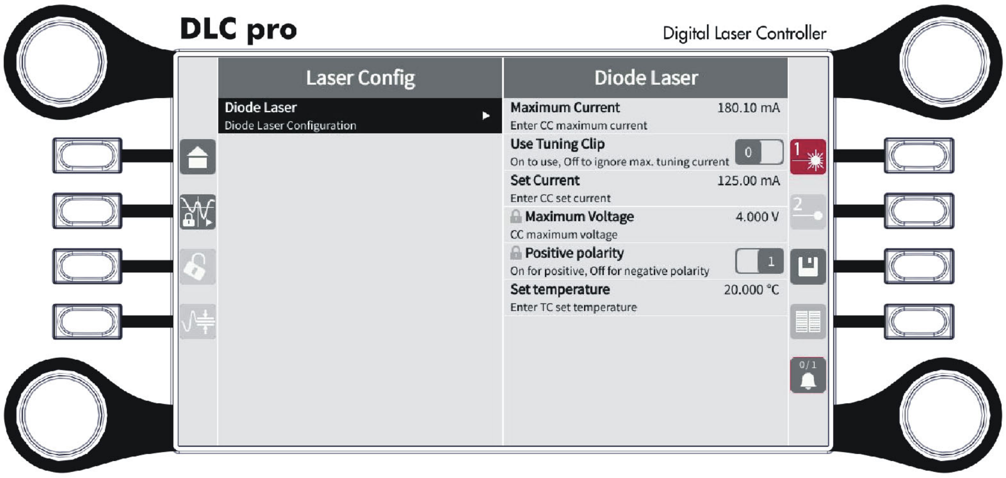


Figure 18 Laser Config screen (example DLC DL pro/DLC DFB pro)

NOTE !	**DLC TA pro/-AL, DLC BoosTA pro and Seed Laser + BoosTA pro Combination:** Configuration of the laser head is only possible in the TOPAS DLC pro PC-GUI (**Menu > Device Configuration > Laser Configuration Section**).

The Laser Config screen allows the configuration of the selected laser head (**Laser 1**/**Laser 2** buttons, see sections 5.8 and 5.9). Depending on the laser type, some or all of these values can be changed.

You can adjust the settings directly without entering the parameter menu. For TOPTICA laser heads, please refer to the corresponding Production and Quality Control Data Sheet for the proper operating parameters.

Example:
Basic Laser Head Current Parameters for Laser 1:

Maximum Current	Parameter: laser1:dl:cc:current-clip
Use Tuning Clip	Checking the box limits the laser diode current to the Maximum Tuning Current. In case this Maximum Tuning Current is lower than the entry in the **Maximum Current** field, this field changes to **Maximum Tuning Current** (display only).

CAUTION !	**Laser heads with Motor pro option**: Checking the **Use Tuning Clip** boxes for diode laser and amplifier (depending on the connected laser head) is **mandatory** before performing a motor scan. This avoids damage to the laser diode (and the amplifier) during a motor scan.

Set Current	I_{set}
Maximum Voltage	U_{max}
Laser Diode Polarity	0: Negative LD polarity 1: Positive LD polarity

Basic Laser Head Temperature Parameters for Laser 1:

Set Temperature	T_{set}

Press the **Load/Save** button or tap the corresponding symbol twice to store the settings to the flash memory of the DLC pro.

5.2.6 Optimization (DLC CTL)

Tap **Optimization** to access the optimization routines for SMILE parameters and FLOW on the touch-screen. For detailed information on SMILE and FLOW, please refer to the CTL manual.

CAUTION !	Do not change any operating parameters (e.g., I_{set}, T_{set}) of the laser during SMILE or FLOW optimization.

NOTE !	**Dual-Laser-Operation**: The optimization routine only affects the laser selected by the **Laser 1**/**Laser 2** button (see sections 5.8 and 5.10.

NOTE !	Normally DLC pro saves the optimized parameters automatically after a SMILE or FLOW optimization is performed. If a new laser head has been connected to the DLC pro and the new system configuration has not yet been saved by pressing the **Save** button, the resulting SMILE and FLOW parameters are not automatically saved as they would not be compatible with the operation parameters of the previous laser head. In this case press the **Save** button before performing a SMILE or FLOW optimization.

NOTE !	The **SMILE** or **FLOW** buttons may be grayed, if a SMILE or FLOW optimization is not possible, e.g. due to an active power stabilization. During a SMILE or FLOW optimization, an active wide scan, scan or ARC is temporarily deactivated.

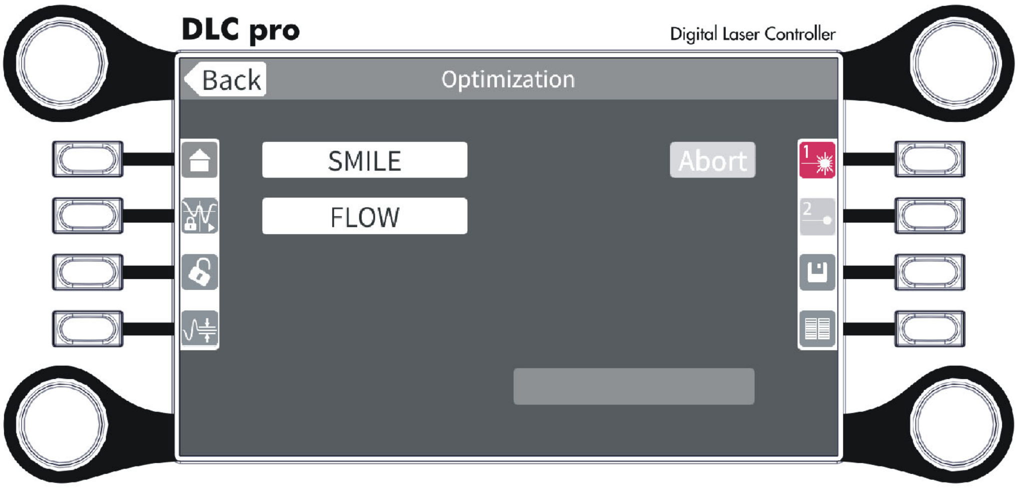


Figure 19 Optimization screen (DLC CTL)

SMILE Tap **SMILE** to start an optimization of SMILE parameters. The progress bar on the touchscreen indicates the status of the optimization. For details, please refer to the CTL manual.

FLOW Tap **FLOW** to start an optimization of the laser threshold and subsequently the SMILE optimization. The progress bar on the touchscreen indicates the status of the optimization. For details, please refer to the CTL manual.

Abort Tap **Abort** to stop the optimization. The previous SMILE/FLOW parameter values are resumed.

Back Tap **Back** to return to the Home screen.

5.2.7 Optimization TA pro AL

NOTE !	The TA pro AL laser head is equipped with the AutoAlign option (motorized mirrors). Depending on the laser head setup, some optimization routines may not be available.

NOTE !	**Dual-Laser-Operation**: The optimization routine only affects the laser selected by the **Laser 1**/**Laser 2** button (see sections 5.8 and 5.10.

Tap **Optimization** to access the optimization routines for laser beam alignment on the touchscreen. For detailed information, please refer to the TA pro AL manual.

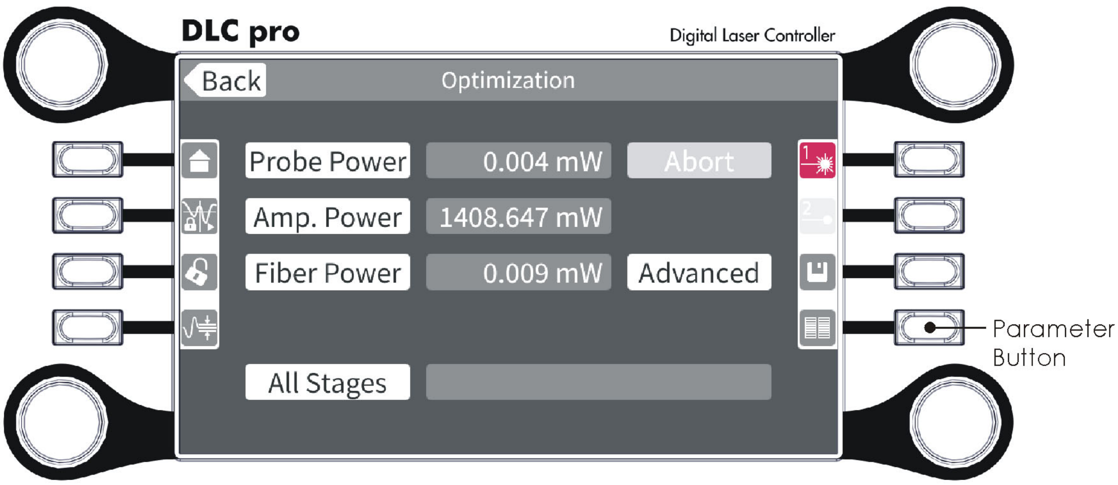


Figure 20 Optimization screen (DLC TA pro AL, example)

Probe Power — **Only available with DLC TA pro AL laser in DL pro and TA pro configuration.** Tap **Probe Power** to start an optimization of the probe laser beam power. The progress bar on the touchscreen indicates the status of the optimization. For details, please refer to the TA pro AL manual.

Amp. Power — **Only available with DLC TA pro AL laser in TA pro and BoosTA pro configuration.** Tap **Amp. Power** to start an optimization of the Tapered Amplifier power. The progress bar on the touchscreen indicates the status of the optimization. For details, please refer to the TA pro AL manual.

Fiber Power — **Only available with DLC TA pro AL laser in TA pro and BoosTA pro configuration.** Tap **Fiber Power** to start an optimization of the fiber output power. The progress bar on the touchscreen indicates the status of the optimization. For details, please refer to the TA pro AL manual.

Fiber Power Advanced — When selected, a combination of optimization algorithms is performed. For details, please refer to the TA pro AL manual.

All Stages Tap **All Stages** to start the available optimization procedures in a pre-set sequence:
1. Probe Power optimization
2. Amp. Power optimization
3. Fiber Power optimization

Abort Tap **Abort** to stop an optimization. The system behavior at **Abort** can be set by the in the context parameter menu (parameter **Power Optimization > XXX Stage > Servo Return at Abort**).

Back Tap **Back** to return to the Home screen.

The parameters for the optimization routines are set in the context parameter menu (please refer to section 5.2.7.1) which is available after pressing the **Parameter** button or tapping the corresponding symbol.

5.2.7.1 Optimization Context Parameter Menu

The parameters for the optimization routines are set in the context parameter menu which appears on the touchscreen after pressing the **Parameter** button with the Optimization screen selected. On the following pages, detailed information about each accessible parameter is provided.

NOTE !	The last line of each parameter description shows the path in the parameter menu. These parameters may also be modified by user specific software. For a detailed description, please refer to the Remote Command Reference for TCP/IP and USB. This document is available as a pdf file in the Documentations folder on the software USB flash drive supplied with the DLC pro.

Power Optimization

Seed Probe Stage (only DLC TA pro AL laser in DL pro and TA pro config.)
Settings for seed probe stage

Servo Return at Abort
Enable or disable servo return at abort
[1: enabled], [0: disabled]
laser1:dl:power-optimization:stage1:restore-on-abort (boolean)

Servo Return at Power Decrease
Servo return behavior at power decrease
[1: enabled], [0: disabled]
laser1:dl:power-optimization:stage1:restore-on-regress (boolean)

Optimization Margin
Enter failure margin for optimization in [%]
If the power has decreased by this margin at the end of the optimization routine, action is taken as defined by the parameter **Servo Return at Power Decrease**.
laser1:dl:power-optimization:stage1:regress-tolerance (real)

Amplifier Stage (only DLC TA pro AL laser in TA pro and BoosTA pro config.)
Settings for amplifier stage

Servo Return at Abort
Enable or disable servo return at abort
[1: enabled], [0: disabled]
laser1:dl:power-optimization:stage2:restore-on-abort (boolean)

Servo Return at Power Decrease
Servo return behavior at power decrease
[1: enabled], [0: disabled]
laser1:dl:power-optimization:stage2:restore-on-regress (boolean)

Optimization Margin
Enter failure margin for optimization in [%]
laser1:dl:power-optimization:stage2:regress-tolerance (real)

Fiber Stage (only DLC TA pro AL laser in DL pro and TA pro config.)
Settings for fiber stage

Servo Return at Abort
Enable or disable servo return at abort
[1: enabled], [0: disabled]
laser1:dl:power-optimization:stage3:restore-on-abort (boolean)

Servo Return at Power Decrease
Servo return behavior at power decrease
[1: enabled], [0: disabled]
laser1:dl:power-optimization:stage3:restore-on-regress (boolean)

Optimization Margin
Enter failure margin for optimization in [%]
laser1:dl:power-optimization:stage3:regress-tolerance (real)

Fiber Advanced Stage (only DLC TA pro AL laser in DL pro and TA pro config.)
Settings for fiber advanced stage

Servo Return at Abort
Enable or disable servo return at abort
[1: enabled], [0: disabled]
laser1:dl:power-optimization:stage4:restore-on-abort (boolean)

Servo Return at Power Decrease
Servo return behavior at power decrease
[1: enabled], [0: disabled]
laser1:dl:power-optimization:stage4:restore-on-regress (boolean)

Optimization Margin
Enter failure margin for optimization in [%]
laser1:dl:power-optimization:stage4:regress-tolerance (real)

Servo Positions

Seed Probe Stage (only DLC TA pro AL laser in DL pro and TA pro config.)
Servo positions of seed probe stage

Servo Position PROBE-1-H
Set horizontal position of first mirror
laser1:dl:servo:probe1-hor:value (integer)

Servo Position PROBE-1-V
Set vertical position of first mirror
laser1:dl:servo:probe1-vert:value (integer)

Amplifier Stage
Servo positions of amplifier stage

Servo Position TA-1-H
Set horizontal position of first mirror
laser1:dl:servo:ta1-hor:value (integer)

Servo Position TA-1-V
Set vertical position of first mirror
laser1:dl:servo:ta1-vert:value (integer)

Servo Position TA-2-H
Set horizontal position of second mirror
laser1:dl:servo:ta2-hor:value (integer)

Servo Position TA-2-V
Set vertical position of second mirror
laser1:dl:servo:ta2-vert:value (integer)

Fiber Stage
Servo positions of fiber stage

Servo Position FIBER-1-H
Set horizontal position of first mirror
laser1:dl:servo:fiber1-hor:value (integer)

Servo Position FIBER-1-V
Set vertical position of first mirror
laser1:dl:servo:fiber1-vert:value (integer)

5.2.8 Optimization (DLC DL-/TA-SHG/FHG pro)

NOTE !	This Optimization screen is only available for DLC DL-/TA-SHG/FHG pro systems with the AutoAlign option (motorized mirrors). Depending on the laser head setup, some optimization routines may not be available.

Tap **Optimization** to access the optimization routines for laser beam alignment on the touchscreen. For detailed information, please refer to the DL-/TA-SHG/FHG pro manual.

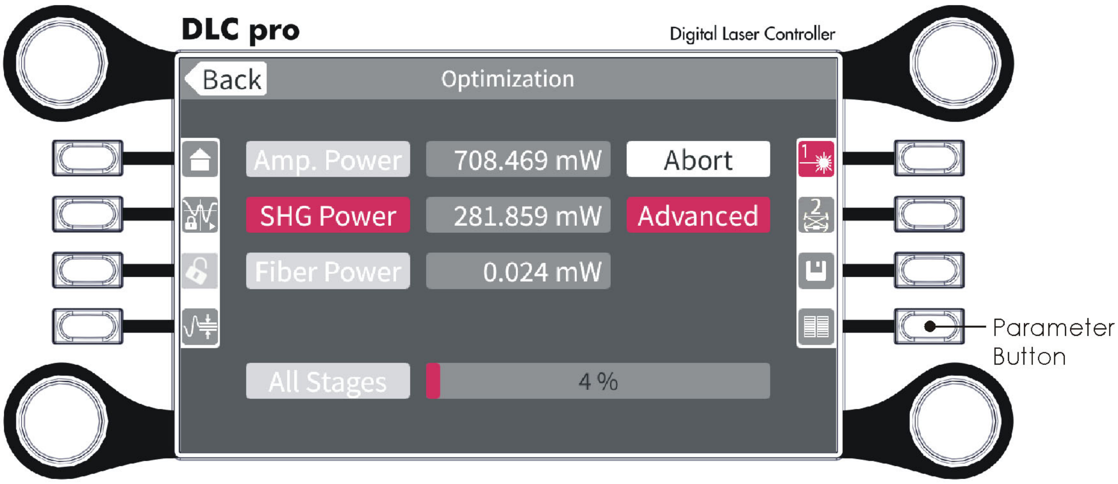


Figure 21 Optimization screen (example DLC DL-/TA-FHG pro system with AutoAlign option)

Amp. Power
Only available with DLC TA-SHG/FHG pro systems. Tap **Amp. Power** to start an optimization of the Tapered Amplifier power. The progress bar on the touchscreen indicates the status of the optimization. For details, please refer to the DL-/TA-SHG/FHG pro manual.

SHG Power
Tap **SHG Power** to start an optimization of the SHG power. The progress bar on the touchscreen indicates the status of the optimization. For details, please refer to the DL-/TA-SHG/FHG pro manual.

FHG Power
Only available with DLC DL-/TA-FHG pro systems. Tap **FHG Power** to start an optimization of the SHG power. The progress bar on the touchscreen indicates the status of the optimization. For details, please refer to the DL-/TA-SHG/FHG pro manual.

Fiber Power
Only available on systems with option FiberMon. Tap **Fiber Power** to start an optimization of the fiber output power. The progress bar on the touchscreen indicates the status of the optimization. For details, please refer to the DL-/TA-SHG/FHG pro manual.

SHG Power Advanced
When selected, a combination of optimization algorithms is performed. For details, please refer to the DL-/TA-SHG/FHG pro manual.

Status: 29.3.22

All Stages

Tap **All Stages** to start the available optimization procedures in a pre-set sequence:

1. Amplifier Power optimization (only DLC TA-SHG/FHG pro)
2. SHG Power optimization
3. FHG Power optimization (only DLC DL-/TA-FHG pro)
4. Fiber Power optimization (only with option FiberMon)

Abort

Tap **Abort** to stop an optimization. The system behavior at **Abort** can be set by the in the context parameter menu (parameter **Power Optimization > XXX Stage > Servo Return at Abort**).

Back

Tap **Back** to return to the Home screen.

The parameters for the optimization routines are set in the context parameter menu (please refer to section 5.2.8.1) which is available after pressing the **Parameter** button or tapping the corresponding symbol.

5.2.8.1 Optimization Context Parameter Menu

The parameters for the optimization routines are set in the context parameter menu which appears on the touchscreen after pressing the **Parameter** button with the Optimization screen selected. On the following pages, detailed information about each accessible parameter is provided.

NOTE !	The last line of each parameter description shows the path in the parameter menu. These parameters may also be modified by user specific software. For a detailed description, please refer to the Remote Command Reference for TCP/IP and USB. This document is available as a pdf file in the Documentations folder on the software USB flash drive supplied with the DLC pro.

Power Optimization

Amplifier Stage (only DLC TA-SHG/FHG pro)
Settings for amplifier stage

Servo Return at Abort
Enable or disable servo return at abort
[1: enabled], [0: disabled]
laser1:nlo:power-optimization:stage1:restore-on-abort (boolean)

Servo Return at Power Decrease
Servo return behavior at power decrease
[1: enabled], [0: disabled]
laser1:nlo:power-optimization:stage1:restore-on-regress (boolean)

Optimization Margin
Enter failure margin for optimization in [%]
If the power has decreased by this margin at the end of the optimization routine, action is taken as defined by the parameter **Servo Return at Power Decrease**.
laser1:nlo:power-optimization:stage1:regress-tolerance (real)

SHG Stage
Settings for SHG stage

Servo Return at Abort
Enable or disable servo return at abort
[1: enabled], [0: disabled]
laser1:nlo:power-optimization:stage2:restore-on-abort (boolean)

Servo Return at Power Decrease
Servo return behavior at power decrease
[1: enabled], [0: disabled]
laser1:nlo:power-optimization:stage2:restore-on-regress (boolean)

Optimization Margin
Enter failure margin for optimization in [%]
laser1:nlo:power-optimization:stage2:regress-tolerance (real)

SHG Advanced Stage
Settings for SHG Advanced stage

Servo Return at Abort
Enable or disable servo return at abort
[1: enabled], [0: disabled]
laser1:nlo:power-optimization:stage3:restore-on-abort (boolean)

Servo Return at Power Decrease
Servo return behavior at power decrease
[1: enabled], [0: disabled]
laser1:nlo:power-optimization:stage3:restore-on-regress (boolean)

Optimization Margin
Enter failure margin for optimization in [%]
laser1:nlo:power-optimization:stage3:regress-tolerance (real)

FHG Stage
Settings for FHG stage

Servo Return at Abort
Enable or disable servo return at abort
[1: enabled], [0: disabled]
laser1:nlo:power-optimization:stage5:restore-on-abort (boolean)

Servo Return at Power Decrease
Servo return behavior at power decrease
[1: enabled], [0: disabled]
laser1:nlo:power-optimization:stage5:restore-on-regress (boolean)

Optimization Margin
Enter failure margin for optimization in [%]
laser1:nlo:power-optimization:stage5:regress-tolerance (real)

Fiber Stage (only with option FiberMon)
Settings for fiber stage

Servo Return at Abort
Enable or disable servo return at abort
[1: enabled], [0: disabled]
laser1:nlo:power-optimization:stage4:restore-on-abort (boolean)

Servo Return at Power Decrease
Servo return behavior at power decrease
[1: enabled], [0: disabled]
laser1:nlo:power-optimization:stage4:restore-on-regress (boolean)

Optimization Margin
Enter failure margin for optimization in [%]
laser1:nlo:power-optimization:stage4:regress-tolerance (real)

Servo Positions

Amplifier Stage (only DLC TA-SHG pro)
Servo positions of amplifier stage

Servo Position TA-1-H
Set horizontal position of first mirror
laser1:nlo:servo:ta1-hor:value (integer)

Servo Position TA-1-V
Set vertical position of first mirror
laser1:nlo:servo:ta1-vert:value (integer)

Servo Position TA-2-H
Set horizontal position of second mirror
laser1:nlo:servo:ta2-hor:value (integer)

Servo Position TA-2-V
Set vertical position of second mirror
laser1:nlo:servo:ta2-vert:value (integer)

SHG Stage
Servo positions of SHG stage

Servo Position SHG-1-H
Set horizontal position of first mirror
laser1:nlo:servo:shg1-hor:value (integer)

Servo Position SHG-1-V
Set vertical position of first mirror
laser1:nlo:servo:shg1-vert:value (integer)

Servo Position SHG-2-H
Set horizontal position of second mirror
laser1:nlo:servo:shg2-hor:value (integer)

Servo Position SHG-2-V
Set vertical position of second mirror
laser1:nlo:servo:shg2-vert:value (integer)

FHG Stage
Servo positions of FHG stage

Servo Position FHG-1-H
Set horizontal position of first mirror
laser1:nlo:servo:fhg1-hor:value (integer)

Servo Position FHG-1-V
Set vertical position of first mirror
laser1:nlo:servo:fhg1-vert:value (integer)

Servo Position FHG-2-H
Set horizontal position of second mirror
laser1:nlo:servo:fhg2-hor:value (integer)

Servo Position FHG-2-V
Set vertical position of second mirror
laser1:nlo:servo:fhg2-vert:value (integer)

Fiber Stage (only with option FiberMon)
Servo positions of fiber stage

Servo Position Fiber-1-H
Set horizontal position of first mirror
laser1:nlo:servo:fiber1-hor:value (integer)

Servo Position Fiber-1-V
Set vertical position of first mirror
laser1:nlo:servo:fiber1-vert:value (integer)

Servo Position Fiber-2-H
Set horizontal position of second mirror
laser1:nlo:servo:fiber2-hor:value (integer)

Servo Position Fiber-2-V
Set vertical position of second mirror
laser1:nlo:servo:fiber2-vert:value (integer)

5.2.9 Stabilization (DLC TA-SHG/FHG pro)

NOTE !	The Stabilization screen is only available for DLC TA-SHG/FHG pro systems.

Tap **Stabilization** to access the screen for the stabilization of various power levels within the laser system during operation by changing the Tapered Amplifier current. For detailed information, please refer to the DL-/TA-SHG/FHG pro manual.

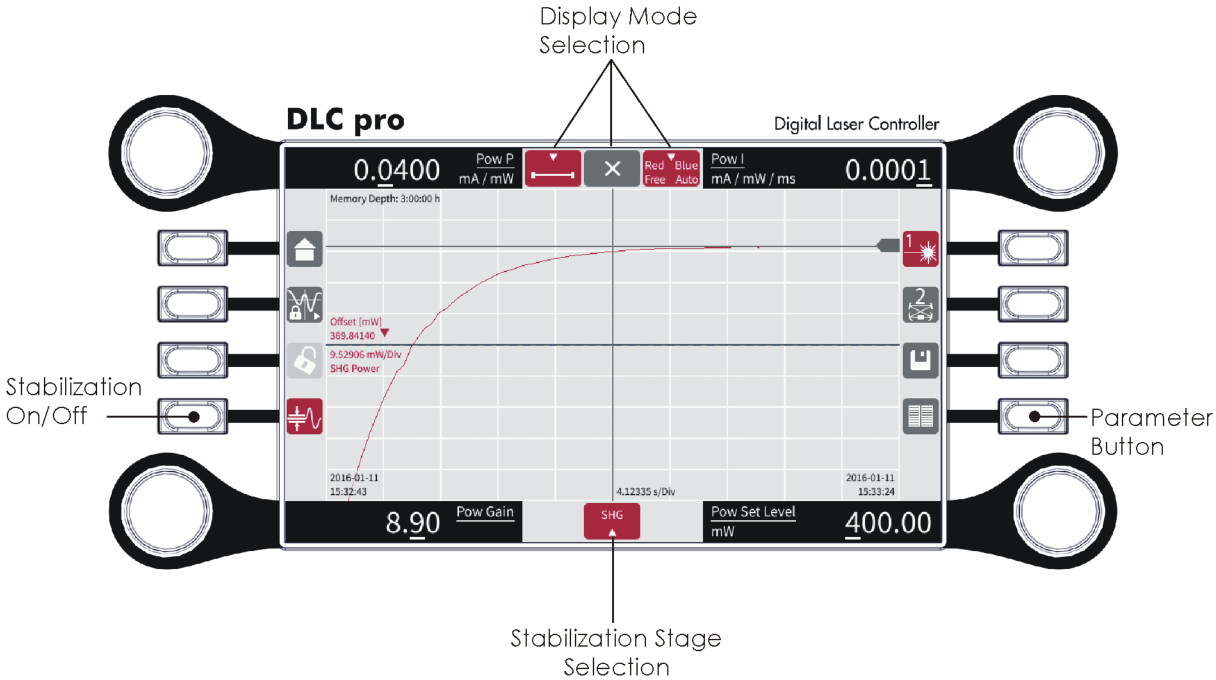


Figure 22 Stabilization screen (example DLC TA-SHG pro)

Rotary Knobs:

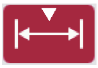
- **Top-left:** **Pow P**: P gain for power stabilization [mA/mW]
- **Bottom-left:** **Pow Gain**: Overall gain for power stabilization
- **Top-right:** **Pow I**: I gain for power stabilization [mA/mW/ms]
- **Bottom-right:** **Pow Set Level**: Desired power level for the stabilization [mW]

Further parameters for the stabilization can be set in the context parameter menu (please refer to section 5.2.9.1) which is available after pressing the **Parameter** button or tapping the corresponding symbol.

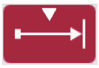
Tap **Stabilization On/Off** to enable/disable the power stabilization with the chosen settings.

NOTE !	If the input channel of External Power is changed during a running power stabilization, the power stabilization is switched OFF.

Display Mode Selection
The display of the touchscreen changes depending on the selected display mode. To select the display mode, tap the corresponding symbol.



Show all: Displays all available data starting from the latest DLC pro boot procedure. The maximum Memory Depth (maximum time interval of displayed signals) depends on the setting of **Power Stabilization > Sampling Interval** in the context parameter menu.



Show latest: Displays the latest signals within the time range selected in the context parameter menu (**Power Stabilization > Display Range**).

Show chosen: Pinch and spread the graph on the display to choose a time range freely. This display mode is automatically switched to from the other display modes if a graph is pinched or spread.

Delete: Deletes all stored signal data and clears the touchscreen display.

Trace Scaling: Tap to select the desired trace scaling.

Input Channel Selection
Tap the symbol and select the input channel to be stabilized to the desired **Pow Set Level** adjusted at the bottom-right rotary knob.

External	The External Power is stabilized with the chosen settings
Amp.	The Amplifier Power is stabilized with the chosen settings.
SHG	The SHG Power is stabilized with the chosen settings.
FHG	The FHG Power is stabilized with the chosen settings (only DLC TA-FHG pro).
Fiber	The Fiber Power is stabilized with the chosen settings (only with option FiberMon).

5.2.9.1 Stabilization Context Parameter Menu

The parameters for power stabilization are set in the context parameter menu which appears on the touchscreen after pressing the **Parameter** button with the Stabilization screen selected. On the following pages, detailed information about each accessible parameter is provided.

NOTE !	The last line of each parameter description shows the path in the parameter menu. These parameters may also be modified by user specific software. For a detailed description, please refer to the Remote Command Reference for TCP/IP and USB. This document is available as a pdf file in the Documentations folder on the software USB flash drive supplied with the DLC pro.

Power Stabilization

Enable Power Stabilization
Enable or disable power stabilization
[1: enabled], [0: disabled]
laser1:power-stabilization:enabled (boolean)

Differential Gain
Enter diff. gain for power stabilization in [mA/mW*µs]
laser1:power-stabilization:gain:d (real)

Hold Output Current on Unlock
Select unlock behavior of output channel
[1: enabled], [0: disabled]
laser1:power-stabilization:hold-output-on-unlock (boolean)

Sign Positive
Select on for positive, off for negative
[1: on], [0: off]
laser1:power-stabilization:sign (boolean)

Actual Level
Actual power level [mW]
laser1:power-stabilization:input-channel-value-act (real)

Window

Enable Stabilization Detection
Enable or disable window for power stabilization
[1: enabled], [0: disabled]
laser1:power-stabilization:window:enabled (boolean)

Window Level
Enter level for out-of-stabilization detection
Level in [mW]
laser1:power-stabilization:window:level-low (real)

Window Hysteresis
Hysteresis between out-of- and in-lock stabilization value
Hysteresis in [mW]
laser1:power-stabilization:window:level-hysteresis (real)

Sampling Interval
Enter time interval between two data points in [s]

Display Range
Enter time interval for latest data in [min]

External Power
External Power settings

Physical Channel
Select physical input for external power
laser1:pd-ext:input-channel

Photo Diode Value
Photo diode voltage of the physical channel [V]
laser1:pd-ext:photodiode (real)

Calibration Factor
Enter calibration factor for external power
laser1:pd-ext:cal-factor (real)

Calibration Offset
Enter calibration offset for external power
laser1:pd-ext:cal-offset (real)

Monitor Diodes

Amplifier Power (only DLC TA-SHG pro)
Read actual amplifier power
Amplifier power in [mW]
laser1:nlo:pd:amp:power

SHG Power
Read actual SHG power
SHG power in [mW]
laser1:nlo:pd:shg:power

FHG Power
Read actual FHG power
FHG power in [mW]
laser1:nlo:pd:fhg:power

Fiber Power (only with option FiberMon)
Read actual fiber power
Fiber power in [mW]
laser1:nlo:pd:fiber:power

External Power
Read actual external power
External power in [mW]
laser1:pd-ext:power

Trace Scaling

Left/Red Y Minimum
Enter Ymin for red curve
Reasonable values depend on the selected power

Left/Red Y Maximum
Enter Ymax for red curve
Reasonable values depend on the selected power

Right/Blue Y Minimum
Enter Ymin for blue curve
Reasonable values depend on the selected signal

Right/Blue Y Maximum
Enter Ymax for blue curve
Reasonable values depend on the selected signal

Trace Selection

Right/Blue Signal

Select signal for blue curve

[„None"]

[„Seed Power (mW)", laser1:nlo:pd:dl:power]

[„Amp. Power (mW)", laser1:nlo:pd:amp:power]

[„SHG Power (mW)“, laser1:nlo:pd:shg:power]

[„FHG Power (mW)“, laser1:nlo:pd:fhg:power] (only DLC TA-FHG pro)

[„Fiber Power (mW), laser1:nlo:pd:fiber:power] (only with option FiberMon)

[„External Power (mW)“, laser1:pd-ext:power]

[„Amp. Current (mA)", laser1:amp:cc:current-act]

[„SHG Intra-Cav. Signal (V)", laser1:nlo:pd:shg-int:photodiode]

[„SHG Cav. Rej. Signal (V)", laser1:nlo:pd:shg-pdh-dc:photodiode]

[„FHG Intra-Cav. Signal (V)", laser1:nlo:pd:fhg-int:photodiode] (only DLC TA-FHG pro)

[„FHG Cav. Rej. Signal (V)", laser1:nlo:pd:fhg-pdh-dc:photodiode] (only DLC TA-FHG pro)

[„SHG PC Voltage (V)", laser1:nlo:shg:pc:voltage-act]

[„FHG PC Voltage (V)", laser1:nlo:fhg:pc:voltage-act] (only DLC TA-FHG pro)

[„PowerLock Set Level (mW)", laser1:power-stabilization:setpoint]

5.3 Scan/Lock Mode

NOTE !	To utilize the DLC pro Lock function modes, a Lock option license is required. When a Lock option license is acquired, TOPTICA provides an option license key via e-mail or USB flash drive. The license is unlimited in time but linked to the individual hardware of the DLC pro and cannot be used for other devices. The license key must be activated via the TOPAS DLC pro PC-GUI (please refer to section 10.19). If purchased along with the DLC pro, the licence is already installed. Otherwise a 30-day trail licence is provided on the USB flash drive in the Options Folder. **Dual-Laser-Operation**: With a single Lock option installed, in combination with the Dual-Laser-Operation upgrade, frequency locking of both lasers is possible.

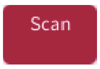
NOTE !	Without a Lock option installed, only the scan and power stabilization functions of the Scan/Lock mode will be accessible.

NOTE !	**DLC pro with PDH module**: The PDH module itself can be used without Lock option license. The Error signals are applied to the SMB-connectors of the PDH module (rear side of the DLC pro) and can be used together with an external controller. Operation parameters of the PDH module are set at the rotary knobs in PDH Ch1/PDH Ch2 function mode and in the context parameter menu (please refer to section 5.3.8).

NOTE !	A DLC DL-SHG/FHG pro is not equipped with power stabilization functionality, as the feed-back onto the Master Oscillator current would disturb the lock of the SHG/FHG cavity.

5.3.1 Function Modes

Depending on the selected function mode, the assignment of the rotary knobs (please refer to section 5.3.7) and the display might change. To select the desired function mode, tap the corresponding symbol (please refer to Figure 23).



Scan: Parameters for the scan function.

Lockpoint: Parameters for identifying lockpoint candidates. Tap the desired **Lockpoint Candidate** to select it. The selection is indicated by an additional red circle as shown in Figure 24.

NOTE !	When **Lock Settings > Lock Without Lockpoint** is enabled in the context parameter menu, no lockpoint candidates are displayed.

ReLock: Parameters for the ReLock function (please refer to section 5.3.11).

NOTE !	By default, the **Lockpoint** function mode is active. To switch to ReLock function mode, tap **Lockpoint** and select **ReLock**.

PID 1, PID 2: Parameters of the PID controllers.

NOTE !	By default, **PID 1** is active. To select **PID 2**, tap **PID 1** and select **PID 2.**

LIR: Lock-In parameters for the Top of Fringe lock type.

PDH Ch1, PDH Ch2: PDH parameters, e.g. for the Top of Fringe PDH lock type (only with PDH module).

NOTE !	By default, PDH Ch1 is active. To select PDH Ch2, tap **PDH Ch1** and select **PDH Ch2.**

Power: Parameters for the power stabilization.

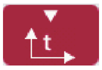
FALC 1, 2: FALC pro module operating parameters (only with FALC pro module connected).

NOTE !	By default, the **Power** function mode is active. To switch to FALC X function mode, tap **Power** and select the desired **FALC X**. The DLC pro supports up to four FALC pro modules in a CAN link chain. Please note that only the two FALC pro modules with the lowest CAN Node IDs (see FALC pro manual) can be operated via the DLC pro touchscreen user interface. Additional FALC pro modules can be operated via the Params tab of the TOPAS DLC pro PC-GUI (see section 6.24, parameter falcX:...)

5.3.2 Display Modes

The display of the touchscreen changes depending on the selected display mode. To select the display mode, tap the corresponding symbol (please refer to Figure 23).

xy: Signals (Y-direction) are plotted against the scan voltage of the laser (X-direction).



t (Time): Signals (Y-direction) are plotted against time (X-direction).

f (Frequency): The fast Fourier transformation of the time-dependent signal (Y-direction) is plotted against the frequency (X-direction).

Trace Scaling: Tap to select the desired trace scaling.

Up to two signal traces, referred to as Input Trace (red) and Auxiliary Trace (blue) may be displayed on the touchscreen in xy display mode, the axis labelling is displayed in the corresponding color. The input channels of the two signals can be selected in the parameter menu which appears on the touchscreen after pressing the **Parameter** button in Scan/Lock mode (please refer to Figure 23).

Depending on the setting (**Input/Auxiliary trace scaling**), the graphs are autoscaled in Y-direction to the full display size or they can be free scaled by gestures (pinch and spread) on the touchscreen. The graph can also be fixed to its current size.

The zero level in X and Y-direction is displayed as a broken line. On the axis the distance to the zero level is indicated by the offset value and the direction to the zero level is indicated by the small triangle. The other value at the axis indicates the scaling per division.

5.3.3 Scan Function Mode

The internal grating of a tunable laser head can be slightly moved by a piezo element for wavelength tuning (scanning). A variable voltage (**Scan Amplitude**) is added to a constant voltage (**Scan Offset**). In Scan function mode, scanning can be enabled/disabled, and all parameters for scanning are set. The scan of the laser as well as the signals depending on the scan (e.g., an absorption signal) can be displayed on the touchscreen.

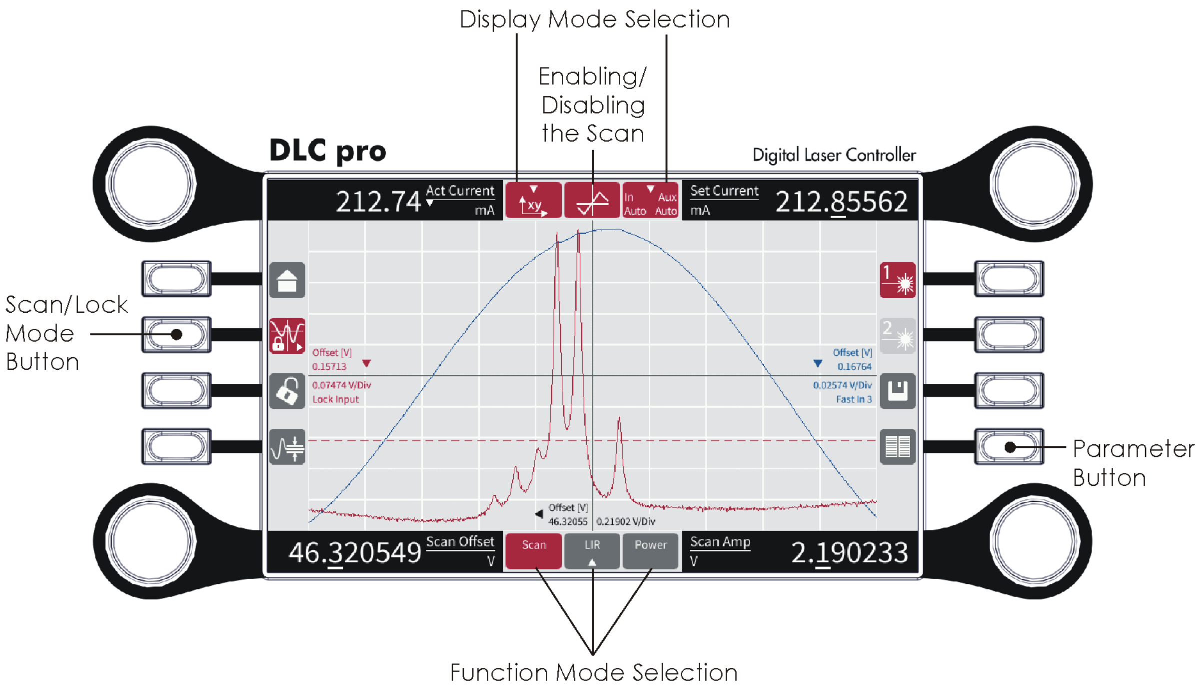


Figure 23 Touchscreen in Scan function mode (example)

Enter Scan function mode by pressing the **Scan/Lock Mode** button several times until display and rotary knob assignment change as shown in Figure 23 or tap the corresponding symbol. The little white arrow in the symbol indicates that there are further options available that can be selected by tapping one of the corresponding symbols which appear after tapping. Select and select the **Scan** function mode field at the bottom of the touchscreen. The display as well as the assignment of the rotary knobs change as needed for setting the most important scan parameters and to optimize the mode hop free tuning of the selected ECDL laser (**Laser 1**/**Laser 2** buttons, see section 5.8 and 5.9).

Further scan and display parameters are set in the context parameter menu (please refer to section 5.3.8) which appears on the touchscreen after pressing the **Parameter** button in Scan/Lock mode.

NOTE !	Scanning continues as long as the scan is enabled even if you leave Scan/Lock mode. Enabling/disabling the scan is done by tapping the symbol at the top of the touchscreen (gray: scan disabled, red: scan enabled) or in the PC-GUI. Please note that the scan can only be enabled when the laser is not locked (see section 5.3.5).

For optimizing the scan, the Feed Forward allows to apply a ramp proportional to the piezo scan ramp (which scans the laser frequency) to the laser diode current. This leads to a change of the refractive index n of the semiconductor material in the laser diode and thus improves the mode-hop free tuning of the laser. The procedure for setting the Feed Forward to eliminate mode hops is described in the laser head manual.

NOTE !	For DFB pro laser heads, and laser systems with a DFB pro Master Oscillator, the Feed Forward current ramp is proportional to the temperature scan ramp.

In addition, you can optimize the scan by changing the laser temperature (**Set Temperature**). As desired for optimization, assign the top-left rotary knob (please refer to section 5.3.7.1).

NOTE !	The **Set Current** comprises the **Feed Forward part dependent on the Scan Offset**, not the part dependent on the **Scan Amplitude**. Due to this, the displayed **Set Current** changes when the **Scan Offset** is adjusted. The **Actual Current** in addition comprises the time-dependent **Feed Forward part of the Scan Amplitude** and possibly additional offsets from PID outputs. To display the actual laser current, select **Actual Current** as top-eft parameter (see section 4.4.2). With a large Feed Forward factor, the set current may also be restricted to values below the clip-limit.

NOTE !	Additional offsets to the **Scan Offset** e.g., due to PID settings or Analog Remote Control (ARC) may lead to a shifting of the displayed signal in X-direction.

NOTE !	If the scan amplitude is set to values below a minimal amplitude the signal trace will collapse to a vertical line as no scan is generated any more. Please note that the scan may be switched off by tapping the symbol at the top of the touchscreen.

On the touchscreen, the scan-dependent signal is displayed in Y-direction. The parameters **Scan Offset** and **Scan Amplitude** are displayed in the bottom-left and bottom-right corner of the display and can be changed by the corresponding rotary knobs. Changes done at the knobs are reflected by the graphical display and changes made with touch gestures on the display are reflected in the numbers in the corners. For example, dragging the display graph right/left changes the scan offset while pinching the graph in X-direction increases the scan amplitude.

5.3.4 Synchronized Scanning of Lasers

At a DLC pro for Dual-Laser-Operation (see section 1.3) the scan of the two connected lasers can be synchronized. The settings for the synchronization can be performed in the Params tab of the TOPAS DLC pro PC-GUI (see section 6.24) or via software commands (see section 10.13).

laser-common:scan:sync-laser1/2	Select the lasers to be synchronized.
laser-common:scan:frequency	Enter the common scan frequency.
laser-common:scan:sync	When the command is executed, the scan generators of all selected lasers are set to the common scan frequency.
laser-common:scan:save	Save the scan-synchronization settings to be used after the next DLC pro boot procedure.

When the scan is enabled by tapping the symbol at the top of the touchscreen, the scans of the selected lasers then are started simultaneously and the lasers are scanned with the same frequency, and with zero relative phase-shift.

5.3.5 Lock Function Modes

NOTE !	To utilize the DLC pro Lock function modes, a Lock option license is required. When a Lock option license is acquired, TOPTICA provides an option license key via e-mail or USB flash drive. The license is unlimited in time but linked to the individual hardware of the DLC pro and cannot be used for other devices. The license key must be activated via the TOPAS DLC pro PC-GUI (please refer to section 10.19). If purchased along with the DLC pro, the licence is already installed. Otherwise a 30-day trail licence is provided on the USB flash drive in the Options Folder. **Dual-Laser-Operation**: With a single Lock option installed, in combination with the Dual-Laser-Operation upgrade, frequency locking of both lasers is possible.

For higher demands on frequency stability, the laser frequency can be locked actively to the wavelength of interest, such as atomic or molecular resonances and cavities. Proportional-Integral-Differential (PID) controllers are used to stabilize the laser frequency to a reference.

Locking the laser to a specific wavelength is based on a spectroscopic signal provided by the experimental setup which serves as a reference (Lock Input signal). The laser can be locked to a slope or to an extremum of the Lock Input signal. The DLC pro provides the scan to find the resonance and lockpoint candidates, derives the Error signal for the Top of Fringe lock type via a lock-in detection unit, and provides two separate PID controllers for the feedback loop.

In addition, the ReLock function (please refer to section 5.3.11) is provided to detect out-of-lock states of the laser to reset the PID controller(s) and to relock the system.

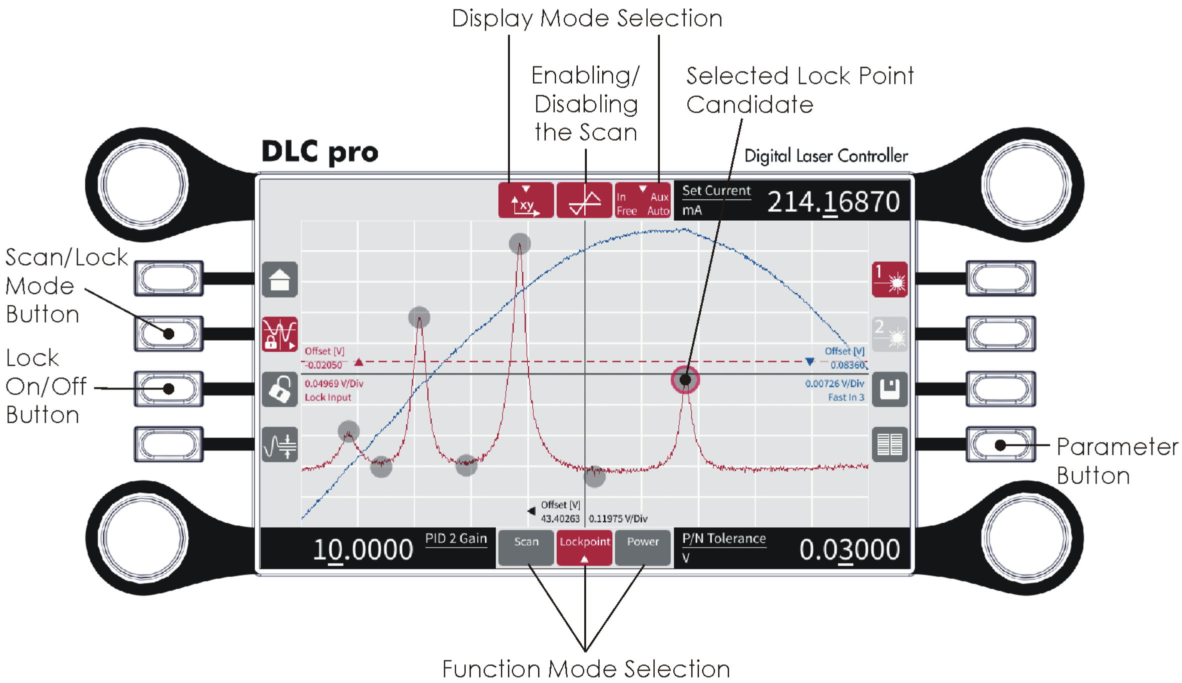


Figure 24 Touchscreen in Lockpoint function mode (example). Lockpoint candidates for Top of Fringe lock type shown

Enter the desired function mode for locking (please refer to section 5.3.1) by pressing the **Scan/Lock Mode** button several times until display and rotary knob assignment change as shown in Figure 24 or tap the corresponding symbol. The little white arrow in the symbol indicates that there are further options available that can be selected by tapping one of the corresponding symbols which appear after tapping. Select and select the desired function mode field at the bottom of the touchscreen. The display as well as the assignment of the rotary knobs (please refer to section 5.3.7) change as needed for setting the most important lock parameters of the selected ECDL laser (**Laser 1**/**Laser 2** buttons, see section 5.8 and 5.9).

Status: 29.3.22

Further lock and display parameters are set in the context parameter menu (please refer to section 5.3.8) which appears on the touchscreen after pressing the **Parameter** button in Scan/Lock mode. Please refer to sections 5.3.9 and 5.3.10 for examples on locking.

NOTE !	If you want to lock without automatically derived lockpoint candidates, please enable **Lock Settings > Lock Without Lockpoint** in the context parameter menu).

5.3.6 Power Stabilization Function Mode

The DLC pro Power function mode allows the stabilization of various power stages (PowerLock) during operation by changing the laser diode or amplifier current, dependent on the laser head. The controls for the power stabilization are accessible at the DLC pro front panel in Scan/Lock mode after tapping the **Power** symbol at the bottom of the touchscreen. Further power stabilization parameters are set in the context parameter menu (please refer to section 5.3.8) which appears on the touchscreen after pressing the **Parameter** button in Scan/Lock mode.

Dependent on the laser head, you can choose between the stabilization of the following power stages by selecting the context parameter **Power Stabilization > Input Channel**:

DL pro:	**External Power**	Laser diode current is controlled
DFB pro:	**External Power**	Laser diode current is controlled
CTL:	**External Power, CTL Power**	Laser diode current is controlled
TA pro:	**External Power, Amp. Power**	Amplifier current is controlled
TA pro AL:		
DL pro config.:	**External Power**	Laser diode current is controlled
TA pro/ BoosTA pro config.:	**External Power, Amp. Power**	Amplifier current is controlled
TA-SHG pro:	**External Power, Amp. Power,** **SHG Power,** **Fiber Power** (only with option FiberMon)	Amplifier current is controlled
TA-FHG pro:	**External Power, Amp. Power,** **SHG Power,** **FHG Power,** **Fiber Power** (only with option FiberMon)	Amplifier current is controlled
TOPO	no power stabilization available	

NOTE !	For stabilization of the **External Power** stage, please refer to section 5.3.6.1 for configuration of the input channel and calibration of the external photo diode.

To change the power level of the selected stage, adjust **Pow Set Level** by the bottom-right rotary knob. Gain parameters for the stabilization can also be adjusted at the rotary knobs.

The power stabilization is switched on and off by pressing the **Stabilization On/Off** button or by tapping the corresponding symbol (see section 5.7). When the stabilization is switched off, you can choose whether the laser diode or amplifier current shall stay at its current value (1) or return to the value before the stabilization was switched on (0) by setting the context parameter **Power Stabilization > Hold Output Current on Unlock**.

NOTE !	If the input channel for External Power is changed (see section 5.3.6.1) during a running power stabilization, the power stabilization is switched OFF.

NOTE !	**DLC TA-SHG/FHG pro**: If a power stabilization loop to the SHG/FHG or fiber monitor photo diode is active and the SHG/FHG cavity falls out of lock, the Tapered Amplifier current will be set to its maximum value allowed by laser1:amp:cc:current-clip. Once the SHG/FHG cavity returns into lock, this may result in an unexpectedly high SHG/FHG output power for a short time, until the SHG/FHG power has returned to its **Pow Set Level**, again.

NOTE !	**DLC TA-SHG/FHG pro**: For convenient Power Stabilization it is recommended to use the Stabilization screen (see section 5.2.9). For detailed information, please see the power stabilization example in the DL-/TA-SHG/FHG pro manual.

5.3.6.1 Configuration of the External Power Stabilization

DANGER !	Do not look into the exiting beam of the laser head as the output can exceed the limits for class 1 specified by the US laws 21 CFR 1040.10 and 2 CFR 1040.11 and the Laser Safety Standard EN 60825-1:2014. Take precautions to eliminate exposure to a direct or reflected beam. Always wear appropriate laser safety goggles.

When **External Power** is selected as input channel for the power stabilization, the laser diode or amplifier current (dependent on the laser head) is stabilized onto the signal of an external photo diode. Please follow the steps noted below to configure an **External Power** stabilization (configuration is also possible via the TOPAS DLC pro PC-GUI).

1. The external photo diode can be connected to one of the four BNC-connectors (**Fine 1/2, Fast 3/4**) on the DLC pro front panel.
Please select the appropriate BNC-connector in the context parameter menu with the Scan/Lock screen selected (**Power Stabilization > External Power > Physical Channel**).

2. Connect the external photo diode to the selected BNC-connector on the DLC pro front panel.

3. Position and align the external photo diode in your experimental beam path as desired.

4. Switch ON laser emission.
Check in the DLC pro Scan/Lock screen context parameter menu whether the **Power Stabilization > External Power > Photo Diode Value** is between 0.5 .and 4 V. If the value is above 4 V, please use an optical attenuator to reduce the incident laser power. If the value is below 0.5 V, please amplify the photo diode signal in order to improve the signal-to-noise ratio.

5. Switch OFF laser emission. Now enter the dark voltage **Power Stabilization > External Power > Photo Diode Value** (with the laser switched off) into **Power Stabilization > External Power > Calibration Offset**.
Check that **Power Stabilization > Actual Level** now shows approximately 0 mW.

6. Switch ON laser emission. Determine the laser power in front of the external photo diode with a suitable (thermal or calibrated) power meter.
Divide the measured power in mW by the voltage calculated by
(**Power Stabilization > External Power > Photo Diode Value** minus **Power Stabilization > External Power > Calibration Offset**)
and enter the resulting value in the parameter **Power Stabilization > External Power > Calibration Factor**. Now, the external photo diode is calibrated and **Power Stabilization > Actual Level** shows the actual laser power at the external photo diode.

7. Save the configuration by pressing the **Load/Save** button on the DLC pro front panel twice.

5.3.6.2 Setup of the Power Stabilization (Example Amp. Power)

Please follow the description below for setting-up and optimizing a power stabilization.

1. Enable the desired laser (**Laser 1**/**Laser 2** buttons, see section 5.8 and 5.9) and switch on laser emission by pressing the **Emission** button on the DLC pro front panel.

2. Select the Power function mode by tapping the **Power** symbol on the touchscreen in Scan/Lock mode.

3. Select the desired stabilization stage, **Amp. Power** in this example (context parameter: **Power Stabilization > Input Channel**).

4. Select the desired behavior of the amplifier current when the stabilization is switched off (context parameter: **Power Stabilization > Hold Output Current on Unlock**.

5. Select the **t** (time) display mode and disable the scan by tapping the symbols at the top of the touchscreen.
It is recommended to select **Display Settings > Trace Selection > Auxiliary Trace Signal > None** for an easier adjustment of the power stabilization.
The PowerLock input signal is displayed as Input Trace (red) by default.

6. Adjust the desired **Pow Set Level** at the bottom-right rotary knob.
Select **Autoscale** as trace scaling for the Input Trace. Zoom out by pinching on the touchscreen until both, the Input Trace and the red Power Set Level line are displayed.

7. Set the corner parameters **Pow I** and **Pow P** to zero with the corresponding rotary knobs.
Set **Pow D** to zero in the context parameter menu (**Power Stabilization > Differential Gain**)
Set **Pow Gain** to 1 as a start value.

8. Tap **Stabilization On/Off** (see section 5.7) to enable the power stabilization.

9. Increase **Pow I** until the stabilization is working. This is indicated on the touchscreen by overlapping of the red Input Trace with the red Power Set Level line.
Increase **Pow I** further until the Input Trace shows oscillation. Then decrease **Pow I** to well below the oscillation threshold.
DLC TA pro/-AL and DLC TA-SHG/FHG pro: For some values of the PowerLock signal, it may not be possible to let the power signal oscillate by increasing **Pow I**. In this case we recommend that you work with the highest **Pow I** possible.

10. Perform step 9 for **Pow P** adjustment.
DLC TA pro/-AL and DLC TA-SHG/FHG pro: For some values of the PowerLock signal, it may not be possible to let the power signal oscillate by increasing **Pow P**. In this case we recommend that you work with the highest **Pow P** possible.

11. The differential gain will have only limited influence on the power stabilization performance.
Optionally perform step 9 with the parameter **Power Stabilization > Differential Gain** in the context menu.

12. Once properly set up, the power stabilization can be enabled/disabled by tapping the **Stabilization On/Off** symbol.
The **Pow Set Level** can be modified at the bottom-right rotary knob.
Please readjust the PID parameters, if necessary.

5.3.7 Scan/Lock Mode Rotary Knob Assignments

The functions assigned to the rotary knobs depend on the selected function mode.

5.3.7.1 Scan Rotary Knobs

Parameter settings for the Scan function mode.

- **Top-left:** As selected in the drop-down menu (see section 4.4.2). Available corner parameters depend on the laser system:
  Feed Forward or **Master Feed Forward** [mA/V]
  [mA/K] only DLC DFB pro and laser systems with DFB pro Master Oscillator
  Set Temperature or **Master Set Temperature** [° C] for optimization,
  Display of **Actual Current** or **Master Actual Current** [mA].
  Amplifier Set Current [mA].
  Amplifier Actual Current [mA].
  Amplifier Feed Forward [mA/V].
  Scan Frequency [Hz].
  Set Wavelength [nm] (only DLC CTL).
- **Bottom-left:** **Scan Offset** [V] if laser is scanned with piezo.
  This parameter is displayed in X-direction on the touchscreen.
- **Top-right:** Laser Diode **Set Current** [mA].
- **Bottom-right:** **Scan Amplitude** [V] if laser is scanned with piezo.
  This parameter is displayed in X-direction on the touchscreen.

5.3.7.2 Lockpoint Rotary Knobs

Parameter settings for the Lockpoint function mode.

- **Top-left:** **Lock Level** [V]: Voltage level for Side of Fringe lockpoint with or without lockpoint candidates.
  Side of Fringe lock type: In the **xy** signal display mode, lockpoint candidates are displayed where the signal crosses the displayed **Lock Level.**
  Top of Fringe lock type: no function.
  Comp. Offset [V]: Only when **Side of Fringe** as **Lock Type** is selected in the context parameter menu and FALC pro module is connected.
  Set compensation offset voltage for Side of Fringe lockpoint candidates.
- **Bottom-left:** **PID1/2 Gain**: Overall gain factor of the selected PID controller.
- **Top-right:** Laser Diode **Set Current** [mA].
- **Bottom-right:** **P/N Tolerance** [V]: If the lockpoints at the extrema are not properly detected automatically, this behavior can be improved by adjusting the **P/N Tolerance** rotary knob correctly for the signal and signal-to-noise ratio used.

5.3.7.3 ReLock Rotary Knobs

Parameter settings for the ReLock function mode.

- **Top-left:** No function.
- **Bottom-left:** **Hysteresis** [V]: Difference between the <Level High> or <Level Low> voltage that determines the out-of-lock state and the signal voltage that determines whether the laser can be locked again. If the signal has left the ReLock window defined by <Level High> and <Level Low>, the corresponding PID controller output is frozen. To reactivate the PID controller, the input signal must be within an "inner" window defined by (<Level High> - <Hysteresis>) and (<Level Low> + <Hysteresis>).
- **Top-right:** **Level High** [V]: Upper voltage limit of the ReLock window.
- **Bottom-right:** **Level Low** [V]: Lower voltage limit of the ReLock window.

5.3.7.4 PID1/PID2 Rotary Knobs

Parameter settings for the PID1 and PID2 function modes.

NOTE !	By default, **PID 1** is active. To select **PID 2**, tap **PID 1** and select **PID 2.**

- **Top-left:** **PID1/2 P**: Proportional gain of the selected PID controller. The unit depends on the selected PID output channel.
- **Bottom-left:** **PID1/2 Gain**: Overall gain factor of the selected PID controller.
  PID1/2 Sign: Signal polarity of the PID controller.
- **Top-right:** **PID1/2 I**: Integral gain of the selected PID controller. The unit depends on the selected PID output channel.
- **Bottom-right:** **PID1/2 D**: Differential gain of the selected PID controller. The unit depends on the selected PID output channel.

5.3.7.5 LIR Rotary Knobs

Parameter settings for the LIR function mode.

- **Top-left:** **Lock Level** [V]: Set level for the PID controller used for the Top of Fringe lock type (normally set to zero).
- **Bottom-left:** **LockIn Ph** [°]: Phase shift of the local oscillator used for demodulation with respect to the applied modulation.
- **Top-right:** **Mod Freq** [Hz]: Frequency of the local oscillator.
- **Bottom-right:** **Mod Amp:** Amplitude of the modulation signal. The unit depends on the selected Lock-In output channel.

5.3.7.6 PDH Ch1/PDH Ch2 Rotary Knobs

Parameter settings for the PDH Ch1 and PDH Ch2 function modes (only with PDH module).

NOTE !	By default, **PDH Ch1** is active. To select **PDH Ch2**, tap **PDH Ch1** and select **PDH Ch2.**

- **Top-left:** **Lock Level** [V]: Set level for the PID controller used for the Top of Fringe PDH lock type (normally set to zero).
- **Bottom-left:** **LockIn Ph** [°]: Phase shift of the local oscillator used for demodulation with respect to the applied modulation.
- **Top-right:** **Scan Frequency** [Hz].
- **Bottom-right:** **Mod Amp** [dBm]**:** Amplitude of the modulation signal.

5.3.7.7 FALC 1/FALC 2 Rotary Knobs

Parameter settings for the FALC 1 and FALC 2 function modes (only with FALC pro module connected).

NOTE !	Select the desired **FALC X** at the function mode buttons (see section 5.3.1).

- **Top-left:** As selected in the drop-down menu (see section 4.4.2).
  I1, I2, I3, D1, D2 Enabled: Enable (True) or disable (False) the respective integrator or differentiator.
- **Bottom-left:** As selected in the drop-down menu (see section 4.4.2).
  Input Offset [V]: Compensates an offset of the input signal.
  Main Gain [dB]: Output gain value of the main circuit branch.
  Unlim Sign: Select the sign (behavior) of the Unlim integrator.
  Positive: Output signal is in phase with the Error Output of the FALC pro module.
  Negative: Output signal is inverted with respect to the Error Output.
  Main Enabled: Enable (True) or disable (False) the main circuit branch of the FALC pro.
  Unlim Enabled: Enable (True) or disable (False) the unlimited integrator of the FALC pro.
- **Top-right:** As selected in the drop-down menu (see section 4.4.2).
  I1, I2, I3 Corner Frequencies [Hz, kHz]: Select left corner frequencies for respective integrator from preset values.
  Unlim Slew Rate: Specify the slew rate setting of the Unlim integrator [1 .. 12].
- **Bottom-right:** As selected in the drop-down menu (see section 4.4.2).
  Input Gain [dB]: Specify the input gain factor of the input signal.
  Available values are 1 and 5.
  D1, D2 Corner Frequencies [kHz, MHz]: Select left corner frequencies for respective differentiator from preset values.
  Unlim Input Offset [mV]: Compensates an offset between the input of the Unlim integrator and the FALC pro internal error signal.
  Unlim Gain [V/V/s]: Display of the resulting integrator gain [V/V/s] that is specified by the output range (context parameter **FALC X > Unlim Output Range**)
  and the **Unlim Slew Rate**.

5.3.7.8 Power Stabilization Rotary Knobs

Parameter settings of the PID controller for the Power function mode.

- **Top-left:** **Pow P** [mA/mW]: Proportional gain of the PID controller.
- **Bottom-left:** **Pow Gain**: Overall gain factor of the PID controller.
- **Top-right:** **Pow I** [mA/mW/ms]: Integral gain of the PID controller.
- **Bottom-right:** **Pow Set Level** [mW]**:** Reference level for power stabilization.

5.3.8 Scan/Lock Mode Context Parameter Menu

Additional scan/lock and display parameters are set in the context parameter menu which appears on the touchscreen after pressing the **Parameter** button in Scan/Lock mode. On the following pages, detailed information about each accessible parameter is provided. This includes parameters that control the modulation, which is essential for a Top of Fringe lock.

NOTE !	The last line of each parameter description shows the path in the parameter menu. These parameters may also be modified by user specific software. For a detailed description, please refer to the Remote Command Reference for TCP/IP and USB. This document is available as a pdf file in the Documentations folder on the software USB flash drive supplied with the DLC pro.

Scan

Enable Scan
Enable or disable scan
[1: enabled], [0: disabled]
laser1:scan:enabled (boolean)

Scan Frequency
Select scan frequency
Scan frequency in [Hz]
laser1:scan:frequency (real)

Scan Start
Enter scan start
The unit is dependent on the scan output channel

"PC Voltage"	[V]
"CC Current"	[mA]
"Out A", "Out B"	[V]
"EOM Voltage Slow"	[V]
"TC Set Temperature"	[°C]
"OPO Slow PZT Voltage"	[V]
"OPO Fast PZT Voltage"	[V]

laser1:scan:start (real)

Scan End
Enter scan end
The unit is dependent on the scan output channel

"PC Voltage"	[V]
"CC Current"	[mA]
"Out A", "Out B"	[V]
"EOM Voltage Slow"	[V]
"TC Set Temperature"	[°C]
"OPO Slow PZT Voltage"	[V]
"OPO Fast PZT Voltage"	[V]

laser1:scan:end (real)

Scan Output
Select scan output channel
["PC Voltage", 50], ["CC Current", 51], ["Out A", 20], ["Out B", 21]
["EOM Voltage Slow", 58] only laser systems with intra-cavity EOM
["TC Set Temperature", 56] only DLC DFB pro and laser systems with DFB pro Master Oscillator
["OPO Slow PZT Voltage", 150], ["OPO Fast PZT Voltage", 151] only DLC TOPO laser systems
laser1:scan:output-channel (integer)

Scan Shape
Select scan shape
["Triangle", 1], ["Sine", 0]
laser1:scan:signal-type (integer)

Feed Forward (**DLC TA pro/-AL and DLC TA-SHG/FHG pro:** Feed Forward for Master Oscillator)
(**not DLC CTL**)

Feed Forward
Enable or disable Feed Forward
[1: enabled], [0: disabled]
laser1:dl:cc:feedforward-enabled (boolean)

Feed Forward Factor
Enter Feed Forward factor
Feed forward factor in [mA/V]
[mA/K] only DLC DFB pro and laser systems with DFB pro Master Oscillator
laser1:dl:cc:feedforward-factor (real)

Output Filters
The output filters allow to limit the rate of change of the output signal to the value set by **Slew Rate**.
PC
PC output filter

Enable
Enable or disable PC output filter
[1: enabled], [0: disabled]
laser1:dl:pc:output-filter:slew-rate-enabled (boolean)

Slew Rate
Enter slew rate (maximum rate of change) for PC output filter in [V/s]
[1: enabled], [0: disabled]
laser1:dl:pc:output-filter:slew-rate (real)

CC
CC output filter
Enable
Enable or disable CC output filter
[1: enabled], [0: disabled]
laser1:dl:cc:output-filter:slew-rate-enabled (boolean)

Slew Rate
Enter slew rate (maximum rate of change) for CC output filter in [mA/s]
[1: enabled], [0: disabled]
laser1:dl:cc:output-filter:slew-rate (real)

Analog Remote Control (ARC)
PC
Analog PC remote control
Please refer to section 10.10.1 for an example on how to configure the PC ARC.

Enable
Enable or disable analog PC remote control
[1: enabled], [0: disabled]
laser1:dl:pc:external-input:enabled (boolean)

Signal Input
Select signal input for PC
["None", -3], ["Fine In 1", 0], ["Fine In 2", 1], ["Fast In 3", 2], ["Fast In 4", 4]
laser1:dl:pc:external-input:signal (integer)

Factor
Enter factor for PC in [V/V]
laser1:dl:pc:external-input:factor (real)

EOM
Analog EOM remote control
Please refer to section 10.10.1 for an example on how to configure the EOM ARC.

Enable
Enable or disable analog EOM remote control
[1: enabled], [0: disabled]
laser1:dl:eom:external-input:enabled (boolean)

Signal Input
Select signal input for EOM
["None", -3], ["Fine In 1", 0], ["Fine In 2", 1], ["Fast In 3", 2], ["Fast In 4", 4]
laser1:dl:eom:external-input:signal (integer)

Factor
Enter factor for EOM in [V/V]
laser1:dl:eom:external-input:factor (real)

CC
Analog CC remote control
Please refer to section 10.10.1 for an example on how to configure the CC ARC.

Enable
Enable or disable analog CC remote control
[1: enabled], [0: disabled]
laser1:dl:cc:external-input:enabled (boolean)

Signal Input
Select signal input for CC
["None", -3], ["Fine In 1", 0], ["Fine In 2", 1], ["Fast In 3", 2], ["Fast In 4", 4]
laser1:dl:cc:external-input:signal (integer)

Factor
Enter factor for CC in [mA/V]
laser1:dl:cc:external-input:factor (real)

TC
Analog TC remote control
Please refer to section 10.10.1 for an example on how to configure the TC ARC.

Enable
Enable or disable analog TC remote control
[1: enabled], [0: disabled]
laser1:dl:tc:external-input:enabled (boolean)

Signal Input
Select signal input for TC
["None", -3], ["Fine In 1", 0], ["Fine In 2", 1], ["Fast In 3", 2], ["Fast In 4", 4]
laser1:dl:tc:external-input:signal (integer)

Factor
Enter factor for TC in [K/V]
laser1:dl:tc:external-input:factor (real)

Amplifier (only DLC TA pro/-AL and DLC TA-SHG/FHG pro)

Enable Amplifier
Enable or disable amplifier
[1: enabled], [0: disabled].
laser1:amp:cc:enabled (boolean)

Amplifier Set Current
Enter amplifier set current
Amplifier set current in [mA]
laser1:amp:cc:current-set (real)

Amplifier Actual Current
Shows actual amplifier current
Actual amplifier current in [mA]
laser1:amp:cc:current-act (real)

Max Amplifier Current
Enter maximum amplifier current
Maximum amplifier current in [mA]
laser1:amp:cc:current-clip (real)

Amplifier Set Temperature
Enter amplifier set temperature
Amplifier set temperature in [° C]
laser1:amp:tc:temp-set (real)

Amplifier Act Temperature
Shows actual amplifier temperature
Actual amplifier temperature in [° C]
laser1:amp:tc:temp-act (real)

Feed Forward

Enable Amplifier Feed Forward
Enable or disable amplifier Feed Forward
[1: enabled], [0: disabled]
laser1:amp:cc:feedforward-enabled (boolean)

Amplifier Feed Forward Factor
Enter amplifier Feed Forward factor
Feed forward factor in [mA/V]
laser1:amp:cc:feedforward-factor (real)

Output Filter
The output filter allows to limit the rate of change of the output signal to the value set by **Slew Rate**.

Enable
Enable or disable amplifier output filter
[1: enabled], [0: disabled]
laser1:amp:cc:output-filter:slew-rate-enabled (boolean)

Slew Rate
Enter slew rate (maximum rate of change) for amplifier output filter in [mA/V]
[1: enabled], [0: disabled]
laser1:amp:cc:output-filter:slew-rate (real)

Limits

Actual Seed Power
Shows actual seed power
Actual seed power in [mW]
laser1:dl:pd:power (real)

Minimum Seed Power
Enter minimum seed power
Minimum seed power in [mW]
laser1:amp:seed-limits:power-min (real)

Maximum Seed Power
Enter maximum seed power
Maximum seed power in [mW]
laser1:amp:seed-limits:power-max (real)

Actual Output Power
Shows actual output power of the TA pro/-AL
Actual output power in [mW]
laser1:amp:pd:amp:power (real)

Minimum Output Power
Enter minimum output power of the TA pro/-AL
Minimum output power in [mW]
laser1:amp:output-limits:power-min (real)

Maximum Output Power
Enter maximum output power of the TA pro/-AL
Maximum output power in [mW]
laser1:amp:output-limits:power-max (real)

Lock Settings

Lock Input Signal (available signals depending on system model)
Select the lock input signal
The lock input signal provides the input for the locking logic (PID controllers, Lock-In, PDH)
["Fine In 1", 0], ["Fine In 2", 1], ["Fast In 3", 2], ["Fast In 4", 4]
Only with PDH Module
["PDH In 1", 41], ["PDH In 2", 43]
laser1:dl:lock:spectrum-input-channel (integer)

Error Input Signal
(only available when **Top of Fringe PDH** is selected as **Lock Type**, but the **Lock Input Signal** is not a PDH-channel)
Error input signal for PIDs
["Fine In 1", 0], ["Fine In 2", 1], ["Fast In 3", 2], ["Fast In 4", 4], ["PDH-Error 1", 40], ["PDH-Error 2", 42]
laser1:dl:lock:error-channel (integer)

Error Input Inverted
(only available when **Top of Fringe PDH** is selected as **Lock Type**, the **Lock Input Signal** is not a PDH-channel, and **FALC Selection** is not **None**)
Select if error input signal is inverted
laser1:dl:lock:error-channel-inverted (boolean)

Lock Type (available options depending on system model)
Select whether to lock on edge or extremum
["Top of Fringe“, 1]: LIR lock to an extremum
["Side of Fringe“, 2]: lock to an edge (slope)
Only with PDH Module
["Top of Fringe PDH“, 3]: PDH lock to an extremum
laser1:dl:lock:type (integer)

NOTE !	**Lock Type Top of Fringe PDH**: If the PDH photo diode is DC-coupled, the **Lock Input Signal** can be derived by selecting **PDH In 1/PDH In 2** from the SMB-connectors on the PDH module.

PDH Selection
(only available when **Top of Fringe PDH** is selected as **Lock Type**, and **FALC Selection** is not **None)**
Select PDH channel to be used
["PDH Channel 1", 1], ["PDH Channel 2", 2]
laser1:dl:lock:pdh-selection (integer)

Lock Without Lockpoint
Select Lock mode without Lockpoint
[1: Lock without Lockpoint], [0: Lock with Lockpoint]
laser1:dl:lock:lock-without-lockpoint (boolean)

PID Selection
Select PIDs used for locking
["None", 0], ["PID 1", 1], ["PID 2", 2], ["PID 1+2", 3]
laser1:dl:lock:pid-selection (integer)

FALC Selection
(only available with FALC 1 and/or FALC 2 connected)
Select FALC module to link for Click & Lock
["None", 0], ["FALC 1", 1], ["FALC 2", 2]
laser1:dl:lock:falc-selection (integer)

Lock Candidate Separation
Enter the min. lock-point separation for side of fringe
Separation in [samples]
laser1:dl:lock:candidate-filter:edge-min-distance (integer)

Peak Lock Candidates
Select to include peak lock candidates
[1: included], [0: not included]
laser1:dl:lock:candidate-filter:top (boolean)

Trough Lock Candidates
Select to include trough lock candidates
[1: included], [0: not included]
laser1:dl:lock:candidate-filter:bottom (boolean)

Positive-Edge Lock Candidates
Select to include lock candidates on positive edges
[1: included], [0: not included]
laser1:dl:lock:candidate-filter:positive-edge (boolean)

Negative-Edge Lock Candidates
Select to include lock candidates on negative edges
[1: included], [0: not included]
laser1:dl:lock:candidate-filter:negative-edge (boolean)

PID 1

Output Channel
Select the output channel for PID 1
["PC Voltage", 50], ["CC Current", 51], ["Out A", 20], ["Out B", 21]
["EOM Voltage Slow", 58] only laser systems with intra-cavity EOM
laser1:dl:lock:pid1:output-channel (integer)

Use I Cut-off
Enable or disable I cut-off on or off
[1: on], [0: off]
laser1:dl:lock:pid1:gain:i-cutoff-enabled (boolean)

I Cut-off Frequency
Enter I cut-off frequency. Frequency in Hz below which the integral gain of the PID controller is limited. If PID 1 is used in parallel with PID 2 in a control system, I-cutoff prevents that the two PID loops accumulate offsets in different directions.
Frequency in [Hz]
laser1:dl:lock:pid1:gain:i-cutoff (real)

Use Limit
Select to turn limit for PID 1 output on or off
[1: on], [0: off]
laser1:dl:lock:pid1:outputlimit:enabled (boolean)

Limit
Symmetric PID1 output limit relative to lock starting point
The unit depends on the output channel
"PC Voltage" [V]
"CC Current" [mA]
"Out A", "Out B" [V]
laser1:dl:lock:pid1:outputlimit:max (real)

Enable PID 1
Enable or disable PID 1 individually
[1: enabled], [0: disabled]
laser1:lock:PID1:enabled (boolean)

PID 2

Output Channel
Select the output channel for PID 2
["PC Voltage", 50], ["CC Current", 51], ["Out A", 20], ["Out B", 21]
["EOM Voltage Slow", 58] only laser systems with intra-cavity EOM
laser1:dl:lock:pid2:output-channel (integer)

Use Limit
Select to turn limit for PID 2 output on or off
[1: on], [0: off]
laser1:dl:lock:pid2:outputlimit:enabled (boolean)

Limit
Symmetric PID 2 output limit relative to lock starting point
The unit depends on the output channel

"PC Voltage"	[V]
"CC Current"	[mA]
"Out A", "Out B"	[V]

laser1:dl:lock:pid2:outputlimit:max (real)

Enable PID 2
Enable or disable PID 2 individually
[1: enabled], [0: disabled]
laser1:lock:PID2:enabled (boolean)

Lock-In

Lock-In Modulation Frequency
Enter Lock-In modulation/demodulation frequency
Frequency in [Hz]
laser1:dl:lock:lockin:frequency (real)

Lock-In Modulation Amplitude
Enter Lock-In modulation amplitude
The unit is dependent on the output channel

"PC Voltage"	[V]
"CC Current"	[mA]
"Out A", "Out B"	[V]

laser1:dl:lock:lockin:amplitude (real)

Lock-In Demodulation Phase
Enter phase difference between Lock-In modulation and demodulation
Phase in [°]
laser1:dl:lock:lockin:phase-shift (real)

Output Channel
Select the output channel for Lock-In modulation
["PC Voltage", 50], ["CC Current", 51], ["Out A", 20], ["Out B", 21]
laser1:dl:lock:lockin:modulation-output-channel (integer)

PDH (only with PDH module)

Channel 1

PDH Modulation Enabled
Enable or disable demodulation/LO signal
[1: enabled], [0: disabled]
pdh1:channel1:modulation-enabled (boolean)

PDH Modulation Frequency
Select PDH modulation/demodulation frequency
[1: 25 MHz], [0: 5 MHz]
pdh1:channel1:use-fast-oscillator (boolean)

PDH Modulation Amplitude
Enter PDH modulation amplitude
Amplitude in [dBm]
pdh1:channel1:modulation-amplitude-dbm (real)

PDH Demodulation Phase
Enter phase difference between PDH modulation and demodulation
Phase in [°]
pdh1:channel1:phase-shift (real)

Maximum Input Level
Enter the maximum signal level expected on the RF input
["-10 dBm", 0]: Signal level valid up to -10 dBm
["0 dBm", 1]: Signal level valid up to 0 dBm
["+10 dBm", 2]: Signal level valid up to +10 dBm
pdh1:channel1:input-level-max (integer)

LO Output Enabled
Enable or disable output of the LO signal
pdh1:channel1:lo-output-enabled (boolean)

LO Output Amplitude
Enter LO Amplitude
pdh1:channel1:lo-output-amplitude-dbm (real)

NOTE !	When **LO Output** is enabled, the **LO Amplitude** can be set as desired. This may affect the error signal generated by the PDH module. If you wish to output the demodulation signal and ensure optimum error signal quality at the same time, set **LO Amplitude** to 8.8 dBm.

Channel 2

PDH Modulation Enabled
Enable or disable demodulation/LO signal
[1: enabled], [0: disabled]
pdh1:channel2:modulation-enabled (boolean)

PDH Modulation Frequency
Select PDH modulation/demodulation frequency
[1: 25 MHz], [0: 5 MHz]
pdh1:channel2:use-fast-oscillator (boolean)

PDH Modulation Amplitude
Enter PDH modulation amplitude
Amplitude in [dBm]
pdh1:channel2:modulation-amplitude-dbm (real)

PDH Demodulation Phase
Enter phase difference between PDH modulation and demodulation
Phase in [°]
pdh1:channel2:phase-shift (real)

Maximum Input Level
Enter the maximum signal level expected on the RF input
["-10 dBm", 0]: Signal level valid up to -10 dBm
["0 dBm", 1]: Signal level valid up to 0 dBm
["+10 dBm", 2]: Signal level valid up to +10 dBm
pdh1:channel2:input-level-max (integer)

LO Output Enabled
Enable or disable output of the LO signal
pdh1:channel2:lo-output-enabled (boolean)

LO Output Amplitude
Enter LO Amplitude
pdh1:channel2:lo-output-amplitude-dbm (real)

NOTE !	When **LO Output** is enabled, the **LO Amplitude** can be set as desired. This may affect the error signal generated by the PDH module. If you wish to output the demodulation signal and ensure optimum error signal quality at the same time, set **LO Amplitude** to 8.8 dBm.

FALC 1/2 (only with FALC pro module connected)

Serial Number
Displays serial number of FALC X.
falcX:serial-number (string)

Path Selection (only with DLC pro Lock option)
Select path(s) to link for Click & Lock.
["None", 0], ["Unlim", 1], ["Main", 2], ["Unlim + Main", 3]
falcX:path-selection (integer)

Hold State
Hold state of the linked path(s).
falcX:hold-state (boolean)

Monitor Output Configuration
Select signal for analog Monitor output of the FALC pro module.
["Error", 0], ["Main", 1], ["Main RMS", 2]
falcX:mon:config (integer)

Enable Main Path
Enable or disable main path.
falcX:main:enabled (boolean)

Use External Gain Input
Use external gain input for main path.
falcX:main:gain:use-external-input (boolean)

Enable Unlim Path
Enable or disable unlim path.
falcX:unlim:enabled (boolean)

Hold Unlim Path
Hold unlim path.
falcX:unlim:hold (boolean)

Unlim Output Range
Set maximum absolute voltage of the Unlimited integrator output signal.
falcX:unlim:output-range (real)

Lock Detection and ReLock

Enable Lock Detection
Lock detection for ReLock, Hold, etc.
[1: enabled], [0: disabled]
laser1:dl:lock:window:enabled (boolean)

Window Input Signal
Select input signal for lock detection window
["Fine In 1, 0"], ["Fine In 2", 1], ["Fast In 3", 2], ["Fast In 4", 4]
Only with PDH Module
["PDH In 1", 41], ["PDH In 2", 43]
laser1:dl:lock:window:input-channel (integer)

Window Level Low
Enter lower level for out-of-lock detection
Level in [V]
laser1:dl:lock:window:level-low (real)

Window Level High
Enter upper level for out-of-lock detection
Level in [V]
laser1:dl:lock:window:level-high (real)

Window Hysteresis
Hysteresis between out-of-lock and in-lock value
Hysteresis in [V]
laser1:dl:lock:window:level-hysteresis (real)

Out-of-lock Action

Delay
Delay to action after out-of-lock state is detected
Enter the delay between detection of the out-of-lock state and the initialization of a reset/relock procedure.
Delay in [ms]
laser1:dl:lock:relock:delay (real)

Enable PID 1/2 Reset
PID reset upon out-of-lock state
[1: enabled], [0: disabled]
laser1:dl:lock:reset:enabled (boolean)

ReLock

Enable ReLock
ReLock upon out-of-lock state
[1: enabled], [0: disabled]
laser1:dl:lock:relock:enabled (boolean)

ReLock Amplitude
Enter amplitude for ReLock scan
Amplitude in [V]
laser1:dl:lock:relock:amplitude (real)

ReLock Frequency
Enter frequency for ReLock scan
Frequency in [Hz]
laser1:dl:lock:relock:frequency (real)

ReLock Output Channel
Select output channel for ReLock
["PC Voltage", 50], ["CC Current", 51], ["Out A", 20], ["Out B", 21]
laser1:dl:lock:relock:output-channel (integer)

Power Stabilization Settings

Enable Power Stabilization
Enable or disable power stabilization
[1: enabled], [0: disabled]
laser1:power-stabilization:enabled (boolean)

Differential Gain
Enter diff. gain for power stabilization in [mA/mW*µs]
laser1:power-stabilization:gain:d (real)

Hold Output Current on Unlock
Select unlock behavior of output channel
[1: enabled], [0: disabled]
laser1:power-stabilization:hold-output-on-unlock (boolean)

Sign Positive
Select on for positive, off for negative
[1: on], [0: off]
laser1:power-stabilization:sign (boolean)

Input Channel
Select power stabilization input channel
Selectable signal channels depend on laser head. Please refer to section 5.3.6 for reference
laser1:power-stabilization:input-channel (integer)

Window Settings

Enable Stabilization Detection
Enable or disable window for power stabilization
[1: enabled], [0: disabled]
laser1:power-stabilization:window:enabled (boolean)

Window Level
Enter level for out-of-stabilization detection
Level in [mW]
laser1:power-stabilization:window:level-low (real)

Window Hysteresis
Hysteresis between out-of- and in-lock stabilization value
Hysteresis in [mW]
laser1:power-stabilization:window:level-hysteresis (real)

External Power
External Power settings
Physical Channel
Select physical input for external power
laser1:pd-ext:input-channel

Photo Diode Value
Photo diode voltage of the physical channel [V]
laser1:pd-ext:photodiode (real)

Calibration Factor
Enter calibration factor for external power
laser1:pd-ext:cal-factor (real)

Calibration Offset
Enter calibration offset for external power
laser1:pd-ext:cal-offset (real)

Feed Forward (only DLC CTL)
Power Stabilization Feed Forward
Enable power stabilization Feed Forward (for description, please refer to section 6.20.4)
Enable or disable power stabilization Feed Forward
[1: enabled], [0: disabled]
laser1:power-stabilization:feedforward-enabled (boolean)

Feed Forward Factor (only DLC CTL)
Enter power stabilization Feed Forward factor
(for description, please refer to section 6.20.4)
Power stabilization Feed Forward factor in [V/mA]
laser1:power-stabilization:feedforward-factor (real)

Display Settings
Trace Scaling
Input Trace Y Minimum
Enter Ymin for left axis.
Reasonable values depend on the selected signal

Input Trace Y Maximum
Enter Ymax for left axis.
Reasonable values depend on the selected signal

Auxiliary Trace Y Minimum
Enter Ymin for right axis.
Reasonable values depend on the selected signal

Auxiliary Trace Y Maximum
Enter Ymax for right axis.
Reasonable values depend on the selected signal

Trace Selection

Input Trace Signal (available signals depending on system model)
Select signal for input trace (red curve)
["None", -3], ["Fine In 1", 0], ["Fine In 2", 1], ["Fast In 3", 2], ["Fast In 4", 4], ["Out A", 20]
["Out B", 21], ["CC Current", 51], ["CC AIn1", 52], ["CC AIn2", 53], ["PC Voltage", 50]
["SC Output", 101], ["Laser PD", 54], ["External Power", 55], ["PowerLock Input", 102]
["Lock Input", 100], ["Lock-In Output", 30], ["PID 1 Output", 31], ["PID 2 Output", 32]
Only with PDH Module
["PDH In 1", 41], ["PDH Error 1", 40], ["PDH In 2", 43], ["PDH Error 2", 42]
Only DLC TA pro/-AL
["Amp. Current", 63], ["AMP AIn", 60], ["Seed Power", 61], ["Amp. Power", 62]
Only DLC CTL
["CTL Power", 70], ["CTL Photodiode", 69]
Only DLC DL-/TA-SHG/FHG pro
["SHG PC Voltage", 90], ["Seed Power", 85], ["Amp. Power", 84], ["SHG Power", 83]
["Fiber Power", 86]
Only DLC DL-/TA-FHG pro
["FHG PC Voltage", 120], ["FHG Power", 113]
laser1:scope:channel1:signal (integer)
Only DLC TOPO
["Pump Power", 144], ["Depl. Pump Power", 145], ["Signal Power", 146]
["OPO Slow PZT Voltage", 150], ["OPO Fast PZT Voltage", 151]
Only laser systems wit intra-cavity EOM
["EOM Voltage Slow", 58]

Auxiliary Trace Signal (available signals depending on system model)
Select signal for auxiliary trace (blue curve)
["None", -3], ["Fine In 1", 0], ["Fine In 2", 1], ["Fast In 3", 2], ["Fast In 4", 4], ["Out A", 20]
["Out B", 21], ["CC Current", 51], ["CC AIn1", 52], ["CC AIn2", 53], ["PC Voltage", 50]
["SC Output", 101], ["Laser PD", 54], ["External Power", 55], ["PowerLock Input", 102]
["Lock Input", 100], ["Lock-In Output", 30], ["PID 1 Output", 31], ["PID 2 Output", 32]
Only with PDH Module
["PDH In 1", 41], ["PDH Error 1", 40], ["PDH In 2", 43], ["PDH Error 2", 42]
Only DLC TA pro/-AL
["Amp. Current", 63], ["AMP AIn", 60], ["Seed Power", 61], ["Amp Power", 62]
Only DLC CTL
["CTL Power", 70], ["CTL Photodiode", 69]
Only DLC DL-/TA-SHG/FHG pro
["SHG PC Voltage", 90], ["Seed Power", 85], ["Amp. Power", 84], ["SHG Power", 83]
["Fiber Power", 86]
Only DLC DL-/TA-FHG pro
["FHG PC Voltage", 120], ["FHG Power", 113]
laser1:scope:channel2:signal (integer)
Only DLC TOPO
["Pump Power", 144], ["Depl. Pump Power", 145], ["Signal Power", 146]
["OPO Slow PZT Voltage", 150], ["OPO Fast PZT Voltage", 151]
Only laser systems wit intra-cavity EOM
["EOM Voltage Slow", 58]

Display Refresh Rate

NOTE !	The actual display refresh rate may be limited by the **Scan > Scan Frequency**, or the **Lock Detection and ReLock > Out-of-lock Action > ReLock > ReLock Frequency**, both set in the context parameter menu. Keep that in mind when setting very low **Scan Frequency** or **ReLock Frequency** values.

Select display refresh rate
Frequency in [Hz]
["1 Hz", 1], ["2 Hz", 2], ["3 Hz", 3], ["4 Hz", 4], ["5 Hz", 5], ["10 Hz", 10]
laser1:scope:update-rate (integer)

Display Mode
Select display mode
[“X/Y”, 0], ["Time", 1], ["Frequency", 2]
laser1:scope:variant (integer)

Time

Time Base
Select time base
Time in [ms]
[“50 μs”, 0.05], [“100 μs”, 0.1], [“200 μs”, 0.2], [“500 μs”, 0.5], [“1 ms”, 1]
[“2 ms”, 2], [“5 ms”, 5], [“10 ms”, 10], [“20 ms”, 20], [“50 ms”, 50]
[“100 ms”, 100], [“200 ms”, 200], [“500 ms”, 500], [“1 s”, 1000]
Laser1:scope:channelx:scope-timescale (real)

Frequency

Frequency Base
Select frequency base
Frequency in [kHz]
[“500 Hz”, 0.5], [“1 kHz”, 1], [“2.5 kHz”, 2.5], [“5 kHz”, 5]
[“10 kHz”, 10], [“25 kHz”, 25], [“50 kHz”, 50], [“100 kHz”, 100]
[“250 kHz”, 250], [“500 kHz”, 500], [“1 MHz”, 1000]
laser1:scope:channelx:scope-spectrum-range (real)

Pressure Compensation (not DLC DFB pro)
Pressure compensation settings

Pressure Compensation
Enable or disable pressure compensation
[1: enabled], [0: disabled]
laser1:dl:pressure-compensation:enabled (boolean)

Averaged Air Pressure
Shows averaged air pressure in [hPa]
laser1:dl:pressure-compensation:air-pressure (real)

Pressure Comp. Factor
Set the factor for linear pressure compensation in [V/hPa]
laser1:dl:pressure-compensation:factor (real)

NOTE !	Please refer to section 10.11 for further information on the pressure compensation.

Pressure Comp. Voltage
Shows pressure compensation voltage
laser1:dl:pressure-compensation:compensation-voltage (real)

5.3.9 Side of Fringe Locking with Touchscreen

NOTE !	In the following, only the basic steps of Side of Fringe locking are described. For a more detailed application example, please refer to section 7.3.1.

Once the laser scans across the spectral function (please refer to section 5.3), a typical application is to lock the laser frequency to the slope of a Doppler-free absorption line.

Prerequisites:

- Experimental setup connected to the DLC pro (for details, see section 7.1):
- Lock option license key activated via the TOPAS DLC pro PC-GUI (please refer to section 10.19).
- Lock Input signal connected to Fine In or Fast In (BNC connectors on DLC pro front panel).
- Laser head connected to the DLC pro as described in section 4.5.3.

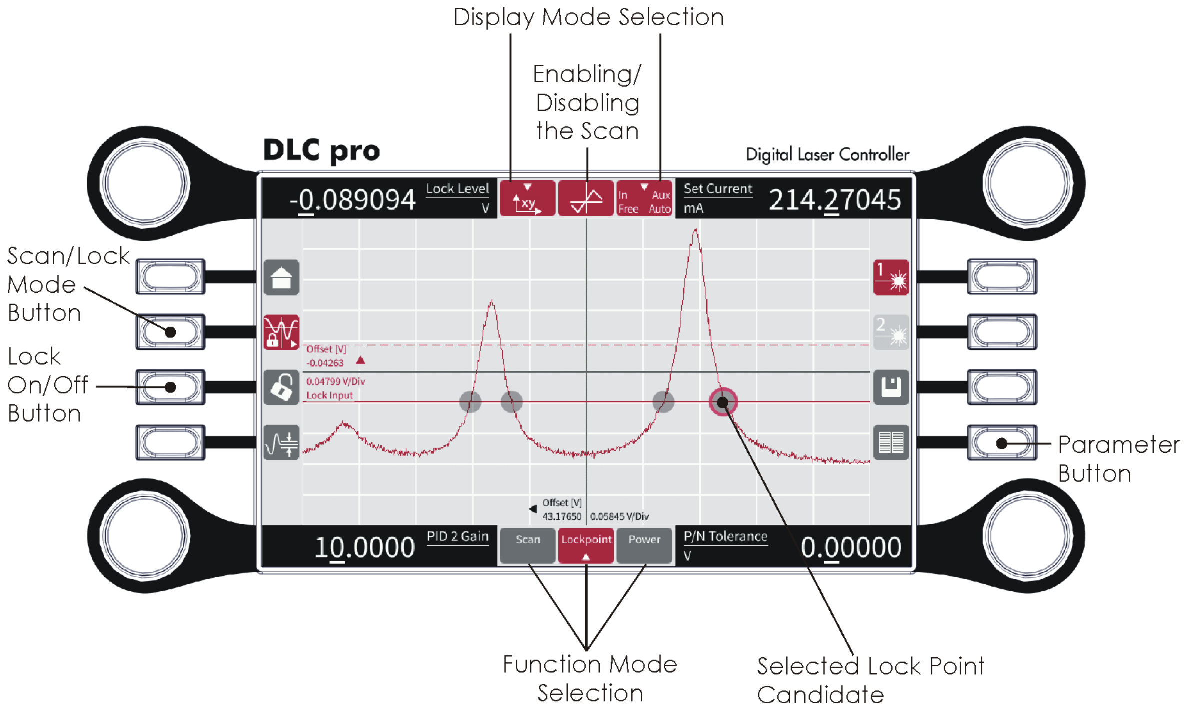


Figure 25 Touchscreen in Lockpoint function mode; Lockpoint candidates for Side of Fringe lock type (example)

1. Switch to Scan/Lock mode by pressing the **Scan/Lock Mode** button.

2. Select the xy display mode by tapping the **xy** symbol.
Select the Lockpoint function mode by tapping the **Lockpoint** symbol.

3. Select the input channel of the Lock Input signal in the parameter menu (**Lock Settings > Lock Input signal**).

4. Select **Lock Settings > Lock Type > Side of Fringe** in the parameter menu.

5. Select the PID controller(s) for regulating the lockpoint (**Lock Settings > PID Selection**).
Ensure that each PID output is configured correctly.

NOTE !	Typically, PID 1 handles the high frequencies by controlling the laser current. PID 2 is responsible for the lower frequencies by controlling the piezo voltage. If PID 1 is used in parallel with PID 2 in a control system, I-cutoff prevents that the two PID loops accumulate offsets in different directions.

6. Zoom and drag the Lock Input signal and adjust the laser current (**Set Current** rotary knob) until the laser scans mode hop-free across the desired lockpoint and the lockpoint in the spectrum is clearly visible on the display.

NOTE !	The current lock voltage level is displayed as a red line. Lockpoint candidates are displayed where the Lock Input signal crosses the lock voltage level line.

7. Set the desired lock level voltage by turning the **Lock Level** rotary knob.

8. **Locking with lockpoint candidates:** Select the lockpoint by tapping on the **Lockpoint Candidate**. For a clearer display, unwanted lockpoint candidates can be deselected in the context parameter menu (**Lock Settings > Positive-Edge/Negative-Edge Lock Candidates**).

Locking without lockpoint candidates: Enable **Lock Settings > Lock Without Lockpoint** in the context parameter menu. Move the spectrum on the touchscreen in x-direction so that the desired region to trigger the lock is located in the center.

9. Press the **Lock On/Off** button or tap the corresponding symbol (see section 5.6).
Locking with lockpoint candidates: The laser scans to the selected lockpoint. When the scan reaches the lockpoint, the scan stops, and the PID controller(s) switch on.

Locking without lockpoint candidates: The laser scans to the center of the spectrum (**Offset**). When the scan reaches this point, the scan stops, and the PID controller(s) switch on.

10. Select the **PID 1** or **PID 2** function modes by tapping on the **PID** symbols.

11. Adjust the **PID Gain** settings with the rotary knobs. See section 8.3 for information on PID controller configuration.

When the laser is locked, the touchscreen shows the Lock Input signal during the last scan before the lock was enabled (default black trace) and the actual Lock Input signal as a point cloud (default red) in red brackets.

NOTE !	Due to the enabled lock, the scan is disabled. In xy display mode the Lock Input signal now appears as a point cloud because the scan output (X-axis) remains constant and all Y-values are plotted against this constant X-value.

In case one of the used PID controller outputs is equal to the scan output, the X-value does not remain constant, reflecting the action of the PID controller. Depending on the required action of the PID controller to keep the lock stable, the point cloud may leave the displayed X-axis range. In this case a red arrow shows the direction to the point cloud. The red arrow also helps to judge if the laser is still locked. When the laser is out-of-lock, the red arrow will not point into the expected direction (please see also Figure 74).

To unlock the laser:
1. Press the **Lock On/Off** button or tap the corresponding symbol (see section 5.6).
The PID controller(s) switch(es) OFF, and the scan starts again.

NOTE !	If you wish to keep the selected PID output channel at the current value after the lock is switched off, check the parameter box laserx:dl:lock:pid1/2:hold-output-on-unlock in the Params tab of the TOPAS DLC pro PC-GUI (see section 6.24). The parameter can be accessed in user level MAINTENANCE, for changing the user level, please refer to section 6.11, Device Configuration section.

5.3.10 Top of Fringe (Lock-In/PDH) Locking with Touchscreen

NOTE !	In the following, only the basic steps on Top of Fringe locking are described. For a more detailed application example, please refer to section 7.3.2. **Only Top of Fringe (Lock-In)**: The Lock Wizard in the TOPAS DLC pro PC-GUI (**Menu > Optimization Tools > Lock Wizard**, see section 6.11) is an interactive tool which helps to set-up a Top of Fringe lock.

NOTE !	**If your DLC pro is equipped with a PDH module** (see section 9.2.9), you can also use the PDH Ch1/PDH Ch2 function modes for Top of Fringe locking, instead of the LIR function mode described in this section. In this case connect your experimental setup as shown in section 7.3.3 and follow the instructions below for Lock-In accordingly. For an application example of a Top of Fringe PDH lock with high-finesse cavity, please refer to section 7.2.

NOTE !	It is possible to route the Lock-In Error signal to the Out A/B BNC connectors on the DLC pro front panel. Please refer to section 6.15.3 for details. By routing the Lock-In Error signal to analog outputs, the signal resolution may be reduced. Please use the parameters io:out-a:external-input:factor or io:out-b:external-input:factor, respectively, in order to increase signal-to-noise.

Prerequisites:
- Experimental setup connected to the DLC pro (for details, see sections 7.3.2 or 7.3.3):
- Lock option license key activated via the TOPAS DLC pro PC-GUI (please refer to section 10.19).
- **Only Lock-In**: Lock Input signal connected to Fine In or Fast In (BNC connectors on DLC pro front panel).
- **Only PDH Lock**: Lock Input signal connected to in 1 or in 2 (SMB connectors on PDH module panel).
- Laser head connected to the DLC pro as described in section 4.5.3.

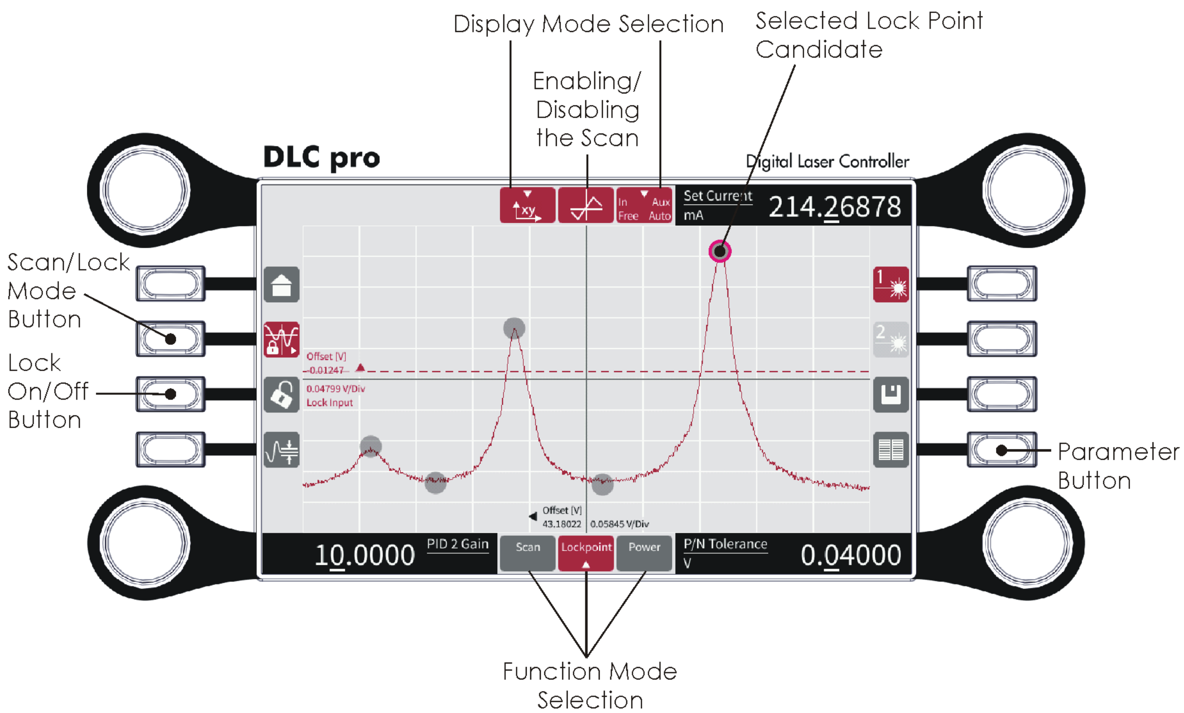


Figure 26 Touchscreen in Lockpoint function mode; Lockpoint candidates for Top of Fringe lock type (example)

Status: 29.3.22

1. Switch to Scan/Lock mode by pressing the **Scan/Lock Mode** button.

2. Select the xy display mode by tapping the **xy** symbol.
Select the Lockpoint function mode by tapping the **Lockpoint** symbol.

3. Select the input channel of the Lock Input signal in the parameter menu (**Lock Settings > Lock Input signal**) depending on the desired **Lock Type** and the experimental setup.

4. Select **Lock Settings > Lock Type > Top of Fringe** or **Top of Fringe PDH** in the parameter menu.

NOTE !	To display only the Lock Input signal, select **Display Settings > Trace Selection > Auxiliary Trace Signal > None** in the parameter menu. Lockpoint candidates are displayed at the extrema of the Lock Input signal. If the lock-points at the extrema are not properly detected automatically, this behavior can be improved by adjusting the **P/N Tolerance** rotary knob correctly for the signal and signal-to-noise ratio used. This parameter is 0 for automatic detection, and automatic detection does not always work perfectly. The parameter should be set to a value that is larger than the peak-to-peak noise and smaller than the peaks that the laser should be locked to.

5. Select the PID controller(s) to regulate the lockpoint (**Lock Settings > PID Selection**).
Ensure that each PID output is configured correctly.

NOTE !	Typically, PID 1 handles the high frequencies by controlling the laser current. PID 2 is responsible for the lower frequencies by controlling the piezo voltage. If PID 1 is used in parallel with PID 2 in a control system, I-cutoff prevents that the two PID loops accumulate offsets in different directions.

6. Zoom and drag the Lock Input signal, and adjust the laser current (**Set Current** rotary knob) until the laser scans mode hop-free across the desired part of the spectrum and the desired lockpoint is clearly visible on the display.

7. Switch to the LIR function mode by tapping the **Lockpoint** symbol and selecting the **LIR** symbol. Display the Lock-In Output signal (Error signal) as the Auxiliary trace (**Display Settings > Trace Selection > Auxiliary Trace Signal**).

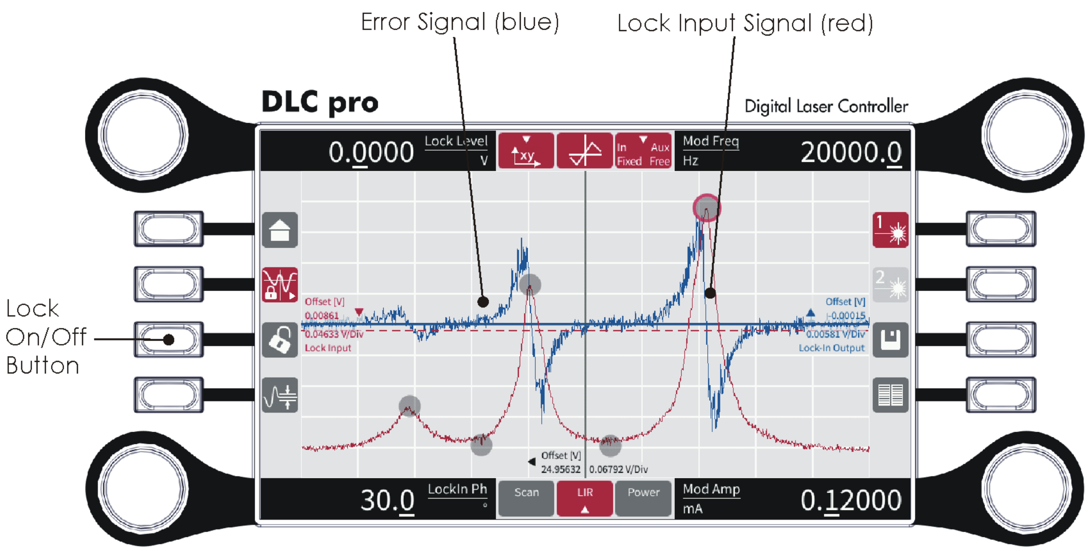


Figure 27 Error signal (blue) and Lock Input signal (red) displayed in LIR lock function mode

8. Set the **Lock Level** to zero at the top-left rotary knob. Adjust the **Modulation Frequency**, **Modulation Amplitude**, and **Lock-In Phase** of the Error signal (rotary knobs).
Modify the demodulation phase (**Lock-In Phase**) until the blue Error signal matches the derivative of the red Lock Input signal and the Error signal runs in the correct direction through the signal extremum to which you want to lock:
- Lockpoint is in signal valley: rising flank of the blue Error signal.
- Lockpoint is on signal peak: falling flank of the blue Error signal.

NOTE !	Please refer to section 8.3 for information on how to configure the PID controller(s). Please refer to section 7.3.2 for reasonable settings of the Lock-In parameters.

9. Switch to Lockpoint function mode.
Locking with lockpoint candidates: Select the lockpoint by tapping on the **Lockpoint Candidate**. For a clearer display, unwanted lockpoint candidates can be deselected in the context parameter menu (**Lock Settings > Peak/Trough Lock Candidates**).

Locking without lockpoint candidates: Enable **Lock Settings > Lock Without Lockpoint** in the context parameter menu. Move the spectrum on the touchscreen in x-direction so that the desired region to trigger the lock is located in the center.

10. Press the **Lock On/Off** button or tap the corresponding symbol (see section 5.6).
Locking with lockpoint candidates: The laser scans to the selected lockpoint. When the scan reaches the lockpoint, the scan stops, and the PID controller(s) switch on.

Locking without lockpoint candidates: The laser scans to the center of the spectrum (**Offset**). When the scan reaches this point, the scan stops, and the PID controller(s) switch on.

11. Select the PID 1 or PID 2 lock function mode by tapping on the **PID** symbols.

12. Adjust the **PID Gain** settings with the rotary knobs to optimize the lock. See section 8.3 for information on PID controller configuration.

NOTE !	The laser is actually locked to the Lock-In Output signal. The Lock-In Output signal is the input signal for the PID controller(s).

When the laser is locked, the touchscreen shows the Lock Input signal during the last scan before the lock was enabled (default black trace) and the actual Lock Input signal as a point cloud (default red) in red brackets.

NOTE !	Due to the enabled lock, the scan is disabled. In xy display mode the Lock Input signal now appears as a point cloud because the scan output (X-axis) remains constant and all Y-values are plotted against this constant X-value.

In case one of the used PID controller outputs is equal to the scan output, the X-value does not remain constant, reflecting the action of the PID controller. Depending on the required action of the PID controller to keep the lock stable, the point cloud may leave the displayed X-axis range. In this case a red arrow shows the direction to the point cloud. The red arrow also helps to judge if the laser is still locked. When the laser is out-of-lock, the red arrow will not point into the expected direction (please see also Figure 74).

To unlock the laser:

1. Press the **Lock On/Off** button or tap the corresponding symbol (see section 5.6).
The PID controller(s) switch(es) off, and the scan starts again.

NOTE !	If you wish to keep the selected PID output channel at the current value after the lock is switched off, check the parameter box laserx:dl:lock:pid1/2:hold-output-on-unlock in the Params tab of the TOPAS DLC pro PC-GUI (see section 6.24). The parameter can be accessed in user level MAINTENANCE, for changing the user level, please refer to section 6.11, Device Configuration section.

5.3.11 ReLock Window and Procedure

The ReLock feature is provided to detect out-of-lock states of the laser, to reset the PID controller(s), and to relock the system if the out-of-lock state is detected (see Figure 29). In order to determine whether the system is in-lock state or not, the DLC pro needs input. The user defines a Window Input signal and conditions for this signal to determine the lock state (ReLock window, see Figure 28).

The Window Input signal can be, for example, a Doppler-broadened absorption signal to distinguish between various Doppler free lines. It may be a fluorescence signal or a TTL signal from some other source within the experimental setup. It could also be the Lock Input signal.

In the ReLock window, the user can choose a voltage range for the Window Input signal which defines the in-lock state. If the signal leaves this range, the out-of-lock state is detected. The system can only return into the in-lock state if the signal is within the chosen voltage range, again.

To prevent the system from hopping between the two states due to noisy signals, a certain hysteresis can be defined between the out-of-lock and in-lock voltages.

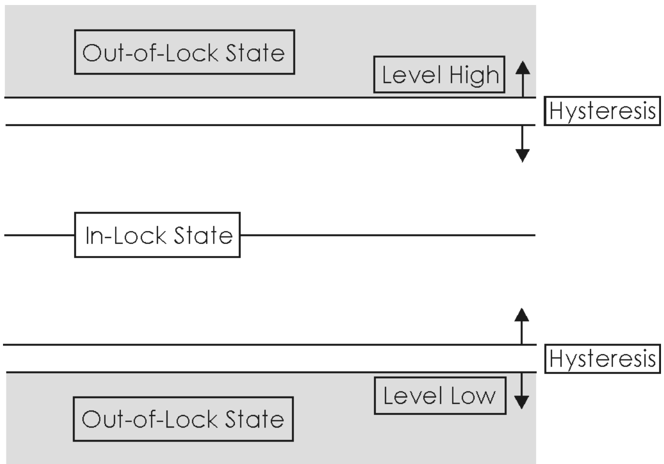


Figure 28 ReLock window

Please configure the Window Input signal and its corresponding levels by selecting the signal in the context parameter menu (**Lock Detection and ReLock > Window Input Signal**) and by defining the parameters of the ReLock window (**Lock Detection and ReLock > Window Level Low** and **High, Window Hysteresis**).

You can also define the limits of the ReLock window with the rotary knobs: **Level High**, **Level Low**, **Hysteresis**. Please note that **Level High** must be ≥ **Level Low + 2 x Hysteresis**.

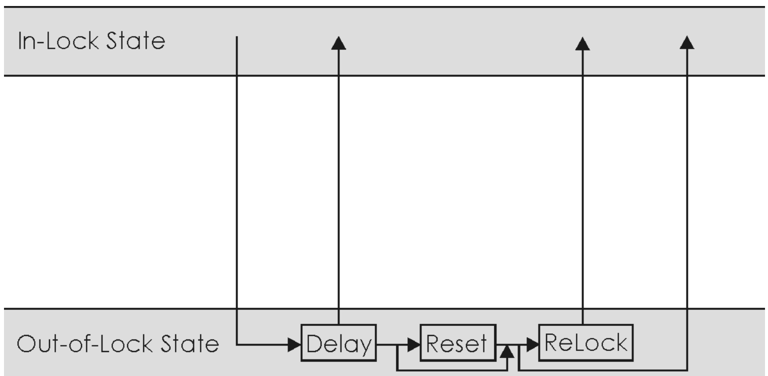


Figure 29 DLC pro ReLock procedure (schematic)

When the out-of-lock-state is detected, the output of the respective PID controller(s) (**Lock Settings > PID**

Selection) is frozen.

- If the in-lock state is reached during the following configurable delay time (**Lock Detection and ReLock > Out-of-Lock Action > Delay**), the PID controller is activated again.

- If the out-of-lock state is still detected after the delay time has expired, the PID controllers are reset to zero if reset is enabled (**Lock Detection and ReLock > Out-of-Lock Action > Enable PID1/2 Reset**) The speed of the reset is dependent on the **Slew Rate** settings (**Output Filters > PC >** or **CC > Slew Rate**) of the selected PID output channels.
  During this reset, the system cannot change back into the in-lock state.

- The Relock scan is initiated as configured (**Lock Detection and ReLock > Out-of-Lock Action > ReLock** submenu) until the in-lock state is reached, again.
  If no ReLock scan is configured, the in-lock state may be reached due to drifts of the laser system or user interaction, again.
  If ReLock is enabled, the DLC pro applies a scan to the **ReLock Output Channel** with the **Relock Frequency** as scan frequency and the **ReLock Amplitude** as scan amplitude.

5.3.11.1 ReLock Configuration with Touchscreen

Prerequisites:

- The Laser is ready to be locked (see sections 5.3.10 and 5.3.9).
- A separate signal for out-of-lock detection (Window Input signal) is connected to Fine In or Fast In (BNC-connectors on DLC pro front panel).

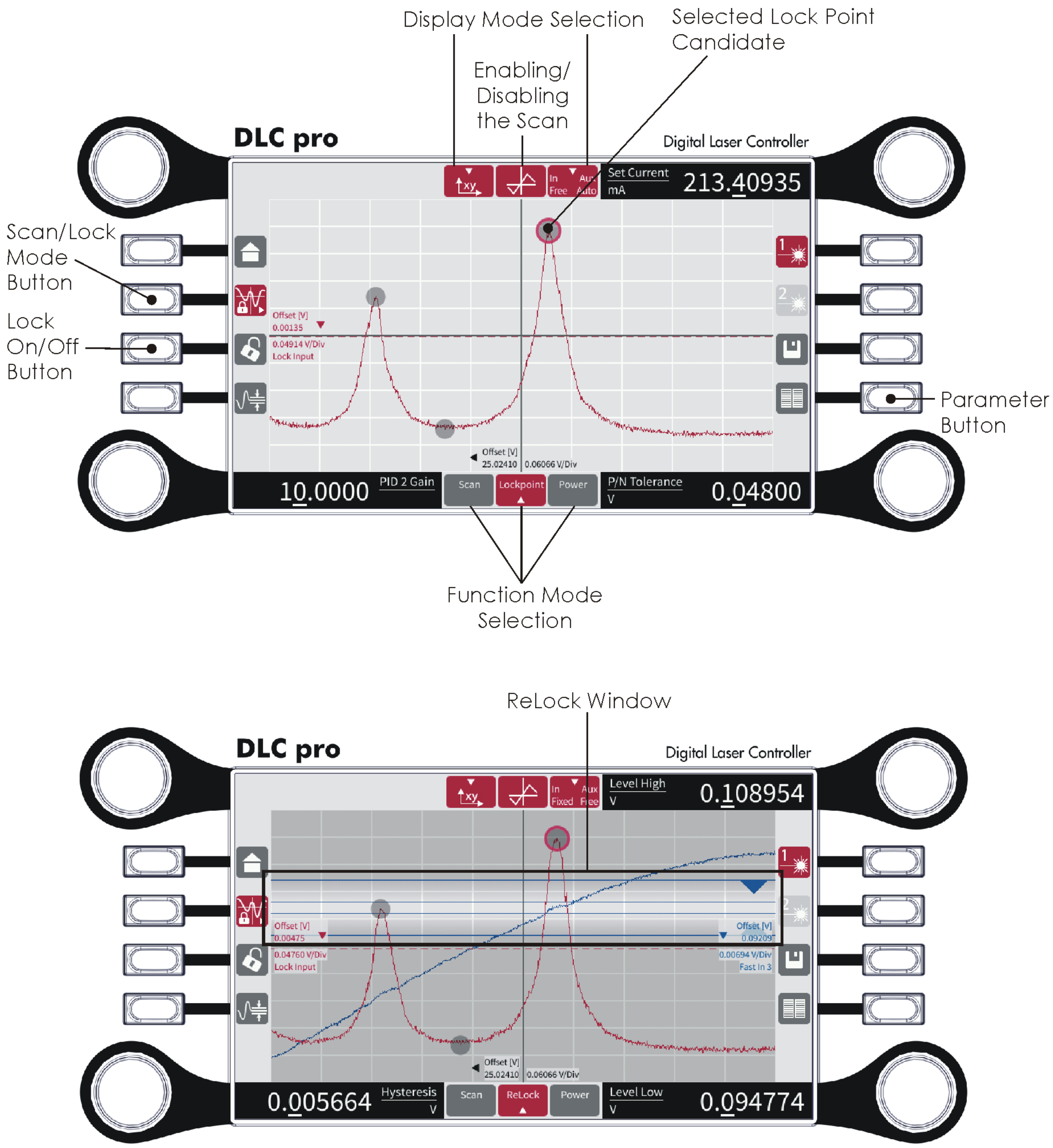


Figure 30 Touchscreen in ReLock function mode; Lockpoint candidates for Top of Fringe lock type shown and ReLock window for out-of-lock detection (example)

1. Select the xy display mode by tapping the **xy** symbol.

2. Enable the out-of-lock detection in the parameter menu (**Lock Detection and ReLock > Enable Lock Detection**).

3. Select the ReLock function mode by tapping the **Lockpoint** symbol and selecting **ReLock**.

4. Select the Window Input signal in the parameter menu (**Lock Detection and ReLock > Window Input Signal**).
To display the Window Input signal, select its channel (**Display Settings > Trace Selection > Auxiliary Trace Signal**) in the parameter menu.

5. Define the limits of the ReLock window for out-of-lock detection with the rotary knobs: **Level High**, **Level Low**, **Hysteresis**.

6. Define the Delay between out-of-lock detection and reset/relock scan activation in the parameter menu (**Lock Detection and ReLock > Out-of-Lock Action > Delay**).

7. Enable/disable Reset for both PID controller(s) (**Lock Detection and ReLock > Out-of-Lock Action > Enable PID1/2 Reset**) and define the **Slew Rate** (**Output Filters > PC >** or **CC > Slew Rate**) of the selected PID output channels.

8. Enable/disable the ReLock in the parameter menu (**Lock Detection and ReLock > Out-of-Lock Action > ReLock > Enable ReLock**).

9. Define ReLock amplitude, frequency, and output channel of the ReLock scan in the parameter menu (**Lock Detection and ReLock > Out-of-Lock Action > ReLock > ReLock Amplitude**, **ReLock Frequency** and **ReLock Output Channel**).

The ReLock should now be configured and work as intended.

NOTE !	In case the **Lock Detection and ReLock > Out-of-lock Action > ReLock > ReLock Frequency** is lower than the **Scan > Scan Frequency** (both set in the context parameter menu), the xy display mode of the touchscreen does not show a whole ReLock scan period. Use the t (time) display mode for proper display.

5.3.12 Wide Scan Mode

NOTE !	The Wide Scan mode is available for all laser heads. Depending on the laser head type, a different set of parameters can be scanned. In Wide Scan mode, the number of recorded data points will be much bigger than displayed by the screen resolution. In order to show even narrow spectral features, the display actually shows an enveloped graph which considers the minimal and maximal values in each interval represented by a data point (or data bar actually). It is possible to zoom into the recorded data while the scan is still in progress. Use the **Full Range** button to return to the full scale display in an easy way. When **Wide Scan > Scan Shape > Triangle** is selected in the context parameter menu (see section 5.3.12.1), do not use the screen display for analysis, as it shows artifacts. The full resolution of all recorded data points can be exported from the Wide Scan Display of the TOPAS DLC pro PC-GUI.

The wavelength of a laser head can be tuned, for example, by varying either the laser diode temperature, the operating current or the piezo voltage. CTL laser heads can additionally be tuned by performing a motor scan.

The Wide Scan mode allows to scan different, laser head depending parameters over a large range and to record data with a high resolution. Operation is described in the Wide Scan relevant sections of this manual (e.g., this section, sections 6.11 and 6.14.1).

To access the Wide Scan mode relevant operator controls, either press the **Scan/Lock Mode** button several times until display and rotary knob assignment change as shown in Figure 31 or tap the corresponding symbol. The little white arrow in the symbol indicates that there are further options available that can be selected by tapping one of the corresponding symbols which appear after tapping. Select  to change the display of the touchscreen as well as the assignment of the rotary knobs as needed for setting the most important wide scan parameters.

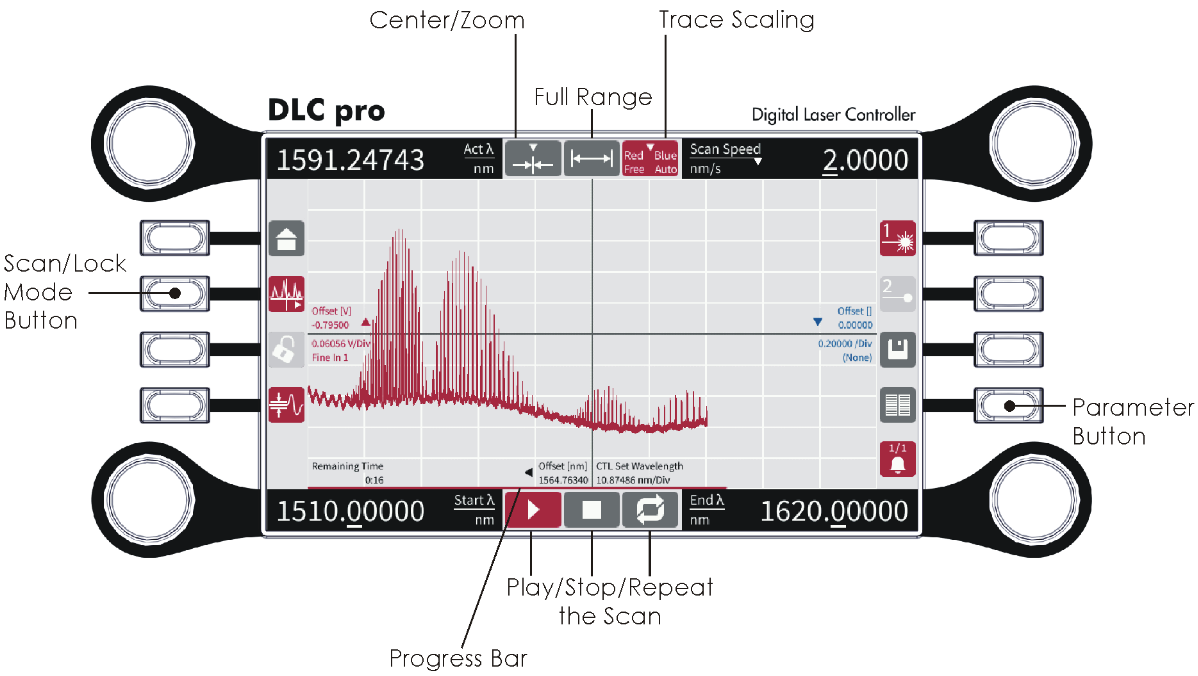


Figure 31 Touchscreen in Wide Scan mode (example DLC CTL)

The parameter to be scanned (**Wide Scan > X-Axis signal**) is selected in the context parameter menu (please refer to section 5.3.12.1) which appears on the touchscreen after pressing the **Parameter** button in Wide Scan mode. Further wide scan parameters are also set in the context parameter menu.

Rotary Knobs:

- **Top-left:** **Set** <value> [mA, V, °C, nm] of the parameter to be scanned when wide scan is not running.
  Actual <value> [mA, V, °C, nm] of the parameter to be scanned when wide scan is running.
- **Bottom-left:** **Start** <value> [mA, V, °C, nm] of the parameter to be scanned.
- **Top-right:** As selected in the drop-down menu (see section 4.4.2):
  Scan Speed [mA/s, V/s, K/s, nm/s]

NOTE !	A high **Scan Speed** together with a small **Wide Scan > Set Recorder Stepsize** (context parameter menu, see section 5.3.12.1) leads to a higher **Recorder > Sampling Rate**. At a **Sampling Rate** above 100 kHz, dropouts during recording may occur.

Actual <value> [mA, V, °C, nm] of the parameter to be scanned or
Set Current of laser diode [mA].

- **Bottom-right:** **End** <value> [mA, V, °C, nm] of the parameter to be scanned.

<value> can be **Current**, **Voltage**, **Temperature** or **Wavelength**.

After the **Start** and **End** values are set, the wide scan is operated by tapping the buttons **Play**, **Stop**, and **Repeat** (see Figure 31). When the laser is scanning, the top-left parameter changes from **Set** value to **Actual** value. A progress bar and a display in the format [min:s] at the bottom of the graph indicate the remaining time of the wide scan (see Figure 31).

Play: The **Start** value of the parameter to be scanned is accessed and the wide scan is initiated with the set **Scan Speed**.

Play Trigger: The icon in the **Play** button indicates that the wide scan is initiated by a input trigger signal and not by tapping the **Play** button (**Wide Scan > Trigger Configuration > Input Trigger > Input Trigger Enable** is set to 1 in the context parameter menu, see section 5.3.12.1).
After tapping the **Play Trigger** button, the **Start** value of the parameter to be scanned is accessed. The wide scan then is initiated with the set **Scan Speed** when a trigger signal is applied to the selected **Wide Scan > Trigger Configuration > Input Trigger > Trigger Input Channel**.
When the trigger signal is removed, the wide scan continues until the **End** value is reached. Tap the **Stop** button to discontinue the wide scan.

Stop: Wide scan is stopped.

Repeat: Wide scan is continuously repeated within the set values. The scan shape for a repeated wide scan can be selected in the context parameter menu (please refer to section 5.3.12.1).
Sawtooth wide scan shape: Return to the start value is performed as fast as possible.
Triangle wide scan shape (default): Return to the start value is performed with scan speed.

NOTE !	When Analog Remote Control (ARC) for the selected **Wide Scan > X-Axis signal** is enabled in the context parameter menu (see section 5.3.12.1), the ramp of the wide scan is superimposed by the ARC signal. This may lead to distorted visualization at the touchscreen display.

Center: Select to set the **Set** value (e.g., the laser diode temperature) to the center value of the actual detail of the touchscreen display (X-axis). The display of **Actual** value will change accordingly.

Zoom Range: Select to set the **Start** and **End** value (e.g., the laser diode temperature) to the outer values of the actual detail of the touchscreen display (X-axis). The display of **Start** and **End** value will change accordingly.

Full Range: Tap to scale the touchscreen display so that the entire wide scan from **Start** value to **End** value is displayed.

Trace Scaling: Tap to select the desired trace scaling.

Notes on the Functionality of the Wide Scan:

The wide scan precisely scans a laser parameter and simultaneously acquires data on two input channels. It enables recording up to 5 million data points per channel in a scan. Depending on the laser type, users can decide to scan one of the following parameters:

- Set wavelength or piezo voltage for DLC CTL
- Laser diode temperature or current for DLC DFB pro
- Piezo voltage or laser diode current for DLC DL pro
- One of the analog outputs Out A or Out B for any of the above

This scan option also works for lasers that are part of a DLC TA pro/-AL or DLC DL-/TA-SHG/FHG pro system, then the available parameters for scanning are according to the seed laser. The scan range is limited by the physical boundaries of the chosen parameter to be scanned. E.g. a wide scan of the CTL wavelength is limited by the minimum and the maximum wavelength of the CTL. A wide scan of the temperature of a DFB pro is limited by the tuning properties of the respective laser diode and/or the working range of the thermistor.

In Wide Scan mode, it is recommended not to change the **Set** value of the parameter to be scanned once the scan has started. For slowly changing parameters, like the laser temperature, please be patient while the laser tunes to the start point of the scan.

In general, the number of data points recorded will be much bigger than the ones displayed on the screen. In order to visualize narrow spectral features, the display actually shows an envelope graph which represents the minimum and maximum values of an interval by a data point each. As the visualization of up to 5 million data points requires quite a bit of computation, the response of the touchscreen can be slower. If the full number of data points is not required, it is recommended to reduce the scan resolution by changing the parameter **Wide Scan > Set Recorder Stepsize** in the context parameter menu, see section 5.3.12.1.

It is possible to zoom into the recorded data while the scan is still in progress. Use the **Full Range** button to return to the full scale display of the scan. A new scan will always start from the set limits, which may differ from the range displayed on the touchscreen, in particular after a zoom.

Once a feature of interest has been found, one may wish to investigate it further, or lock the laser frequency to it. The button **Center** changes the **Set** value of the parameter to be scanned (e.g., the laser diode temperature, CTL wavelength, …) to the center of the currently zoomed window. Once the change has taken effect, it is possible to switch to Scan/Lock mode (see section 5.3), e.g. for investigating narrow features with a reduced/faster scan or to lock the laser.

Alternatively the button **Zoom Range** sets the **Start** and **End** values of the wide scan to the left and right borders of the current zoom. The wide scan can then be repeated more slowly and/or with higher resolution.

Note on Thermal Tuning of a DFB pro Laser:

The Wide Scan mode offers a very high temperature resolution: 1 bit corresponds to 1.4×10^{-6} K. The actual temperature resolution may differ, due to electronic noise and the properties of the TEC in the diode package. The effective temperature resolution is on the order of 50 µK.

The limits of a wide scan are ultimately given by the measurement range of the thermistor inside the laser head, which typically works from 2.2 °C to 51.8 °C.

The useable temperature range of a specific DFB laser depends on the characteristics of the respective diode: When the temperature is tuned, the gain of the semiconductor medium typically shifts about 4 times faster than the grating-defined lasing wavelength. This may cause the diode to jump into a “free-running” (i.e. no longer frequency-stabilized) operation mode at the gain maximum. These operation regimes are excluded by TOPTICA, by restricting the temperature range accordingly.

5.3.12.1 Wide Scan Mode Context Parameter Menu

Additional wide scan and display parameters are set in the context parameter menu which appears on the touchscreen after pressing the **Parameter** button in Wide Scan mode. On the following pages, detailed information about each accessible parameter is provided.

NOTE !	The last line of each parameter description shows the path in the parameter menu. These parameters may also be modified by user-specific software. For a detailed description, please refer to the Remote Command Reference for TCP/IP and USB. This document is available as a pdf file in the Documentations folder on the software USB flash drive supplied with the DLC pro.

Wide Scan Settings

CTL Control (only DLC CTL)

Microsteps
Enable or disable microsteps scan
[1: enabled], [0: disabled]
laser1:ctl:motor:microsteps (boolean)

NOTE !	The motor of the CTL laser head is able to perform so-called microsteps (**μ-steps**, < 1 pm) while scanning. By default, these microsteps are enabled. Above a certain **Scan Speed** (top-right rotary knob), the CTL automatically switches the microsteps off, e.g., when returning to the **Start Wavelength** (bottom-left rotary knob) with a sawtooth **Wide Scan > Scan Shape**. If for some reason the user wants to disable microsteps, they can be disabled.

SMILE
Enable or disable mode control (SMILE)
[1: enabled], [0: disabled]
laser1:ctl:mode-control:loop-enabled (boolean)

Wide Scan

X-Axis Signal (available signals depending on system model)
Select signal channel for X-Axis
["CC Current", 51], ["PC Voltage", 50], ["TC Temp", 57], ["TC Set Temp", 56],
["CTL Wavelength", 79], ["CTL Set Wavelength", 78], ["Out A", 20], ["Out B", 21]
laser1:wide-scan:output-channel (integer)

Scan Offset
Enter scan offset
Scan offset in [mA], [V], [°C], [nm]
laser1:wide-scan:offset (real)

Scan Amplitude
Enter scan amplitude
Scan amplitude in [mA], [V], [K], [nm]
laser1:wide-scan:amplitude (real)

Set Recorder Stepsize
Enter set value for recorder stepsize
Set recorder stepsize in [mA], [V], [K], [nm]
laser1:wide-scan:recorder-stepsize-set (real)

NOTE !	A high **Scan Speed** (top-right rotary knob) together with a small **Set Recorder Stepsize** leads to a higher **Recorder > Sampling Rate**. At a **Sampling Rate** above 100 kHz, dropouts during recording may occur.

Actual Recorder Stepsize
Read actual value for recorder stepsize
Actual recorder stepsize in [mA], [V], [K], [nm]
laser1:wide-scan:recorder-stepsize (real)

NOTE !	**Set Recorder Stepsize** and **Actual Recorder Stepsize** values < 0.00001 are shown as 0.00000 due to the displayed number of decimal digits.

Scan Shape
Select scan shape
["Triangle", 1], ["Sawtooth", 0]
laser1:wide-scan:shape (integer)

Scan Duration
Read scan duration
Scan duration in [s]
laser1:wide-scan:duration (integer)

Trigger Configuration
Wide scan trigger configuration

Input Trigger
Trigger input for scan start

Input Trigger Enable
Enable or disable input trigger
[1: enabled], [0: disabled]
laser1:wide-scan:trigger:input-enabled (boolean)

Trigger Input Channel
Enter trigger input channel
["Digital Input 2"], ["Digital Input 3"]
at Digital I/O connector on MC+ module (please refer to section 10.9.4)
laser1:wide-scan:trigger:input-channel (integer)

Output Trigger
Trigger output at specified **Trigger Threshold**

Output Trigger Enable
Enable or disable output trigger
[1: enabled], [0: disabled]
laser1:wide-scan:trigger:output-enabled (boolean)

Trigger Output Channel
Enter trigger output channel
["Digital Output 1"], ["Digital Output 3"]
at Digital I/O connector on MC+ module (please refer to section 10.9.4)
laser1:wide-scan:trigger:output-channel (integer)

NOTE !	["Digital Output 1"], ["Digital Output 3"] must be configured for wide scan trigger in the parameter menu (please refer to sections 9.2.3 and 5.12): The parameter **io > digital-out1** or **3 > mode** must be set to 2.

Trigger Threshold
Enter output trigger position [mA, V, K, nm]
Trigger output level is high if current value is above threshold.
laser1:wide-scan:trigger:output-threshold (real)

Feed Forward (not DLC CTL)

Feed Forward
Enable or disable Feed Forward
[1: enabled], [0: disabled]
laser1:dl:cc:feedforward-enabled (boolean)

Feed Forward Factor
Enter Feed Forward factor
Feed forward factor in [mA/K], [mA/V]
laser1:dl:cc:feedforward-factor (real)

Recorder

Sample Count
Read the actual number of data points of the recorder
laser1:recorder:sample-count (integer)

Sampling Interval
Read the sampling interval of the recorder
Sampling interval in [ms]
laser1:recorder:sampling-interval (real)

Sampling Rate
Read the sampling rate of the recorder
Sampling interval in [Hz]
laser1:recorder:sampling-rate (real)

NOTE ! **Sample Count**, **Sampling Interval**, and **Sampling Rate** are only displayed properly during a running wide scan.

Low-Pass Filter Configuration
Recorder low-pass filter configuration

Low-Pass Filter Channel 1
Low-pass filter configuration for channel 1

Enable
Enable or disable low-pass filter for channel 1
[1: enabled], [0: disabled]
laser1:recorder:channel1:low-pass-filter:enabled (boolean)

Cut-Off Frequency
Enter cut-off frequency for channel 1
Cut-off frequency in [Hz]
laser1:recorder:channel1:low-pass-filter:cut-off-frequency (real)

Low-Pass Filter Channel 2
Low-pass filter configuration for channel 2

Enable
Enable or disable low-pass filter for channel 2
[1: enabled], [0: disabled]
laser1:recorder:channel2:low-pass-filter:enabled (boolean)

Cut-Off Frequency
Enter cut-off frequency for channel 2
Cut-off frequency in [Hz]
laser1:recorder:channel2:low-pass-filter:cut-off-frequency (real)

Output Filters
The output filters allow to limit the rate of change of the output signal to the value set by **Slew Rate**.

PC (only DLC CTL and DL pro based laser systems)
PC output filter

Enable
Enable or disable PC output filter
[1: enabled], [0: disabled]
laser1:dl:pc:output-filter:slew-rate-enabled (Boolean)

Slew Rate
Enter slew rate (maximum rate of change) for PC output filter in [V/s]
laser1:dl:pc:output-filter:slew-rate (real)

CC
CC output filter

Enable
Enable or disable CC output filter
[1: enabled], [0: disabled]
laser1:dl:cc:output-filter:slew-rate-enabled (boolean)

Slew Rate
Enter slew rate (maximum rate of change) for CC output filter in [mA/s]
laser1:dl:cc:output-filter:slew-rate (real)

Analog Remote Control (ARC)

PC
Analog PC remote control
Please refer to section 10.10.1 for an example on how to configure the PC ARC.

Enable
Enable or disable analog PC remote control
[1: enabled], [0: disabled]
laser1:dl:pc:external-input:enabled (boolean)

Signal Input
Select signal input for PC remote control
["None", -3], ["Fine In 1", 0], ["Fine In 2", 1], ["Fast In 3", 2], ["Fast In 4", 4]
laser1:dl:pc:external-input:signal (integer)

Factor
Enter factor for PC remote control in [V/V]
laser1:dl:pc:external-input:factor (real)

CC
Analog CC remote control
Please refer to section 10.10.1 for an example on how to configure the CC ARC.

Enable
Enable or disable analog CC remote control
[1: enabled], [0: disabled]
laser1:dl:cc:external-input:enabled (boolean)

Signal Input
Select signal input for CC remote control
["None", -3], ["Fine In 1", 0], ["Fine In 2", 1], ["Fast In 3", 2], ["Fast In 4", 4]
laser1:dl:cc:external-input:signal (integer)

Factor
Enter factor for CC remote control in [mA/V]
laser1:dl:cc:external-input:factor (real)

TC (not DLC CTL)
Analog TC remote control
Please refer to section 10.10.1 for an example on how to configure the TC ARC.

Enable
Enable or disable analog TC remote control
[1: enabled], [0: disabled]
laser1:dl:tc:external-input:enabled (boolean)

Signal Input
Select signal input for TC remote control
["None", -3], ["Fine In 1", 0], ["Fine In 2", 1], ["Fast In 3", 2], ["Fast In 4", 4]
laser1:dl:tc:external-input:signal (integer)

Factor
Enter factor for TC remote control in [K/V]
laser1:dl:tc:external-input:factor (real)

Motor (only DLC CTL)
Analog CTL motor remote control
Please refer to section 10.10.2 for an example on how to configure the motor ARC.

Enable
Enable or disable analog motor remote control
[1: enabled], [0: disabled]
laser1:ctl:remote-control:enabled (boolean)

Signal Input
Select signal input for motor remote control
["Fine In 1", 0], ["Fine In 2", 1], ["Fast In 3", 2], ["Fast In 4", 4]
laser1:ctl:remote-control:signal (integer)

Factor
Enter factor for motor remote control in [nm/V]
laser1:ctl:remote-control:factor (real)

Display Settings

Trace Scaling

Left/Red Y Minimum
Enter Ymin for red curve
Reasonable values depend on the selected signal

Left/Red Y Maximum
Enter Ymax for red curve
Reasonable values depend on the selected signal

Right/Blue Y Minimum
Enter Ymin for blue curve
Reasonable values depend on the selected signal

Right/Blue Y Maximum
Enter Ymax for blue curve
Reasonable values depend on the selected signal

Trace Selection

NOTE !	A selected signal is displayed not until after a start of a wide scan.

Left/Red Signal (available signals depending on system model)
Select signal for left/red curve)
["None", -3], ["Fine In 1", 0], ["Fine In 2", 1], ["Fast In 3", 2], ["Fast In 4", 4], ["Out A", 20]
["Out B", 21], ["CC Current", 51], ["CC AIn1", 52], ["CC AIn2", 53]
["TC Set Temp", 56], ["TC Temp", 57], ["PC Voltage", 50], ["SC Output", 101]
["Laser PD", 54], ["External Power", 55], ["PowerLock Input", 102], ["Lock Input", 100]
["Lock-In Output", 30], ["PID 1 Output", 31], ["PID 2 Output", 32]
Only with PDH Module
["PDH In 1", 41], ["PDH Error 1", 40], ["PDH In 2", 43], ["PDH Error 2", 42]
Only DLC TA pro/-AL
["Amp. Current", 63], ["AMP AIn", 60], ["Seed Power", 61], ["Amp. Power", 62]
Only DLC CTL
["CTL Photodiode", 69], ["CTL Set Wavelength", 78], ["CTL Wavelength", 79]
Only DLC DL-/TA-SHG/FHG pro
["SHG PC Voltage", 90], ["Seed Power", 85], ["Amp. Power", 84], ["SHG Power", 83]
["Fiber Power", 86]
Only DLC DL-/TA-FHG pro
["FHG PC Voltage", 120], ["FHG Power", 113]
laser1:recorder:channel1:signal (integer)

Right/Blue Signal (available signals depending on system model)
Select signal for right/blue curve)
["None", -3], ["Fine In 1", 0], ["Fine In 2", 1], ["Fast In 3", 2], ["Fast In 4", 4], ["Out A", 20]
["Out B", 21], ["CC Current", 51], ["CC AIn1", 52], ["CC AIn2", 53]
["TC Set Temp", 56], ["TC Temp", 57], ["PC Voltage", 50], ["SC Output", 101]
["Laser PD", 54], ["External Power", 55], ["PowerLock Input", 102], ["Lock Input", 100]
["Lock-In Output", 30], ["PID 1 Output", 31], ["PID 2 Output", 32]
Only with PDH Module
["PDH In 1", 41], ["PDH Error 1", 40], ["PDH In 2", 43], ["PDH Error 2", 42]
Only DLC TA pro/-AL
["Amp. Current", 63], ["AMP AIn", 60], ["Seed Power", 61], ["Amp. Power", 62]
Only DLC CTL
["CTL Photodiode", 69], ["CTL Set Wavelength", 78], ["CTL Wavelength", 79]
Only DLC DL-/TA-SHG/FHG pro
["SHG PC Voltage", 90], ["Seed Power", 85], ["Amp. Power", 84], ["SHG Power", 83]
["Fiber Power", 86]
Only DLC DL-/TA-FHG pro
["FHG PC Voltage", 120], ["FHG Power", 113]
laser1:recorder:channel2:signal (integer)

5.3.13 Motor Control Mode (only for Laser Heads with Motor pro Option)

The Motor pro option for DL pro laser heads or DL pro Master Oscillators of amplified laser heads allows to quickly tune the laser to a new wavelength within its tuning range by moving the internal grating of the DL pro by a motor drive. Please refer to the DL pro laser head manual and the Motor pro manual for a detailed description.

The motor can tune the wavelength across the tuning range of the integrated laser diode. Please note that the motor drive can move the internal grating of the DL pro into positions, where the laser does not emit light. Please refer to the Production and Quality Control Data Sheet of the connected laser head for its wavelength range. Due to its mechanical nature, the motorized tuning is performed by hopping from one longitudinal mode to the next. It should be used for coarse wavelength selection only. Operation is described in the Motor Control relevant sections of this manual and in the Motor pro manual.

Fine tuning of the laser wavelength is achieved by a piezo actuator. Its frequency resolution is a few kHz, only limited by the resolution of the high-voltage driver electronics (PC module). The fine-tuning range is limited by the stroke of the piezo to a couple of tens of GHz. Operation is described in the Scan function mode relevant sections of this manual.

To access the Motor Control mode relevant operator controls, either press the **Scan/Lock Mode** button several times until display and rotary knob assignment change as shown in Figure 32 or tap the corresponding symbol. The little white arrow in the symbol indicates that there are further options available that can be selected by tapping one of the corresponding symbols which appear after tapping. Select to change the display of the touchscreen as well as the assignment of the rotary knobs as needed for setting the most important motor control parameters.

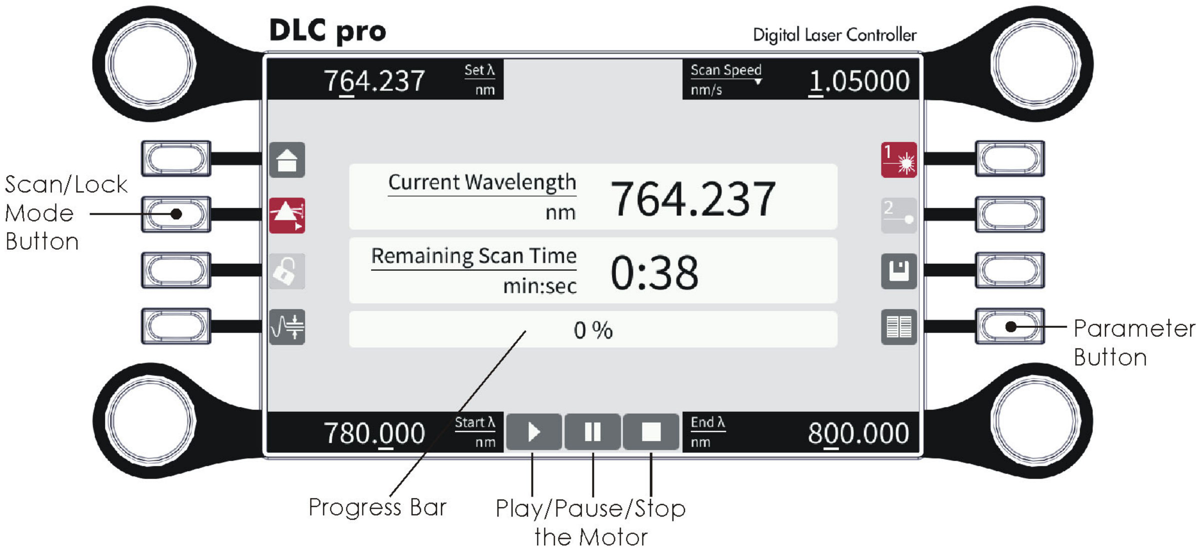


Figure 32 Touchscreen in Motor Control mode (only laser heads with Motor pro option)

Depending on whether you use the touchscreen to display a spectrum/signal or not, you can toggle between displaying the signals, the values of the (piezo) scan parameters or the values of the motor control parameters by pressing the **Scan/Lock Mode** button or by tapping the corresponding symbol (toggle function). Further motor control parameters are set in the context parameter menu (please refer to section 5.3.13.1) which appears on the touchscreen after pressing the **Parameter** button in Motor Control mode.

Rotary Knobs:

NOTE !	All wavelengths in the Motor Control section are internally converted into motor step positions, so the wavelength mainly depends on the stored calibration data. Please refer to section 6.11 (**Menu > Optimization Tools > Motor Calibration Laser 1/2**) and to the Motor pro manual for instructions to perform a wavelength calibration.

- **Top-left:** **Set Wavelength** [nm]. Desired target wavelength.
- **Bottom-left:** **Start Wavelength** [nm] for a motor scan.
- **Top-right:** As selected in the drop-down menu (see section 4.4.2). Available corner parameters depend on the laser system:
  Motor **Scan Speed** [nm/s].
  Laser Diode **Set Current** [mA].
- **Bottom-right:** **End Wavelength** [nm] for a motor scan.

NOTE !	Please note that the motor drive can move the internal grating of the DL pro into positions, where the laser does not emit light. Please refer to the Production and Quality Control Data Sheet of the connected laser head for its wavelength range.

When the **Start** and **End Wavelength** values are set, the motor drive is operated by tapping the symbols **Play**, **Pause**, and **Stop** (see Figure 32). A progress bar and a display in the format [min:s] indicate the remaining time of the motor scan (see Figure 32). After the scan is finished, the laser returns to the **Set Wavelength**.

Play: The **Start Wavelength** is accessed and the motor scan is initiated with the set **Scan Speed**.

CAUTION !	Checking the **Use Tuning Clip** boxes for diode laser and amplifier (depending on the connected laser head) in the Laser Config screen (touchscreen user interface, see section 5.2.5) is **mandatory** before performing a motor scan. Checking the box(es) reduces the laser diode (and amplifier) currents to the Maximum Tuning Currents to avoid damage to the laser diode (and the amplifier) during a motor scan.

Pause: Motor scan is paused. Tap **Play** to continue the motor scan.

Stop: Motor scan is stopped and the **Set Wavelength** is accessed.

5.3.13.1 Motor Control Context Parameter Menu

Motor Scan Settings

Scan Shape
Enter scan shape
["Triangle", 1], ["Sawtooth", 0]
Triangle motor scan shape (default): Return to the **Start Wavelength** is performed with scan speed.
Sawtooth motor scan shape: Return to the **Start Wavelength** is performed as fast as possible.
laser1:dl:motor:scan:shape (integer)

Trigger Threshold
Enter output trigger wavelength [nm]
Trigger output level is high if current wavelength is above, and low if current wavelength is below the threshold wavelength.
The trigger output is available at the Dig I/O D-Sub 15 HD connector at the Motor pro module (Please refer to the Motor pro manual for details).
laser1:dl:motor:scan:threshold-trigger:threshold (real)

5.4 SHG/FHG Cavity Scan/Lock Mode (DLC DL-/TA-SHG/FHG pro)

5.4.1 SHG/FHG Cavity Selection

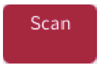
DLC DL-/TA-FHG pro: By pressing the **SHG/FHG Cavity** button (see Figure 33) several times or tapping the symbol aside, you can choose the desired cavity. The front panel controls change accordingly to control the scan and lock.

SHG Cavity: The cavity **index 2** at the front panel controls symbolizes the SHG cavity for the 2 nd harmonic generation.

FHG Cavity: The cavity **index 4** at the front panel controls symbolizes the FHG cavity for the 4 th harmonic generation.

5.4.2 Function Modes

Depending on the selected cavity and function mode, the assignment of the rotary knobs (please refer to section 5.4.6) and the display might change. To select the desired function mode, tap the corresponding symbol at the bottom of the touchscreen (please refer to Figure 33). Please refer to the DL-/TA-SHG/FHG pro manual for details on setting the parameters.



Scan: Parameters for the SHG/FHG cavity scan.

ReLock: Parameters for the SHG/FHG cavity ReLock function.

PID Slow, PID Fast, P Analog: Parameters of the PID controllers.
DLC DL-/TA-FHG pro: Please note that **P Analog** is only available with the SHG cavity selected and the laser must be configured for P Analog adjustment. Please refer to the DL-/TA-SHG/FHG pro manual for details.

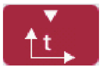
NOTE !	By default, **PID Slow** is active. To select **PID Fast** or **P Analog**, tap **PID Slow** and select the desired controller.

PDH: Parameters of the PDH lock.

5.4.3 Display Modes

The display of the touchscreen changes depending on the selected display mode. To select the display mode, tap the corresponding symbol at the top of the touchscreen.

xy: Signals (Y-direction) are plotted against the cavity scan voltage (X-direction).



t (Time): Signals (Y-direction) are plotted against time (X-direction).

f (Frequency): The fast Fourier transformation of the time-dependent signal (Y-direction) is plotted against the frequency (X-direction).

Trace Scaling: Tap to select the desired trace scaling.

Up to two traces (**Left/Red Signal** and **Right/Blue Signal**, axis labelling in the corresponding color) may be displayed on the touchscreen. The input channels of the two signals can be selected in the context parameter menu which appears on the touchscreen after pressing the **Parameter** button in SHG/FHG Cavity Scan/Lock mode (please refer to Figure 33).

Depending on the setting (**Input/Auxiliary trace scaling**), the graphs are autoscaled in the Y-direction to the full display size or they can be free-scaled by gestures (pinch and spread) on the touchscreen. The graph can also be fixed to its current size.

The zero levels in X- and Y-directions are displayed as dashed lines. On each axis, the distance to the zero level is indicated by the offset value and the direction to the zero level is indicated by a small triangle. The other value at the axis indicates the scaling per division.

5.4.4 SHG/FHG Cavity Scan Function Mode

By changing the round-trip length of the SHG/FHG cavity periodically, the user can gain important information about the intra-cavity mode, such as cavity finesse, the incoupling efficiency, or the shape of the Error signal. This length change is called a SHG/FHG cavity scan and is performed by applying a triangle voltage to the slow piezo element that is located on one of the cavity mirrors (please refer to the DL-/TA-SHG/FHG pro manual for details on SHG/FHG cavity scanning).

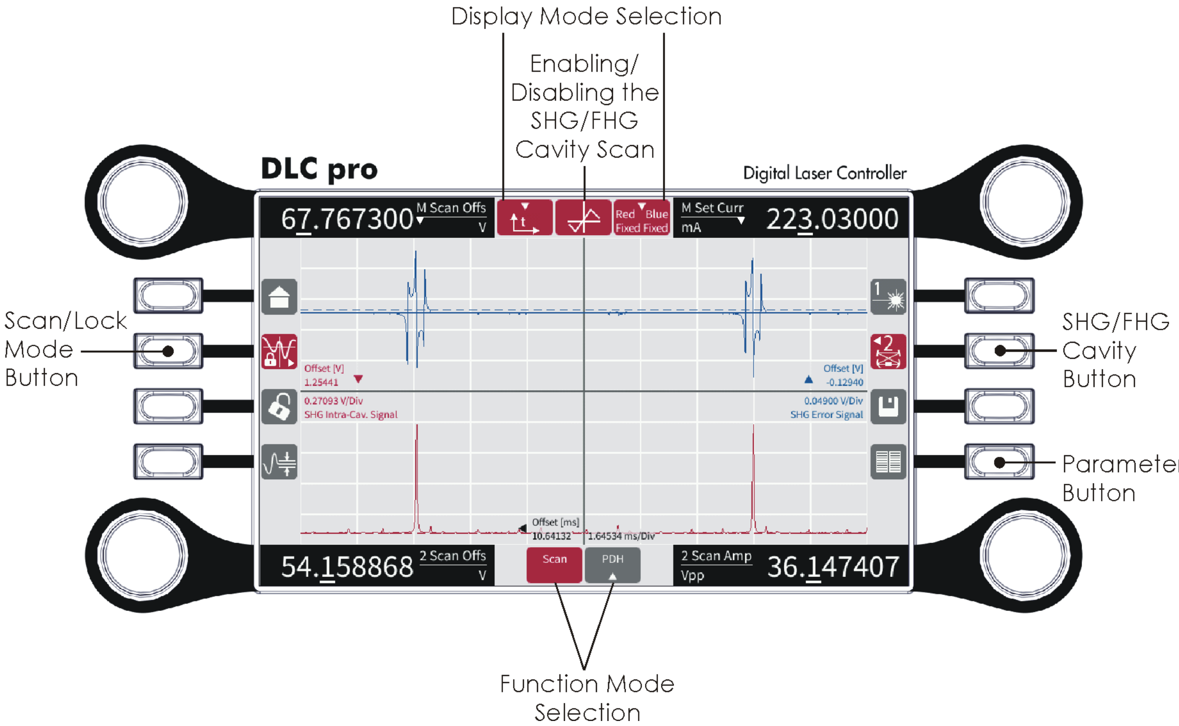


Figure 33 Touchscreen in SHG Cavity Scan function mode (example DLC DL-/TA-FHG pro)

To access the SHG/FHG Cavity Scan function mode relevant operator controls, either press the **SHG/FHG Cavity** button to choose the SHG- or FHG cavity, the **Scan/Lock Mode** button, and select the Scan function mode until display and rotary knob assignment change as shown in Figure 33 or tap the corresponding symbols. Further SHG/FHG cavity scan and lock parameters are set in the context parameter menu (please refer to section 5.4.7) which appears on the touchscreen after pressing the **Parameter** button in SHG/FHG Cavity Scan/Lock mode.

NOTE !	SHG/FHG cavity scanning continues as long as the scan is enabled even if you leave the SHG/FHG Cavity Scan function mode. Enabling/disabling the SHG/FHG cavity scan is done by tapping the symbol at the top of the touchscreen (gray: scan disabled, red: scan enabled) or in the TOPAS DLC pro PC-GUI.

On the touchscreen, the SHG/FHG cavity scan-dependent signal is displayed in the Y-direction. The parameters **2/4 Scan Offset** and **2/4 Scan Amplitude** are displayed in the bottom-left and bottom-right corners of the display and can be changed by the corresponding rotary knobs. Changes done at the knobs are reflected by the graphical display and changes made with touch gestures on the display are reflected in the numbers in the corners. For example, dragging the display graph right/left in xy display mode changes the SHG/FHG cavity scan offset while pinching the graph in X-direction increases the SHG/FHG cavity scan amplitude.

5.4.5 SHG/FHG Cavity Lock Function Modes

The fundamental beam of the Master Oscillator is only coupled into the SHG cavity efficiently if the round-trip length of the cavity is locked to a multiple of the fundamental wavelength. The same holds for the coupling of the SHG beam into the FHG cavity. TOPTICA uses the Pound-Drever-Hall (PDH) technique to perform this length stabilization of the cavity round trip.

In order to imprint sidebands onto the laser carrier frequency, either the laser diode current is modulated directly or the fundamental beam passes an electro-optical modulator. For details on SHG/FHG cavity locking, please refer to the DL-/TA-SHG/FHG pro manual.

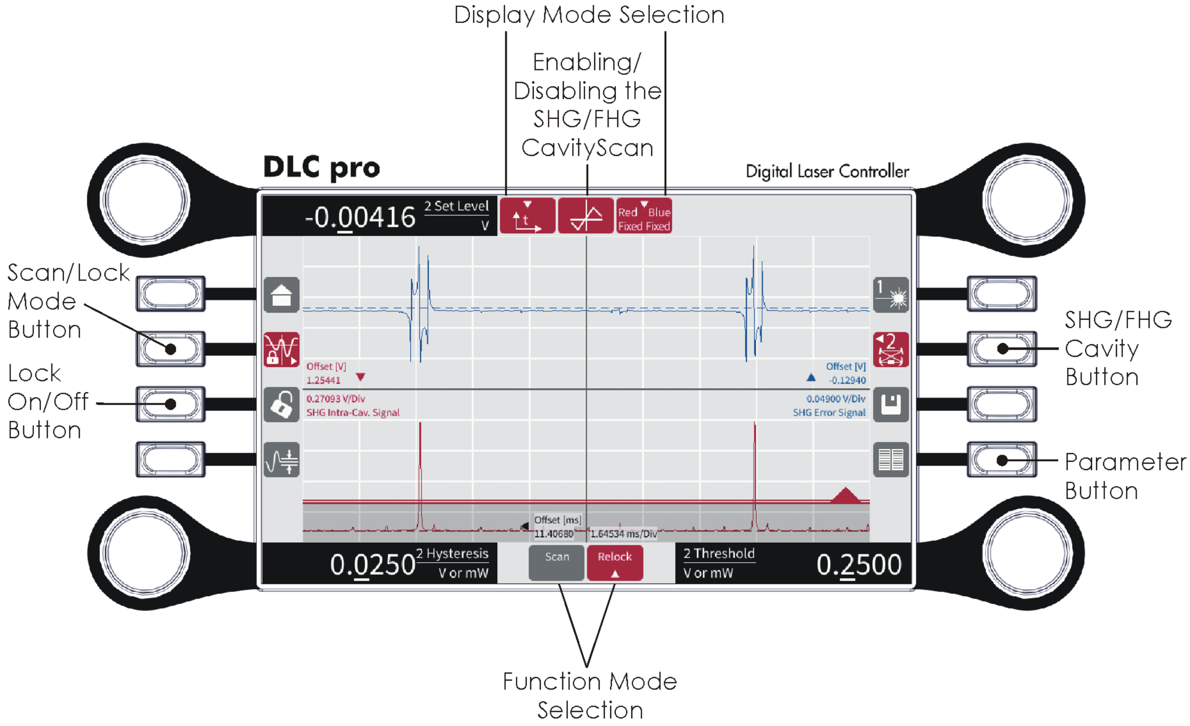


Figure 34 Touchscreen in SHG Cavity ReLock function mode (example DLC DL-/TA-FHG pro)

Enter the desired function mode for SHG/FHG Cavity locking (please refer to section 5.4.2) by first pressing the **SHG/FHG Cavity** button to choose the SHG- or FHG cavity, then the **Scan/Lock Mode** button (or by tapping the corresponding symbols), and select the desired function mode field at the bottom of the touchscreen. The display and rotary knob assignment change as shown in Figure 34. Further SHG/FHG cavity scan and lock parameters are set in the context parameter menu (please refer to section 5.4.7) which appears on the touchscreen after pressing the **Parameter** button in SHG/FHG Cavity Lock mode.

Press the **Lock On/Off** button to enable/disable the SHG/FHG cavity lock.

NOTE !	When the SHG/FHG cavity lock is disabled, scanning is resumed automatically.

5.4.6 SHG/FHG Cavity Scan/Lock Mode Rotary Knob Assignments

The functions assigned to the rotary knobs depend on the selected cavity and function mode. The cavity **index 2** at the front panel controls symbolizes the SHG cavity for the 2 nd harmonic generation. The cavity **index 4** at the front panel controls symbolizes the FHG cavity for the 4 th harmonic generation.

5.4.6.1 Scan Rotary Knobs

Parameter settings for the SHG/FHG Cavity Scan function mode.

- **Top-left:** As selected in the drop-down menu (see section 4.4.2). Available corner parameters depend on the laser system:
  M Scan Offs [V]: Scan offset for the Master Oscillator scan.
  Amp Curr [mA]: Tapered Amplifier set current.
  2/4 Set Temp [°C]: SHG/FHG crystal set temperature.
- **Bottom-left:** **2/4 Scan Offs** [V]: SHG/FHG cavity scan offset.
- **Top-right:** As selected in the drop-down menu (see section 4.4.2). Available corner parameters depend on the laser system:
  M Set Curr [mA]: Master Oscillator set current,
  2/4 Act Temp [°C]: Display of the SHG/FHG crystal temperature.
  2/4 Cav. FF Factor [V/V]: SHG/FHG cavity Feed Forward factor
- **Bottom-right:** **2/4 Scan Amp** [V_{pp}]: Scan Amplitude for the SHG/FHG cavity scan.

5.4.6.2 ReLock Rotary Knobs

Parameter settings for the SHG/FHG Cavity ReLock function mode.

- **Top-left:** **2/4 Set Level** [V]: Reference voltage for the SHG/FHG cavity lock Error signal.
- **Bottom-left:** **2/4 Hysteresis** [V or mW]: Tolerance between the out-of-lock voltage/power level (**2/4 Threshold**) and the voltage/power level which determines that the laser is in lock again (please refer to the DL-/TA-SHG/FHG pro manual for ReLock configuration).
- **Top-right:** No function.
- **Bottom-right:** **2/4 Threshold** [V or mW]: Lower voltage/power limit of the SHG/FHG cavity ReLock window.

5.4.6.3 PID Slow/PID Fast Rotary Knobs

Parameter settings for the Proportional-Integral-Differential (PID) controllers **PID Slow** and **PID Fast**.

NOTE !	By default, **PID Slow** is active. To select **PID Fast**, tap **PID Slow** and select **PID Fast.**

- **Top-left:** **2/4 Slow/2/4 Fast P** [V/V]: Proportional gain of the selected PID controller.
- **Bottom-left:** **2/4 Slow/2/4 Fast Gain**: Overall gain factor of the selected PID controller.
- **Top-right:** **2/4 Slow/2/4 Fast I** [V/V/ms]: Integral gain of the selected PID controller.
- **Bottom-right:** **2/4 Slow/2/4 Fast D** [V/V x µs]: Differential gain of the selected PID controller.

5.4.6.4 P Analog Rotary Knobs (only DLC DL-/TA-SHG pro)

Parameter settings for the Proportional controller **P Analog**.

NOTE !	By default, **PID Slow** is active. To select **P Analog**, tap **PID Slow** and select **P Analog.** Please note that the laser must be configured for P Analog adjustment. Please refer to the DL-/TA-SHG/FHG pro manual for details.

- **Top-left:** **2 Analog P** [V/V]: Proportional gain of the P Analog controller.

5.4.6.5 PDH Rotary Knobs

Parameter settings for the PDH lock.

- **Top-left:** **2/4 Set Level** [V]: Reference voltage for the SHG/FHG cavity lock Error signal.
- **Bottom-left:** **2/4 LO Phase** [°]: Phase shift of the local oscillator used for demodulation with respect to the applied modulation.
- **Top-right:** no function.
- **Bottom-right:** **2/4 PDH Gain** [V/V]**:** Gain for adjusting the peak-to-peak amplitude of the SHG/FHG Error signal.

5.4.7 SHG/FHG Cavity Scan/Lock Mode Context Parameter Menu

Additional SHG/FHG cavity scan/lock and display parameters are set in the context parameter menu which appears on the touchscreen after pressing the **Parameter** button in SHG/FHG Cavity Scan/Lock mode. On the following pages, detailed information about each accessible parameter is provided.

NOTE !	The last line of each parameter description shows the path in the parameter menu. These parameters may also be modified by user-specific software. For a detailed description, please refer to the Remote Command Reference for TCP/IP and USB. This document is available as a pdf file in the Documentations folder on the software USB flash drive supplied with the DLC pro.

NOTE !	**DLC DL-/TA-FHG pro:** The FHG Cavity Scan/Lock Mode context parameter menu is equivalent for control of the FHG Stage. Please note that P Analog is not available.

SHG Cavity Scan

Enable SHG Cavity Scan
Enable or disable SHG cavity scan
[1: enabled], [0: disabled]
laser1:nlo:shg:scan:enabled (boolean)

SHG Cavity Scan Frequency
Enter SHG cavity scan frequency
Scan frequency in [Hz]
laser1:nlo:shg:scan:frequency (real)

SHG Cavity Scan Amplitude
Enter SHG cavity scan amplitude
Scan amplitude in [V]
laser1:nlo:shg:scan:amplitude (real)

SHG Cavity Scan Offset
Enter SHG cavity scan offset
Scan offset in [V]
laser1:nlo:shg:scan:offset (real)

Feed Forward for SHG Cavity

SHG Cavity Feed Forward
Enable or disable SHG cavity Feed Forward
[1: enabled], [0: disabled]
laser1:nlo:shg:pc:feedforward-enabled (boolean)

SHG Cavity Feed Forward Factor
Enter SHG cavity Feed Forward factor
SHG cavity Feed Forward factor in [V/V]
laser1:nlo:shg:pc:feedforward-factor (real)

SHG Lock Settings

PID Selection
Select PIDs used for SHG cavity locking
["None", 0], ["PID Slow", 1], ["PID Slow + P Analog", 3], ["PID Slow + Fast", 2]
["PID Slow + Fast + P Analog", 4]
laser1:nlo:shg:lock:pid-selection (integer)

SHG PID Fast

Use I Cut-off
Turn I cut-off on or off
[1: on], [0: off]
laser1:nlo:shg:lock:pid1:gain:i-cutoff-enabled (boolean)

I Cut-off Frequency
Enter I cut-off frequency. Frequency below which the integral gain of the PID Fast controller is limited.
Frequency in [Hz]
laser1:nlo:shg:lock:pid1:gain:i-cutoff (real)

Cavity PDH

Enable Cavity Local Oscillator
Enable or disable cavity local oscillator
[1: enabled], [0: disabled]
laser1:nlo:shg:lock:local-oscillator:enabled (boolean)

Cavity Local Oscillator Amplitude
Select local oscillator amplitude in [V_{pp}]
[„0.65“, 0], [„0.58“, 2], [„0.52“, 4], [„0.46“, 6],[„0.39“, 9], [„0.33“, 12], [„0.26“, 16], [„0.19“, 21]
[„0.13“, 28], [„0.065“, 40], [„0.017“, 64]
laser1:nlo:shg:local-oscillator:attenuation-raw (integer)

Enable External Local Oscillator
Enable or disable external local oscillator
[1: enabled], [0: disabled]
laser1:nlo:shg:lock:local-oscillator:use-external-oscillator (boolean)

Cav. Lock Detection and ReLock

Input Channel
Select input channel for out-of-lock detection
[„Intra-Cavity Signal“,1], [„SHG Power“, 4]
laser1:nlo:shg:lock:window:input-channel (integer)

Enable ReLock
ReLock upon out-of-lock state
[1: enabled], [0: disabled]
laser1:nlo:shg:lock:relock:enabled (boolean)

ReLock Frequency
Enter frequency for ReLock scan
Frequency in [Hz]
laser1:nlo:shg:lock:relock:frequency (real)

ReLock Amplitude
Enter amplitude for ReLock scan
Amplitude in [Vpp]
laser1:nlo:shg:lock:relock:amplitude (real)

Delay
Delay to action after out-of-lock state is detected
Enter the delay between out-of-lock detection and the start of a reset/relock.
Delay in [s]
laser1:nlo:shg:lock:relock:delay (real)

Enable SHG Crystal Temperature
Enable or disable SHG crystal temperature stabilization
[1: enabled], [0: disabled, T_{set} = 25 °C]
laser1:nlo:shg:tc:enabled (boolean)

Display Settings

Trace Scaling

Left/Red Y Minimum
Enter Ymin for red curve
Reasonable values depend on the selected signal.

Left/Red Y Maximum
Enter Ymax for red curve
Reasonable values depend on the selected signal.

Right/Blue Y Minimum
Enter Ymin for of blue curve
Reasonable values depend on the selected signal.

Right/Blue Y Maximum
Enter Ymax for of blue curve
Reasonable values depend on the selected signal.

Trace Selection

Left/Red Signal (available signals depending on system model)
Select signal for red curve
["None", -3], ["SHG PC Voltage", 90], ["SHG PID Fast Output", 91]
["Seed Power", 85], ["Amp. Power", 84], ["SHG Power", 83]
["Fiber Power", 86], ["SHG Intra-Cav. Signal", 82]
["SHG Error Signal", 80], ["SHG Cav. Rej. Signal", 81]
Only DLC DL-/TA-FHG pro: ["FHG PC Voltage", 120], ["FHG Power", 113]
laser1:nlo:shg:scope:channel1:signal (integer)

Right/Blue Signal (available signals depending on system model)
Select signal for blue curve
Select signal for red curve
["None", -3], ["SHG PC Voltage", 90], ["SHG PID Fast Output", 91]
["Seed Power", 85], ["Amp. Power", 84], ["SHG Power", 83]
["Fiber Power", 86], ["SHG Intra-Cav. Signal", 82]
["SHG Error Signal", 80], ["SHG Cav. Rej. Signal", 81]
Only DLC DL-/TA-FHG pro: ["FHG PC Voltage", 120], ["FHG Power", 113]
laser1:nlo:shg:scope:channel2:signal (integer)

Display Refresh Rate
Select display refresh rate
Frequency in [Hz]
["1 Hz", 1], ["2 Hz", 2], ["3 Hz", 3], ["4 Hz", 4], ["5 Hz", 5], ["10 Hz", 10]
laser1:nlo:shg:scope:update-rate (integer)

Display Mode
Select display mode
[“X/Y”, 0], ["Time", 1], ["Frequency", 2]
laser1:nlo:shg:scope:variant (integer)

Time

Time Base
Select time base
Time in [ms]
[“10 µs”, 0.01], [“20 µs”, 0.02], [“50 µs”, 0.05], [“100 µs”, 0.1], [“200 µs”, 0.2]
[“500 µs”, 0.5], [“1 ms”, 1], [“2 ms”, 2], [“5 ms”, 5], [“10 ms”, 10], [“20 ms”, 20]
[“50 ms”, 50], [“100 ms”, 100], [“200 ms”, 200], [“500 ms”, 500], [“1 s”, 1000]
Laser1:nlo:shg:scope:channelx:scope-timescale (real)

Frequency

Frequency Base
Select frequency base
Frequency in [kHz]
[“500 Hz”, 0.5], [“1 kHz”, 1], [“2.5 kHz”, 2.5], [“5 kHz”, 5], [“10 kHz”, 10]
[“25 kHz”, 25], [“50 kHz”, 50], [“100 kHz”, 100], [“250 kHz”, 250]
[“500 kHz”, 500], [“1 MHz”, 1000], [“2.5 MHz”, 2500], [“5 MHz”, 5000]
laser1:nlo:shg:scope:channelx:scope-spectrum-range (real)

5.5 Wavelength Control Mode (DLC TOPO)

The wavelength of a TOPO laser head can be tuned by varying the diode temperature of the DFB pro BFY pump laser or the intracavity crystal position (Motor Position), the intracavity etalon angle (Etalon Servo Position), or the intracavity piezo (PZT) voltage (OPO Slow PZT Voltage). Tuning the crystal position is best for coarse tuning over wide wavelength ranges whereas etalon angle tuning is preferred for moderate wavelength jumps (30 GHz). For fine wavelength accuracy, pump laser thermal tuning has the advantage of large mode-hop-free scans (up to 500 GHz for the idler output of the TOPO laser head). Piezo voltage tuning is best for applications requiring fast scanning over very small ranges (50 MHz), such as line locking. Detailed information on wavelength selection and operation is provided in the dedicated TOPO laser head manual.

To access the Wavelength Control mode relevant operator controls, either press the **Scan/Lock Mode** button several times until display and rotary knob assignment change as shown in Figure 35 or tap the corresponding symbol. The little white arrow in the symbol indicates that there are further options available that can be selected by tapping one of the corresponding symbols that appear after tapping. Select to change the display of the touchscreen as well as the assignment of the rotary knobs as needed for setting the most important wavelength control parameters.

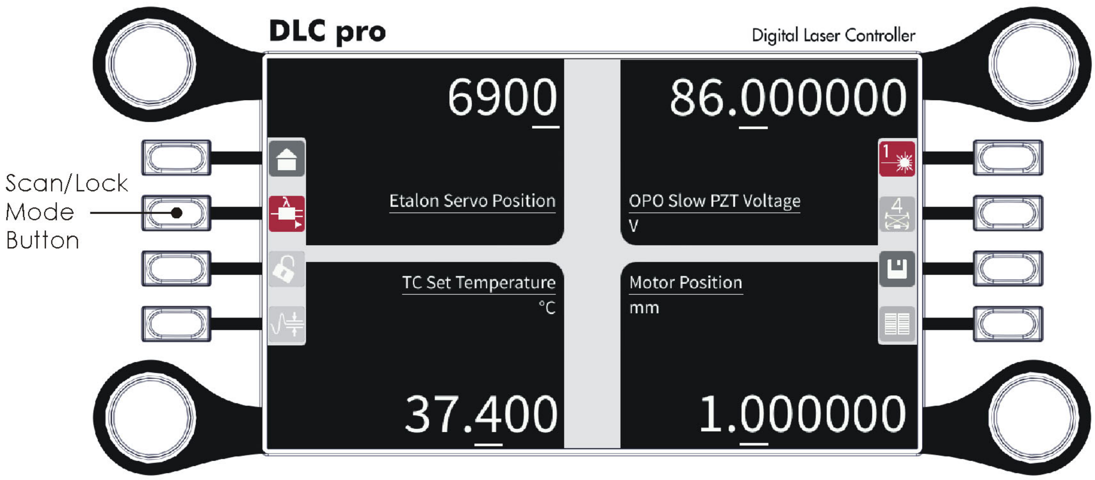


Figure 35 Wavelength Control mode (DLC TOPO)

Rotary Knobs:

- **Top-left:** **Etalon Servo Position** [servo steps]: The etalon motor moves in 10-step increments, with each increment giving 20 arc-minutes of resolution (range: 4000 - 8000).
- **Bottom-left:** **TC Set Temperature** [° C]: DFB pro BFY pump laser temperature.
- **Top-right:** **OPO Slow PZT Voltage** [V]: Intracavity piezo (PZT) voltage in the range of 0 - 140 V.
- **Bottom-right:** **Motor Position** [mm]: Intracavity crystal position with a resolution of 40 nm over a 0 - 17.5 mm range.

NOTE !	Adjustments smaller than 100 nm do not cause any noticeable changes in wavelength or power of the DLC TOPO laser system.

NOTE !	The external fiber amplifier of the DLC TOPO laser system requires 2 - 5 mW of input power. To make sure that the DFB pro BFY pump laser output is inside this range, the **Set Current** (see section 5.3.7.1) of the DFB pro BFY pump laser should never be changed from the factory setting (see *DFB CC Set Current* in section 02 of the DLC TOPO Production and Quality Control Data Sheet). Consequently, please use CC Analog Remote Control of the DFB pro BFY current only for locking purposes, and do not use the Feed Forward feature, as this also affects the laser diode current.

TOPTICA PHOTONICS

Status: 29.3.22

5.6 Lock On/Off

NOTE !	**DLC DL-/TA-SHG/FHG pro**: The **Lock On/Off** button controls the lock of the component which is selected by the **Laser 1** or **SHG/FHG Cavity** button. **Laser 1** selected and highlighted: Master Oscillator lock is controlled. **SHG/FHG Cavity** selected and highlighted: SHG/FHG cavity lock is controlled.

To lock the laser frequency to the wavelength of interest, either a lockpoint candidate must be selected on the signal (see section 5.3.5), or **Lock Settings > Lock Without Lockpoint** must be enabled in the context parameter menu. For examples on locking, please refer to section 5.3.9 and section 5.3.10.

Lock the selected laser (**Laser 1**/**Laser 2** buttons, see section 5.8 and 5.9) by tapping the lockpoint candidate (if present) and then pressing the **Lock On/Off** button or tapping the corresponding symbol. The laser is unlocked by pressing the **Lock On/Off** button or by tapping the corresponding symbol, again. The Lock On/Off symbol changes corresponding to the locked (red)/unlocked (gray) status.

The SHG/FHG cavity lock does not use the lockpoint concept but locks the SHG/FHG PC voltage to a cavity resonance close to the center of the SHG/FHG PC voltage range.

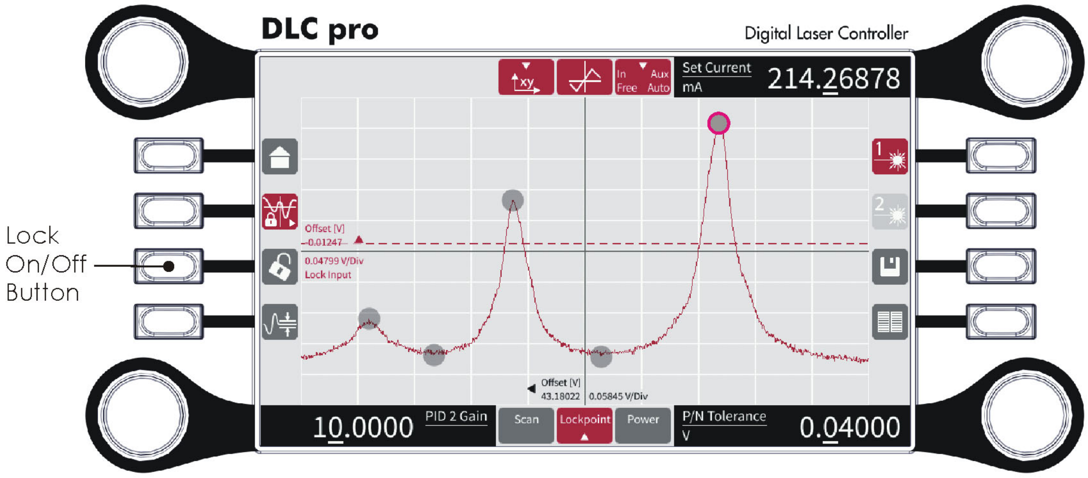


Figure 36 Touchscreen in Scan/Lock mode, laser unlocked (example)

5.6.1 Lock On/Off at a DLC pro for Dual-Laser-Operation

At a DLC pro for Dual-Laser-Operation with Lock option installed, the Lock On/Off symbol is split.

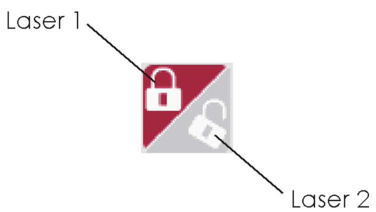


Figure 37 Lock On/Off button with
Dual-Laser-Operation and Lock option installed

Lock the selected laser (**Laser 1**/**Laser 2** buttons, see section 5.8 and 5.9) by tapping the lockpoint candidate (if present) and then pressing the **Lock On/Off** button or tapping the corresponding symbol. The laser is unlocked by pressing the **Lock On/Off** button or by tapping the corresponding symbol, again. The area of the Lock On/Off symbol corresponding to the laser changes according to the locked (red)/unlocked (gray) status.

Status: 29.3.22

5.7 Stabilization On/Off

NOTE !	Please refer to sections 5.2.9 and 5.3.6 for detailed information on the power stabilization.

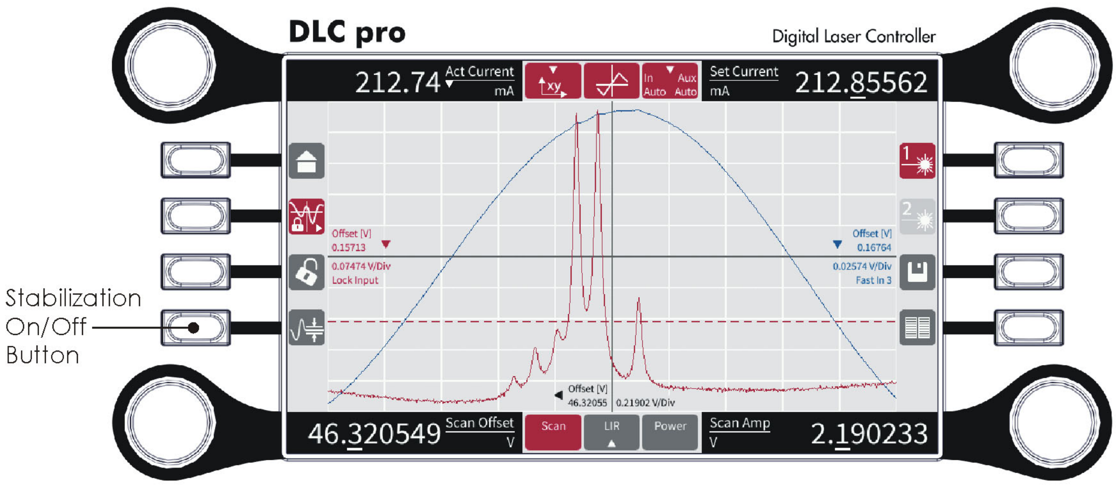


Figure 38 Stabilization On/Off button

Lock the power of the selected laser (**Laser 1**/**Laser 2** buttons, see section 5.8 and 5.9) by pressing the Power **Stabilization On/Off** button or tapping the corresponding symbol (PowerLock). The Power Stabilization On/Off symbol changes its color corresponding to the locked (red)/unlocked (gray) status. Unlock the laser power by pressing the Power **Stabilization On/Off** button or by tapping the corresponding symbol, again.

5.7.1 Stabilization On/Off at a DLC pro for Dual-Laser-Operation

At a DLC pro for Dual-Laser-Operation, the Stabilization On/Off symbol is split.

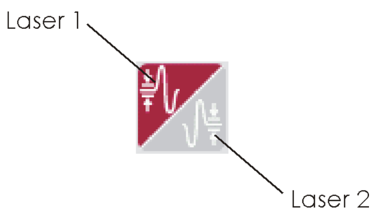


Figure 39 Stabilization On/Off symbol at a DLC pro for Dual-Laser-Operation

Lock the power of the selected laser (**Laser 1**/**Laser 2** push buttons, see section 5.8 and 5.9) by pressing the Power **Stabilization On/Off** button or tapping the corresponding symbol (PowerLock). The area of the Power Stabilization On/Off symbol corresponding to the laser changes according to the locked (red)/ unlocked (gray) status. Unlock the laser power by pressing the Power **Stabilization On/Off** button or by tapping the corresponding symbol, again.

5.8 Laser 1

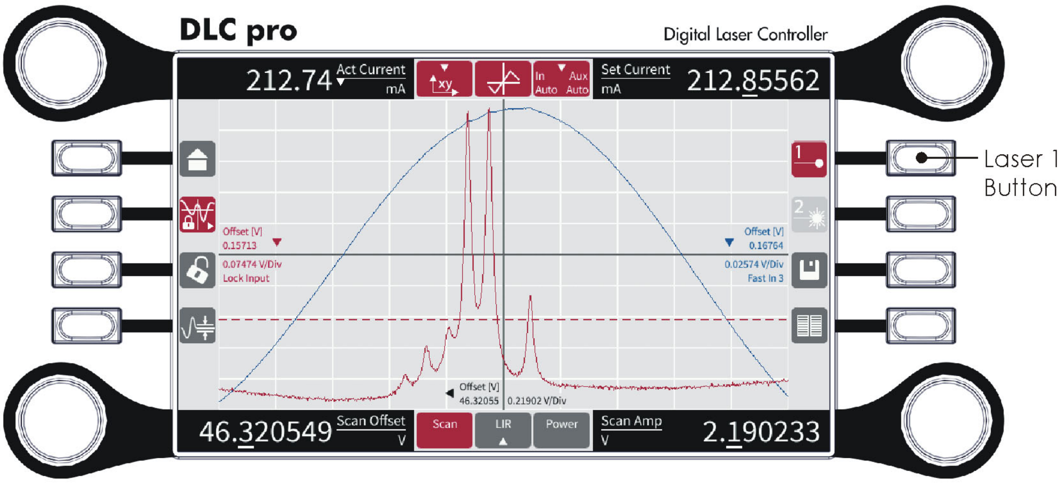


Figure 40 Touchscreen in Scan/Lock mode, Laser 1 selected (example)

After pressing the **Laser 1** button or tapping the symbol aside, you can control the laser which is connected to the DLC pro as laser 1. The Laser 1 symbol turns red and the front panel controls change accordingly.

To enable laser 1 for laser emission, press the **Laser 1** button or tap the symbol aside until the symbol changes as shown in Figure 41 (right). Now laser emission can be switched on/off by pressing the **Emission** push button.

DANGER !	**Laser emission is immediately switched on** when the laser is enabled by the **Laser 1** button and the **Emission** push button has been toggled to on before. Toggling the **Laser 1** button to enabled **switches on all laser 1 CC modules**.

Laser 1
Selected

Laser 1
Enabled

Figure 41 Laser 1 selected (left) and enabled for laser emission (right)

Laser 1
Not Selected
and not Enabled

Laser 1
Not Selected but Enabled

Figure 42 Laser 1 not selected and not enabled (left)
Laser 1 not selected **but enabled for laser emission** (right)

5.9 Laser 2 at a DLC pro for Dual-Laser-Operation

NOTE !	To use the DLC pro for control of two lasers (Dual-Laser-Operation), an Upgrade for Control of a 2nd laser is required. When the Dual-Laser-Operation upgrade is acquired, TOPTICA provides a license key via e-mail or USB flash drive and additional hardware, such as modules and cables. For installation of the modules, please refer to sections 10.4 and 10.5. The license key must be activated via the TOPAS DLC pro PC-GUI (please refer to section 10.19). If purchased along with the DLC pro, the licence and the hardware will already be installed.

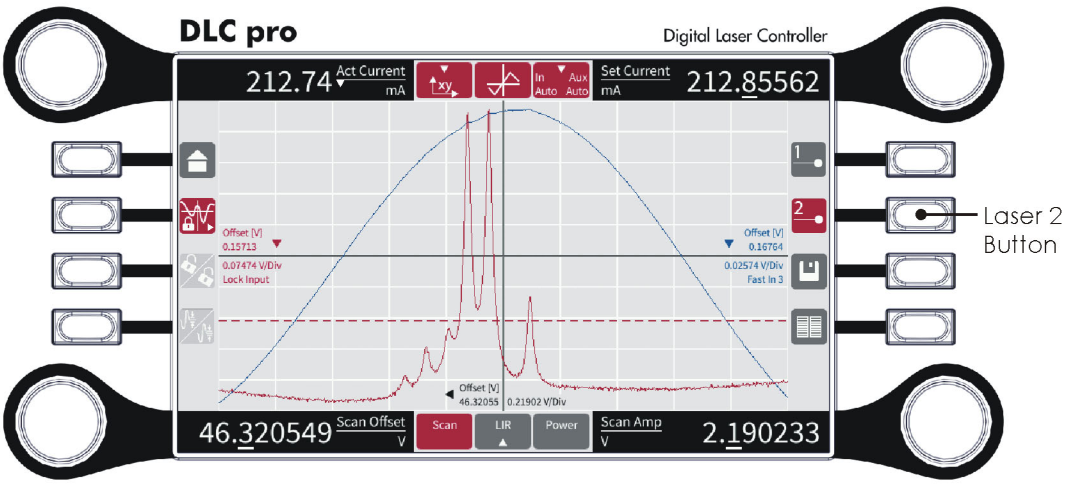


Figure 43 Touchscreen in Scan/Lock mode, Laser 2 selected (example)

After pressing the **Laser 2** button or tapping the symbol aside, you can control the laser which is connected to the DLC pro as laser 2. The Laser 2 symbol turns red and the front panel controls change accordingly. Only laser 1 or laser 2 can be selected at a time.

Status: 29.3.22

To enable laser 2 for laser emission, press the **Laser 2** button or tap the symbol aside until the symbol changes as shown in Figure 44 (right). Now laser emission can be switched on/off by pressing the **Emission** push button.

DANGER !	**Laser emission is immediately switched on** when the laser is enabled by the **Laser 2** button and the **Emission** push button has been toggled to on before. Toggling the **Laser 2** button to enabled **switches on all laser 2 CC modules**.

Laser 2
Selected

Laser 2
Enabled

Figure 44 Laser 2 selected (left) and enabled for laser emission (right)

Laser 2
Not Selected

Laser 2
Not Selected but Enabled

Laser 2 Not Connected
or No Upgrade
for Control of a 2nd Laser

Figure 45 Laser 2 not selected and not enabled (left)
Laser 2 not selected **but enabled for laser emission** (middle)
Symbol light gray: Laser 2 not connected or no Upgrade for Control of a 2nd Laser (right)

5.10 SHG/FHG Cavity

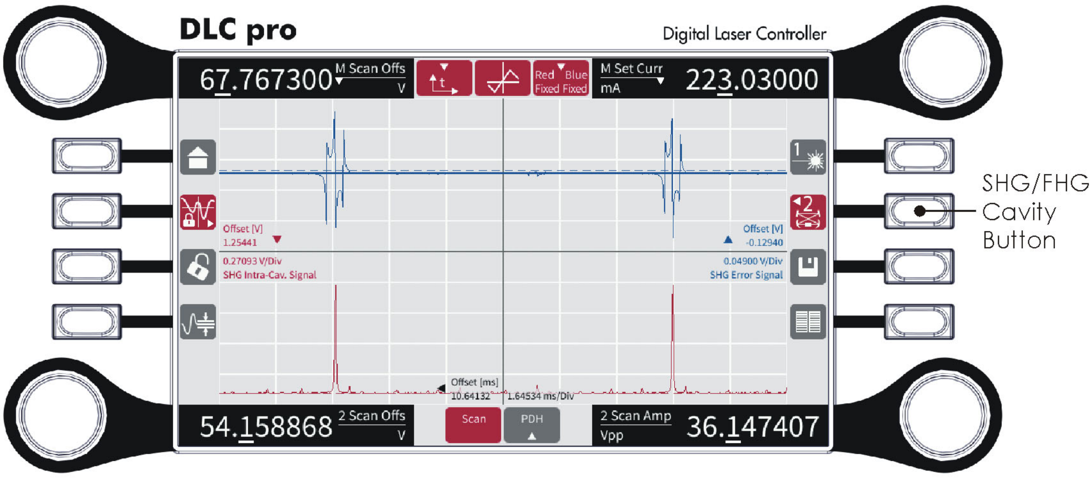


Figure 46 Touchscreen in SHG Cavity Scan/Lock mode, SHG Cavity selected (example DLC DL-/TA-FHG pro)

DLC DL-/TA-FHG pro: By pressing the SHG/FHG Cavity button several times or tapping the symbol aside, you can choose the desired cavity. The front panel controls change accordingly to control the scan and lock.

SHG Cavity	The cavity **index 2** at the front panel controls symbolizes the SHG cavity for the 2 nd harmonic generation.
FHG Cavity	The cavity **index 4** at the front panel controls symbolizes the FHG cavity for the 4 th harmonic generation.

5.11 Load/Save

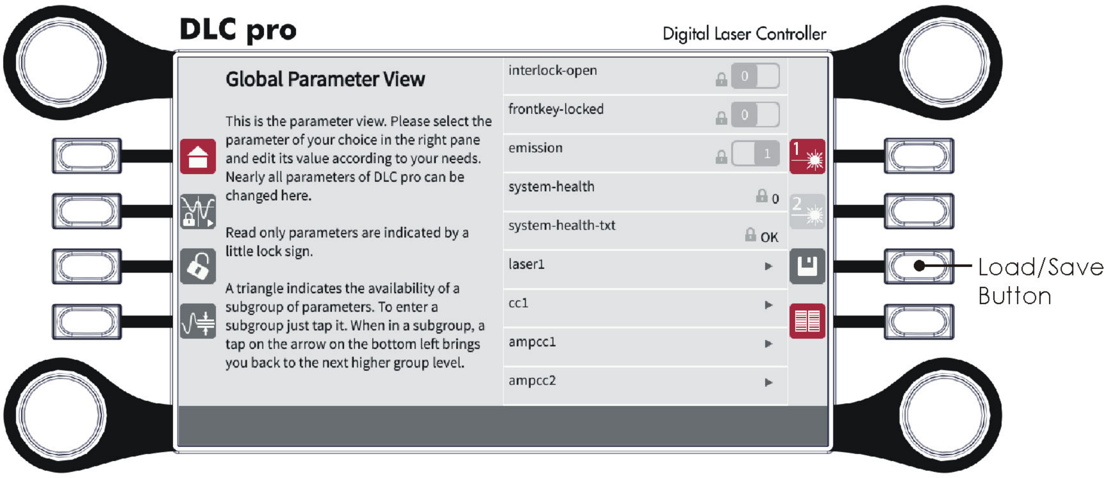


Figure 47 Load/Save button

Pressing the **Load/Save** button or tapping the corresponding symbol allows to perform different tasks:

- Press the **Load/Save** button once or tap the corresponding symbol once to open the Configuration Manager (please refer to section 5.11.1).
- Press the **Load/Save** button twice or tap the corresponding symbol twice to quickly store the most important settings of the parameter menu (please refer to section 5.12) to the flash memory of the DLC pro. Storing the settings is possible on any screen. Tap Back on the Configuration Manager screen (see Figure 48) to return to the previous screen.
  The stored parameters are immediately active and also loaded upon the next restart of the DLC pro.

NOTE !	The function of pressing the **Load/Save** button twice is equal to **Menu > Save Configuration** in the TOPAS DLC pro PC-GUI and to the command **laser1/2:save**.

- Press the **Load/Save** button on the DLC pro front panel for 5 - 8 seconds to take a screenshot of the touchscreen. Please refer to section 10.12 for details.

5.11.1 Configuration Manager

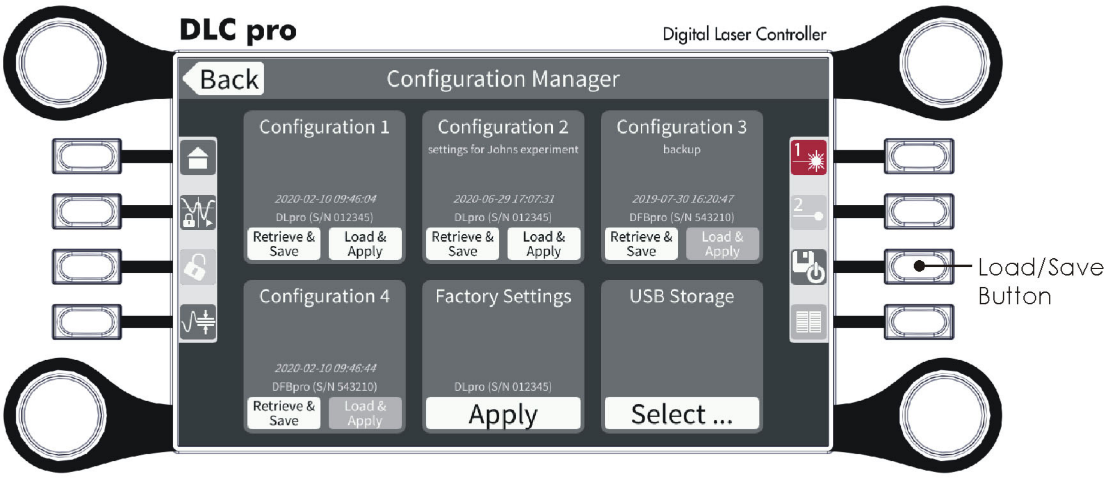


Figure 48 Configuration Manager

Press the **Load/Save** button or touch the symbol aside to access the Configuration Manager. Select the desired laser head by pressing the **Laser 1**/**Laser 2** button. The Configuration Manger allows to save and load several device parameter configurations, which include laser head operation parameters as well as not laser head specific settings of the DLC pro, e.g., display settings. A configuration file contains the laser head type and its serial number and can only be loaded if this data matches the selected laser head.

DANGER !	Always switch off the laser emission of the connected laser heads when handling configurations !

NOTE !	Press the **Load/Save** button to have the last loaded/saved device parameter configuration resumed at the DLC pro boot procedure.

NOTE !	Servo positions used for the AutoAlign option (motorized mirrors) of the laser head are not stored in the configuration file.

The Configuration Manager screen shows six sections:

- Four device parameter configurations which are stored on the DLC pro (Configuration 1 .. 4).
- A section for loading the factory settings.
- A section (USB Storage, see Figure 49) for selecting configurations from a USB flash drive connected to the USB connector on the DLC pro front panel.

Sections for Device Parameter Configuration 1 .. 4

The four configurations are indicated by a caption (if assigned in the Configuration Manager available in the menu of the TOPAS DLC pro PC-GUI see section 6.11), date and time of the last saving, the laser head type and its serial number.

Retrieve&Save

Tapping saves the device parameter configuration for the selected laser head to the DLC pro (**Configuration 1 .. 4**) or a USB flash drive (**USB Storage** selected).

Load&Apply

Tapping loads the device parameter configuration. A configuration file contains the laser head type and its serial number and can only be loaded if this data matches the selected laser head (**Laser 1**/**Laser 2** button). Otherwise the **Load&Apply** field is greyed out.

Section for USB Storage

Connect a USB flash drive to the USB connector on the DLC pro front panel and tap **Select** to open the USB Storage window.

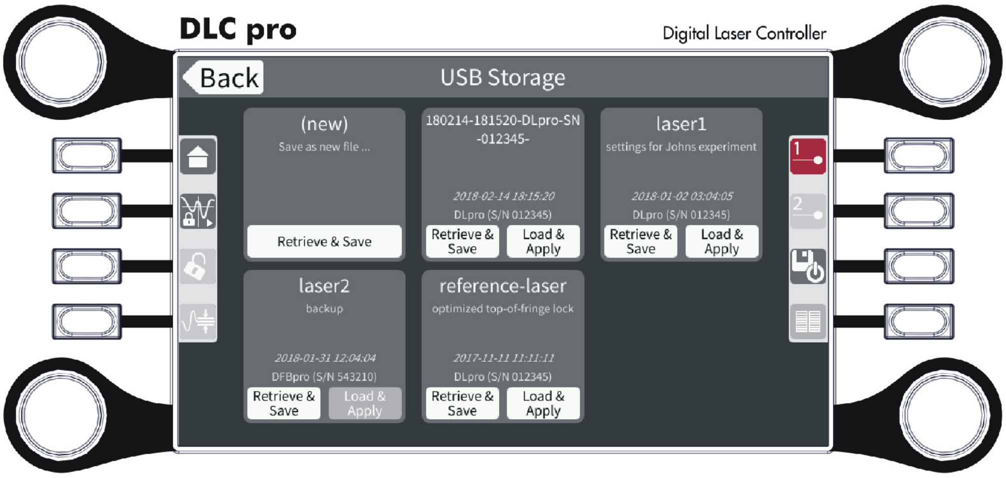


Figure 49 Configuration Manager, USB Storage window

The available configurations on the USB flash drive are indicated by the file name, a caption (if assigned in the Configuration Manager available in the menu of the TOPAS DLC pro PC-GUI see section 6.11), date and time of the last saving, the laser head type and its serial number.

NOTE !	To be able to save a configuration, the USB flash drive needs a folder "\toptica". Configuration files (*.laserconf) must be located in the folder "\toptica" to be detected.

By tapping **Retrieve&Save** or **Load&Apply** you can handle the configurations as described above.

Section for Factory Settings

Apply

Tapping loads the parameter values from the factory settings.

NOTE !	Factory settings are certain laser head specific operation parameters, such as laser diode maximum voltages and currents, laser diode polarity, photo diode calibration data and other mostly laser safety related settings. **Please note that the factory settings may have been changed formerly by the user**, e.g. after an exchange of the laser diode.

5.12 Parameter Menu

NOTE !	For normal operation, set all relevant parameters on the predefined screens and in their context parameter menus. To enable the touchscreen user to change parameters that are not accessible via any predefined screens, review the complete set of DLC pro parameters listed in the parameter menu. For a detailed description on the parameters and associated codes, please refer to the Remote Command Reference for TCP/IP and USB. This document is available as a pdf file in the Documentations folder on the software USB flash drive supplied with the DLC pro.

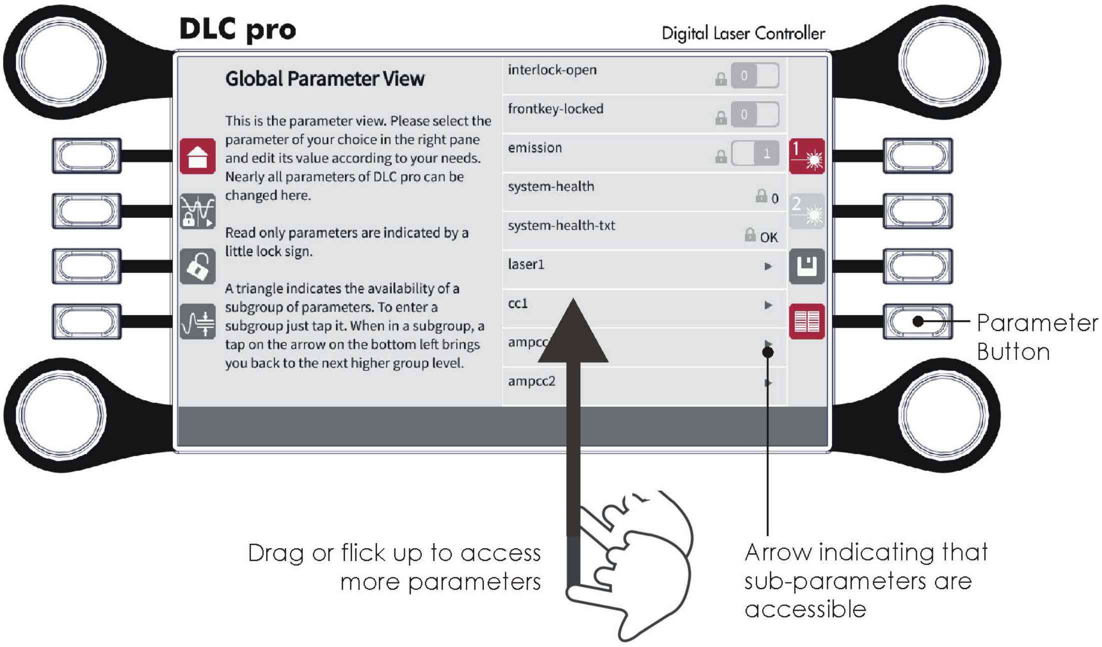


Figure 50 Touchscreen showing the parameter menu (example)

Press the **Parameter** button or tap the corresponding symbol to open the parameter menu on the touch-screen to check and/or change the desired settings.

- The full parameter menu is displayed on the Home screen. A context parameter menus is displayed in Scan/Lock mode. Drag or flick through the list to access more parameters.
- An arrow indicates that further sub-parameters are accessible (see Figure 51). The sub-parameters are context sensitive; only parameters relevant to the respective DLC pro system appear.
- Move the parameter menu up/down by dragging or flicking.
- Tap a parameter to change it. Depending on the parameter, you can tap switches, select pre-defined settings or open an editor.

Status: 29.3.22

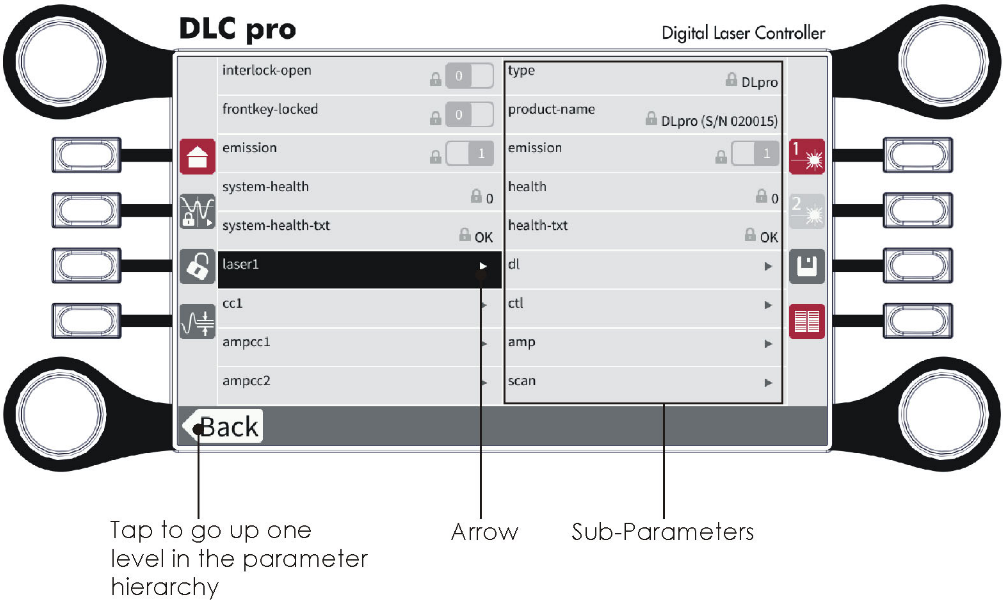


Figure 51 Sub-parameters

For a complete list of the available parameters and their limits, please refer to the Remote Command Reference for TCP/IP and USB. This document is available as a pdf file in the Documentations folder on the software USB flash drive supplied with the DLC pro.

6 TOPAS DLC pro Graphical User Interface (PC-GUI)

This section describes all controls of the TOPAS DLC pro graphical user interface (PC-GUI) in detail.

6.1 System Requirements

System requirements for installation of the TOPAS DLC pro graphical user interface (PC-GUI):

- Windows 8, 8.1or 10 operating system
- TOPAS DLC pro is tested with Windows 10 operating system
- Min. 1-GHz-Processor
- Min. 1 GB RAM
- Min. 100 MB memory available on hard-disk
- Recommended screen resolution: 1920 x 1200
- Recommended setting of Windows Display Scaling: 100 %
- Depending on the Windows setup, it might be necessary to log in with administrator rights

NOTE !	We recommend operating the DLC pro via Ethernet over using a USB connection due to the higher communication bandwidth. Using a USB to Ethernet adapter on the PC side allows fast communication while having a point-to-point connection between PC and DLC pro – without connecting the DLC pro to the local network or disconnecting the PC from it.

6.2 Installation and Start of TOPAS DLC pro

NOTE !	Before installing a new release of the TOPAS DLC pro software, please uninstall the current version on your computer. Please follow the procedure described below to install the new software release.

For TOPAS DLC pro installation on your computer, please connect the supplied TOPAS DLC pro USB flash drive and start the installer (path: 1_TOPTICA DLC pro SOFTWARE_x.y.z\ 2_PC-GUI\TOPAS_DLC_pro_x.y.z.exe). The installer will guide you through the installation process.

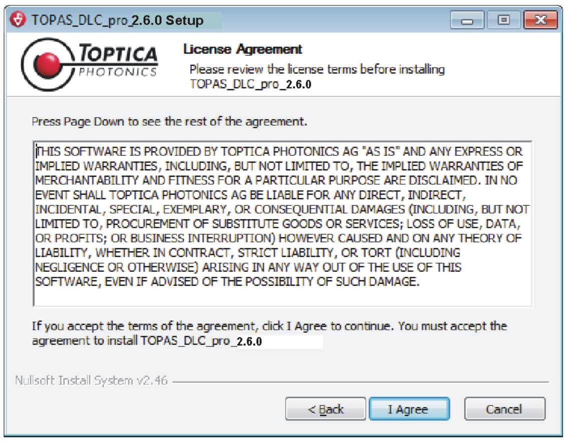


Figure 52 Installation and license agreement screen

Start the installation and confirm the license agreement by clicking **I Agree**.

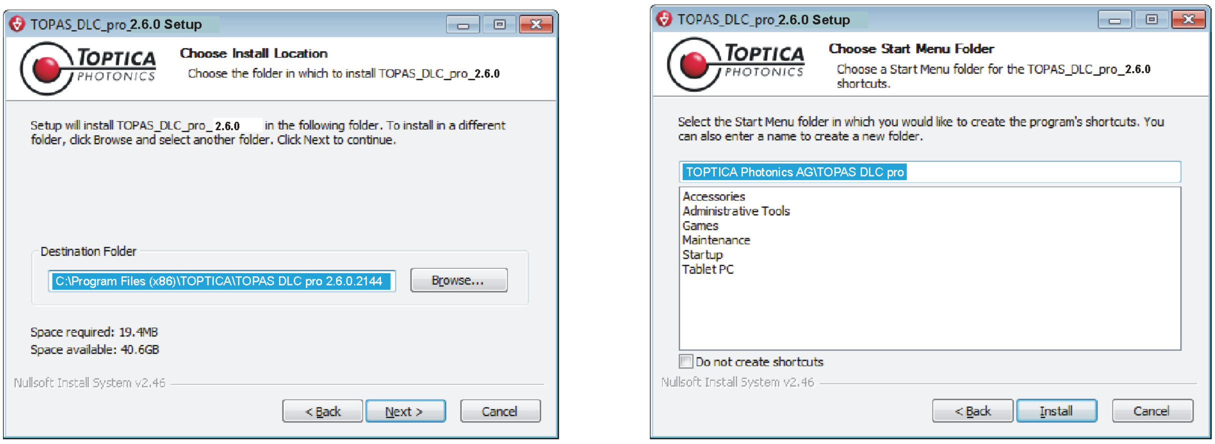


Figure 53 TOPAS DLC pro folder selection screen

Select the folder where TOPAS DLC pro will be installed. Click **Next** to continue to the following window. Now all components of TOPAS DLC pro will be installed. In the next window (Figure 53 right) you may choose the name of the program folder which is created in the start menu. Click **Install** to continue.

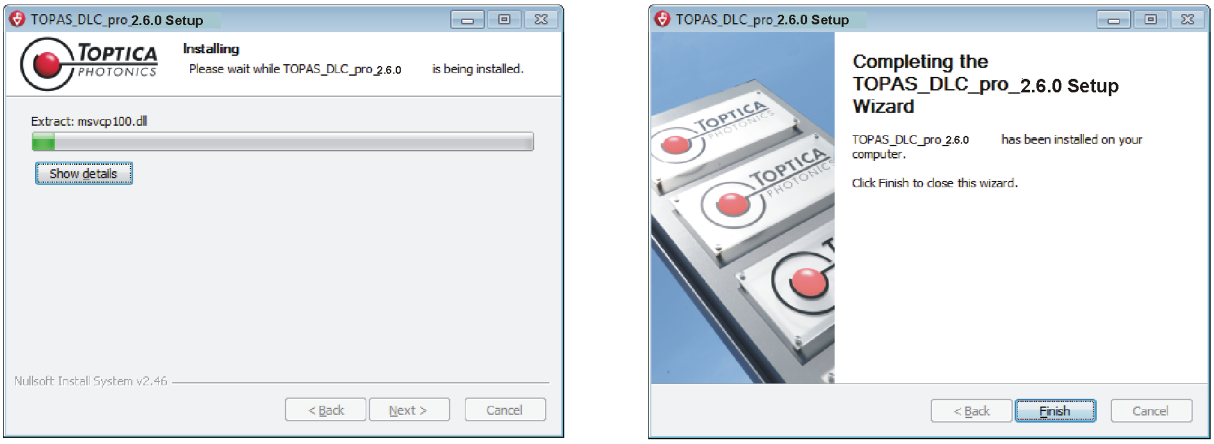


Figure 54 Finishing the installation

After the installation is completed, click **Finish** to close the TOPAS DLC pro installer.

Start the TOPAS DLC pro software by clicking the entry in the Start menu.

6.3 TOPAS DLC pro Screen Areas

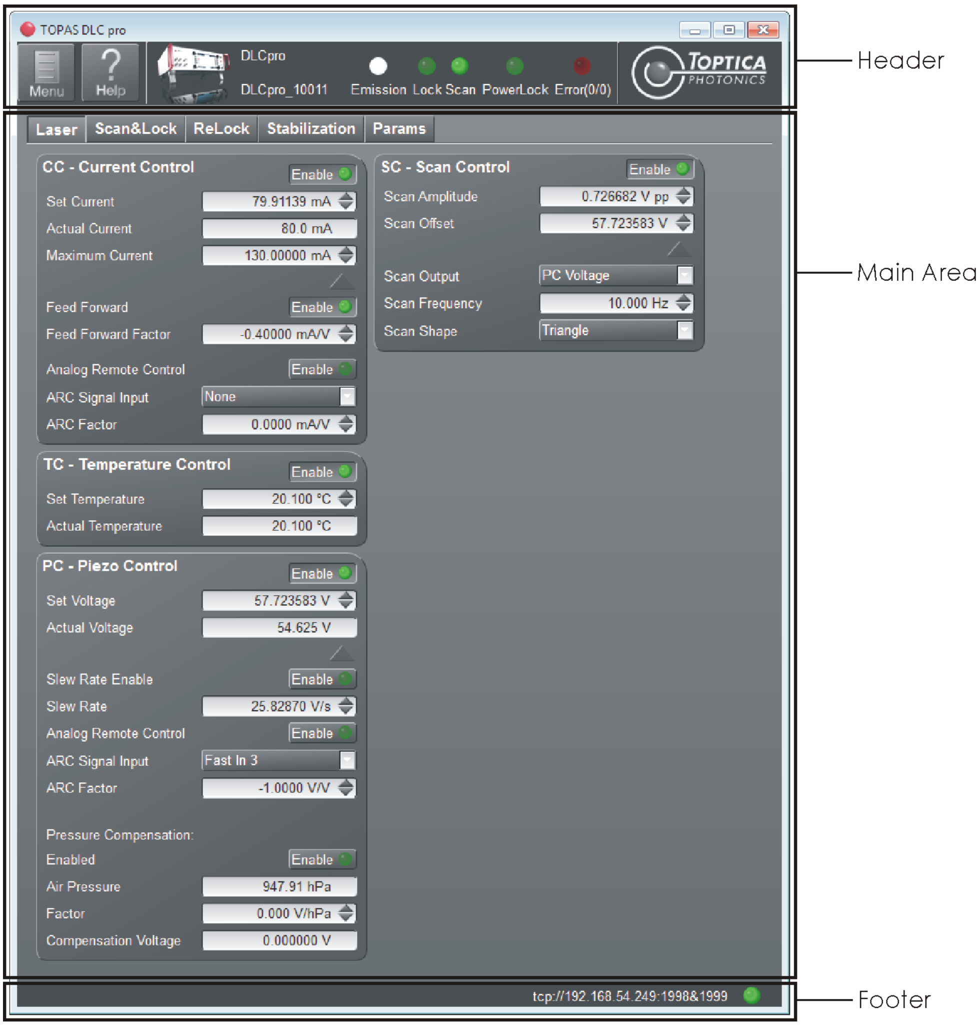


Figure 55 Screen areas

6.4 Control of two Lasers (Dual-Laser-Operation)

NOTE !	To use the DLC pro for control of two lasers (Dual-Laser-Operation), an Upgrade for Control of a 2nd laser is required. When the Dual-Laser-Operation upgrade is acquired, TOPTICA provides a license key via e-mail or USB flash drive and additional hardware, such as modules and cables. For installation of the modules, please refer to sections 10.4 and 10.5. The license key must be activated via the TOPAS DLC pro PC-GUI (please refer to section 10.19). If purchased along with the DLC pro, the licence and the hardware will already be installed.

The Digital Laser Controller DLC pro is capable of controlling two laser systems of the type DL pro, DFB pro, TA pro, BoosTA pro or two modules in the TA pro AL (MTA pro) laser head. In this manual, mainly the operation of one laser is described, the second laser is operated in the same way. In the TOPAS DLC pro PC-GUI, Indicators and controls for laser 2 are provided in the Header (see section 6.6), in the Menu and in the Laser 2, Scan&Lock 2, ReLock 2 and Stabilization 2 tabs which are identical to the tabs described in this manual. Additional information on the connection and operation of two lasers is noted in this manual where necessary.

6.5 Header

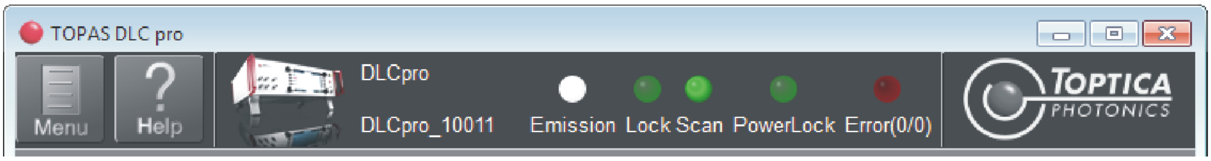


Figure 56 General display section at the top

Menu For information about the Menu, please refer to section 6.11.

Help For information about the Help function, please refer to section 6.13.

Connected DLC pro The screen displays the connected DLC pro, its label (if assigned), and its serial number to the right of the Help icon.

Indicators

Emission The white indicator corresponds to the Emission Radiation Warning LED on the DLC pro front panel and indicates laser emission.

DANGER !	When the Laser Radiation Emission Warning indicator lights up white, be aware that there is laser emission.

Lock The indicator shows the status of the lock.
Dark green: Laser is not locked.
Yellow: Laser is not locked, locking procedure is in progress.
Light green: Laser is locked.

Scan The green indicator lights up while the SC is switched on and a scan is performed.

PowerLock The indicator shows the status of the PowerLock.
Dark green: PowerLock disabled.
Yellow: - PowerLock enabled, but power is not stabilized, locking procedure is in progress.
- **Actual Current** not sufficient for reaching the desired power **Set Level**.
Light green: PowerLock enabled and power is stabilized.

Error The red indicator shows that an error has occurred. The error is displayed in the communication display section in the footer (see Figure 60).
Clicking on the **Error** indicator opens a window where system messages are displayed (see section 6.10).

6.6 Header at a DLC pro for Dual-Laser-Operation

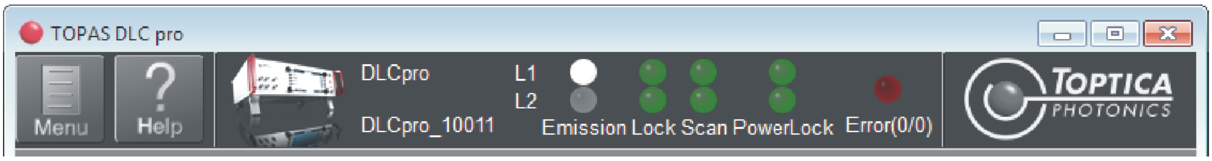


Figure 57 General display section at the top

Menu — For information about the Menu, please refer to section 6.11.

Help — For information about the Help function, please refer to section 6.11.

Connected DLC pro — The screen displays the connected DLC pro, its label (if assigned), and its serial number to the right of the Help icon.

Indicators — Indicators for laser 1 (L1) and laser 2 (L2)

Emission — The white indicators correspond to the Emission Radiation Warning LED on the DLC pro front panel and indicate laser emission of the respective laser 1/2.

> **DANGER !** When at least one Laser Radiation Emission Warning indicator lights up white, be aware that there is laser emission.

Lock — The indicators show the status of the lock of the respective laser 1/2.
Dark green: Laser is not locked.
Yellow: Laser is not locked, locking procedure is in progress.
Light green: Laser is locked.

Scan — The green indicators light up while the SC is switched on and a scan of the respective laser 1/2 is performed.

PowerLock — The indicators shows the status of the PowerLock of the respective laser 1/2.
Dark green: PowerLock disabled.
Yellow: - PowerLock enabled, but power is not stabilized, locking procedure is in progress.
- **Actual Current** not sufficient for reaching the desired power **Set Level**.
Light green: PowerLock enabled and power is stabilized.

Error — The red indicator shows that an error has occurred. The error is displayed in the communication display section in the footer (see Figure 60).
Clicking on the **Error** indicator opens a window where system messages are displayed (see section 6.10).

6.7 Header (DLC DL-/TA-SHG/FHG pro)

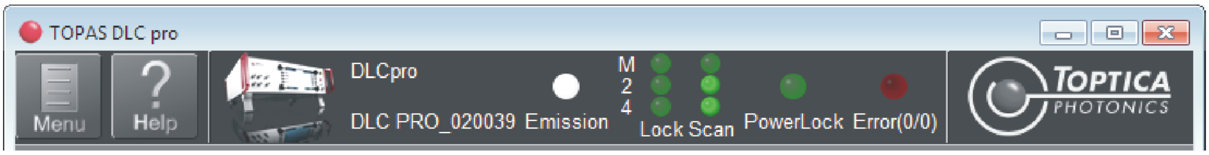


Figure 58 General display section at the top (example DLC DL-/TA-FHG pro)

Menu
For information about the Menu, please refer to section 6.12.

Help
For information about the Help function, please refer to section 6.11.

Connected DLC pro
The screen displays the connected DLC pro, its label (if assigned), and its serial number to the right of the Help icon.

Indicators

Emission
The white indicator corresponds to the Emission Radiation Warning LED on the DLC pro front panel and indicates laser emission.

DANGER !	When the Laser Radiation Emission Warning indicator lights up white, be aware that there is laser emission.

Lock M
The indicator shows the lock status of the Master Oscillator.
Dark green: Laser is not locked.
Yellow: Laser is not locked, locking procedure is in progress.
Light green: Laser is locked.

Lock 2
The indicator shows the lock status of the SHG cavity (2 nd harmonic).
Dark green: SHG cavity is not locked.
Yellow: SHG cavity is not locked, locking procedure is in progress.
Light green: SHG cavity is locked.

Lock 4
only DLC DL-/TA-FHG pro
The indicator shows the lock status of the FHG cavity (4 th harmonic).
Dark green: FHG cavity is not locked.
Yellow: FHG cavity is not locked, locking procedure is in progress.
Light green: FHG cavity is locked.

Scan M
The green indicator lights up while the SC for the Master Oscillator is switched on and a scan is performed.

Scan 2
The green indicator lights up while a scan of the SHG cavity is performed.

Scan 4
only DLC DL-/TA-FHG pro
The green indicator lights up while a scan of the FHG cavity is performed.

PowerLock	The indicator shows the status of the PowerLock.	
	Dark green:	PowerLock disabled.
	Yellow:	- PowerLock enabled, but power is not stabilized, locking procedure is in progress. - **Actual Current** not sufficient for reaching the desired power **Set Level**.
	Light green:	PowerLock enabled and power is stabilized.
Error	The red indicator shows that an error has occurred. The error is displayed in the communication display section in the footer (see Figure 60). Clicking on the **Error** indicator opens a window where system messages are displayed (see section 6.10).	

6.8 Header (DLC TOPO)

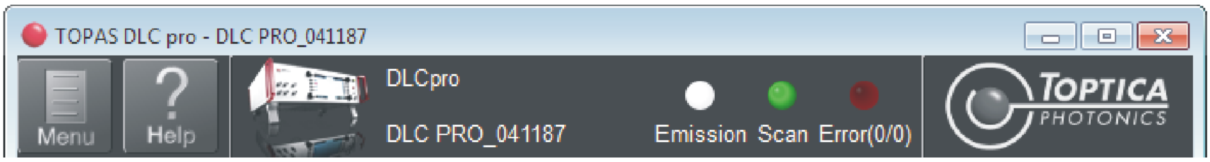


Figure 59 General display section at the top

Menu For information about the Menu, please refer to section 6.11.

Help For information about the Help function, please refer to section 6.13.

Connected DLC pro The screen displays the connected DLC pro, its label (if assigned), and its serial number to the right of the Help icon.

Indicators

Emission The white indicator corresponds to the Emission Radiation Warning LED on the DLC pro front panel and indicates laser emission of the DL pro DFY pump laser.

DANGER !	When the Laser Radiation Emission Warning indicator lights up white, be aware that there is laser emission.

Scan The green indicator lights up while the SC for the DL pro DFY pump laser is switched on and a scan is performed.

Error The red indicator shows that an error has occurred. The error is displayed in the communication display section in the footer (see Figure 60).
Clicking on the **Error** indicator opens a window where system messages are displayed (see section 6.10).

6.9 Footer

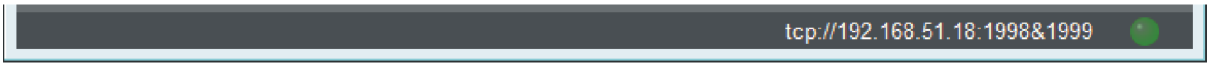


Figure 60 Communication display section in the footer

System Message When a malfunction occurs, the system message and the related code are displayed in the footer.

Connection Displays the connection currently used for communication with the device.

Communication Indicator **Bright green:** Communication.
Dark green: No communication.

6.10 System Messages Window

The System Messages window opens after clicking on the red **Error** indicator in the Header of the TOPAS DLC pro PC-GUI.

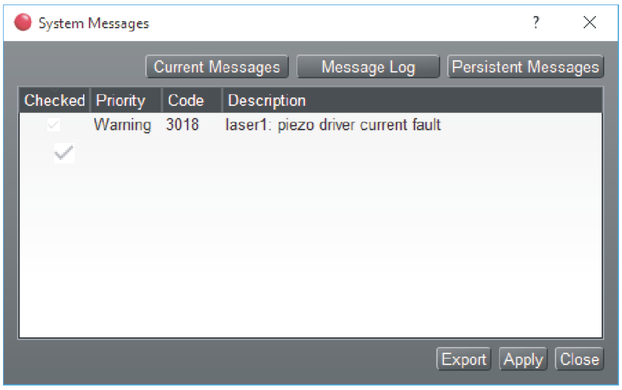


Figure 61 System Messages window

Current Messages The window displays current system messages. To confirm a message, check the box and click **Apply**.

NOTE !	A system message is only deleted, if the cause of the malfunction is resolved.

Message Log The window displays all system messages from the last boot procedure of the DLC pro. An empty *Description* at a message indicates that the respective system message is deleted.

Persistent Messages For TOPTICA service purposes: The window displays all severe system messages, which are not deleted when the DLC pro is switched off.

Export Click to save the content of the window as a .txt file.

Apply Confirms the marked (checkbox) current system message.

Close Closes the System Messages window.

6.11 Menu

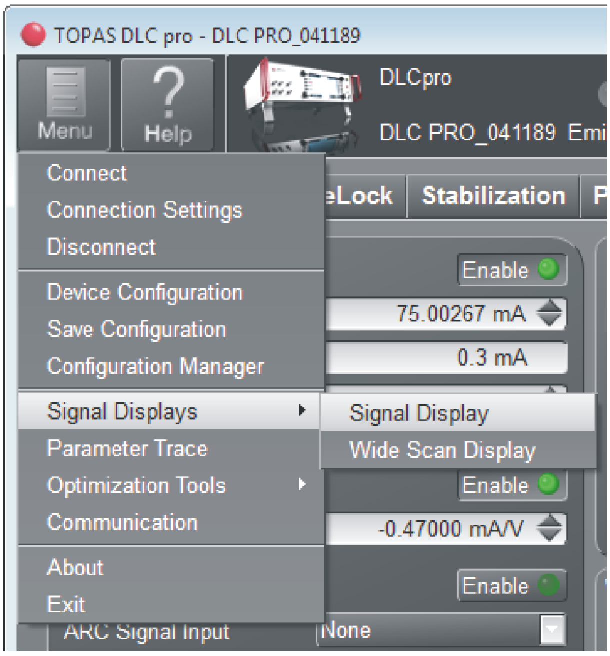


Figure 62 TOPAS DLC pro menu (example)

> Menu > Connect Establishes a connection to the device selected in the Connection Settings window.

> Menu > Connection Settings

The Connection Settings window (see Figure 63) opens for configuring the connection settings.

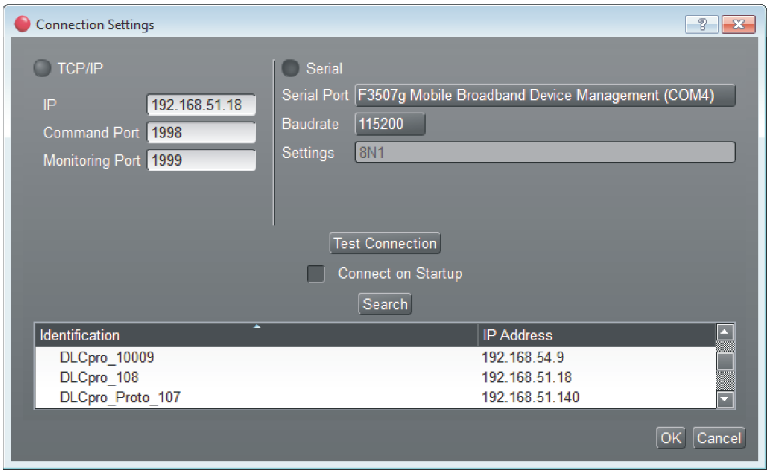


Figure 63 Connection Settings window

TCP/IP

When selected, all devices connected via TCP/IP to the local network are listed in the display area of the Connection Settings Window. After selecting a device, its connection properties (**IP address**, **Command Port** and **Monitoring Port**) are displayed in the respective fields.

Serial

Select **Serial Port** for establishing a serial connection to a device.

Serial Port

Select serial port to which the DLC pro is connected.

Baudrate

Not relevant, setting is ignored by software.

Settings

Not relevant, setting is ignored by software.

Test Connection

Establishes a test connection to the selected device and then closes. When the connection test was successful, a pop-up window displays details on the selected device and the DLC pro plays an acoustic signal. In other cases, a system message appears.

Connect on Startup

When checked, the connection saved by clicking **OK** is automatically established at the next software start.

Search

Starts a new search for devices connected via TCP/IP.

OK

Saves the settings and closes the window. To establish a connection with these settings, select **Menu > Connect**

Cancel

Discards changes and closes the window.

> Menu > Disconnect

Closes the connection to the device.

> Menu > Device Configuration The Device Configuration window opens.

NOTE !	Please note that, depending on the connected laser head, some tabs of the Device Configuration menu may not be available.

> Menu > Device Configuration User Level Section

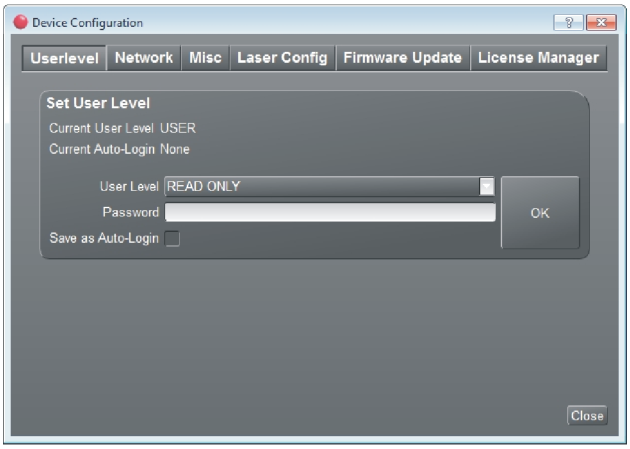


Figure 64 Device Configuration Window User Level Section

Set User Level Section for changing the user level.

Current User Level Displays current user level.

Current Auto-Login Displays current setting for Auto-Login.

User Level Select user level.

NOTE !	Changing the user level only affects operation via TOPAS DLC pro PC-GUI. For touchscreen operation the USER level is fixed.

READ ONLY: TOPAS DLC pro is set for only displaying the laser operation, all PC-GUI controls are disabled.
USER: Setting for daily DLC pro operation.
MAINTENANCE: User level for operations needed to maintain the laser (according to the laser safety standard).
SERVICE: User level for operations that may change the laser safety classification such as changing the maximum operating current of the laser (service operation according to the laser safety standard).
INTERNAL: For internal TOPTICA use only.

NOTE !	If a password for the USER level is introduced (see section 4.9.1), for changing to the MAINTENANCE level this password plus the MAINTENANCE password must be entered as a combined but single password. The SERVICE password remains unchanged.

DANGER ! **CAUTION !**	The user levels MAINTENANCE and SERVICE may only be accessed by authorized and specially-trained service personnel. Customers entering the MAINTENANCE or SERVICE level need to be aware that wrong parameter values may harm and destroy laser diodes and warranty may be voided. The INTERNAL level is not for customers use.

NOTE !	The user level required for changing a certain parameter is noted in the parameter description in the Remote Command Reference for TCP/IP and USB. This document is available as a pdf file in the Documentations folder on the software USB flash drive supplied with the DLC pro. The user level nomenclatures in the Remote Command Reference and in this manual correspond as follows: **4 > READ-ONLY** **3 > USER** **2 > MAINTENANCE** **1 > SERVICE** **0 > INTERNAL**

Password — Input field for entering the password required for the respective user level.
READ ONLY: No password required.
USER: No password required. Please refer to section 4.9.1 for introducing a password for the USER level.
MAINTENANCE: For password please refer to the Production and Quality Control Data Sheet. See note below.
SERVICE: For password please refer to the Production and Quality Control Data Sheet.

NOTE !	If a password for the USER level is introduced, for changing to the MAINTENANCE level this password plus the MAINTENANCE password must be entered as a combined but single password. The SERVICE password remains unchanged.

Save as Auto-Login Checkbox — When checked, the entered password is saved for Auto-Login.

OK — Clicking changes the user level.

Close — Closes the window.

> Menu > Device Configuration Network Section

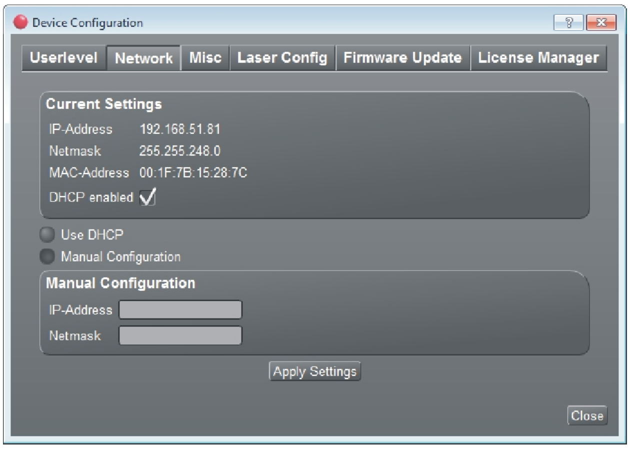


Figure 65 Device Configuration Window Network Section

NOTE !	**To activate the new network settings while the DLC pro is connected via TCP/IP**, please click **Apply Settings and** select **No** in the following confirmation dialog window. Disconnect the TOPAS DLC pro PC-GUI and switch off and on the DLC pro by the ON/OFF switch on the rear panel. After switching off, please wait for at least 10 seconds before switching the DLC pro on again. Then open **Menu > Connection Settings**, double click the DLC pro with its new IP address and click **Menu > Connect**. When changing network settings while the DLC pro is connected **via TCP/IP, do not restart the DLCpro's network adapter** by clicking **Apply Settings** and confirming the following dialog window with **Yes**. Restarting the network adapter while using it will cause an undefined state of the adapter. Changing the settings and restarting the adapter works properly if you are connected via USB.

Current Settings

IP-Address — Shows the currently active IP address of the connected device.

Netmask — Shows the currently active subnet mask of the connected device.

MAC-Address — Shows the hardware/MAC address of the connected device´s network adapter.

DHCP enabled — Indicates whether the device is configured for automatic IP configuration by a DHCP server.

Use DHCP — Changes the device’s network adapter configuration for automatic setup by a DHCP server. After selecting this option, the IP address and netmask will not yet have changed to the new values. In order to use the DHCP mechanism, use the **Apply Settings** button and confirm the following dialog window with **Yes** or reboot the system.

Manual Configuration	Changes the device's network adapter configuration to a static IP configuration. Provide the desired IP address and netmask in the **IP address** and **Netmask** field, respectively. After doing this, the IP address and netmask will not yet have changed to the new values. In order to use the new address, click the **Apply Settings** button and confirm the following dialog window with **Yes or** reboot the DLC pro.
IP-Address	Input field for the IP address if you want to use the **Manual Configuration** button for setting up a fixed IP address. Please enter an IPv4 address in the format "xxx.xxx.xxx.xxx", (e.g., "192.168.1.1").
Netmask	Input field for the subnet mask if you want to use the **Manual Configuration** button for setting up a fixed IP address. Please enter an IPv4 netmask in the format "xxx.xxx.xxx.xxx", (e.g., "255.255.255.0").
Apply Settings	Restarts the network adapter, making use of the new network configuration. Please note that you might lose your current TCP/IP connection if you click the **Apply Settings** button and confirm the following dialog window with **Yes**. Please see **NOTE !** above.
Close	Closes the window.

> Menu > Device Configuration Misc Section

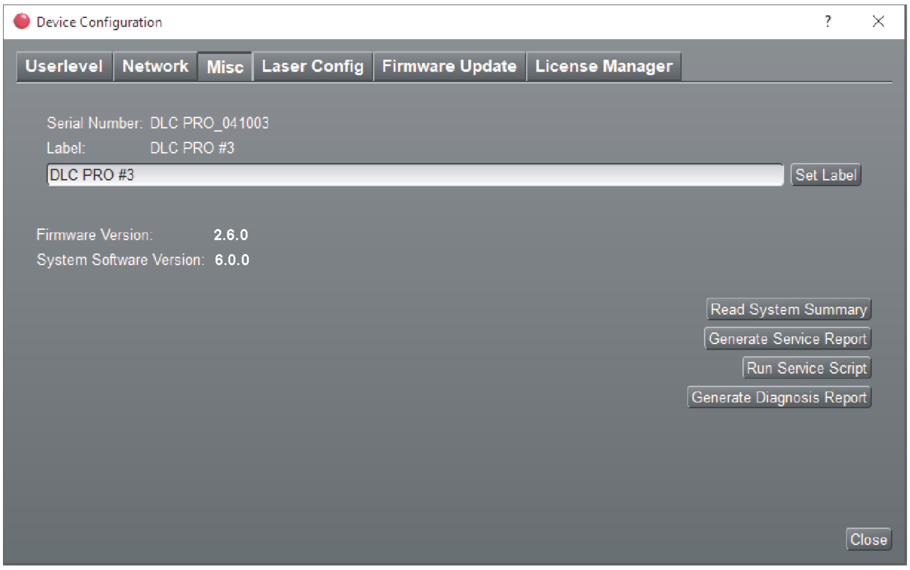


Figure 66 Device Configuration Window Misc Section (user level SERVICE)

Serial Number	Displays the serial number of the connected device.
Label	Displays the individual name with which the connected device is identified in the local network.
Label Input Field	Input field for entering an individual name for the currently connected device. The number of characters is limited to 15.
Set Label	Saves the individual name as a label.

NOTE !	The label is displayed in the header and in the device list in the Connection Settings window (see Figure 63) !

Read System Summary	Displays a detailed summary of the DLC pro and the connected laser head.
Generate Service Report	Generates a binary file (*.bin) for TOPTICA service purposes. A dialog window appears to choose the destination to save the generated file. Click **Cancel** to stop the process.

NOTE !	Do not change settings within the TOPAS DLC pro PC-GUI or the DLC pro front panel while the Service Report is being generated.

Run Service Script	Functionality to run a service script provided by TOPTICA.
Generate Diagnosis Report	Available only in user level SERVICE: Generates a binary file (*.bin) for TOPTICA service purposes. Depending on the laser head type, the generation of this report includes the monitoring of characteristic curves for laser diodes and amplifier chips, as well as for piezo and servo health. System parameters may be altered during the generation of this report. A dialog window appears to choose the destination to save the generated file. Click **Cancel** to stop the process.

NOTE !	It is recommended to generate the diagnosis report only in a stable system status, e.g. after all temperatures have settled.

Close	Closes the window.

> Menu > Device Configuration Laser Configuration Section

DLC DL pro/DLC DFB pro

NOTE !	With a DLC pro for Dual-Laser-Operation, the Laser Config tab is present for laser 1 and laser 2, if connected.

Figure 67 Device Configuration Window Laser Configuration Section (DLC DL pro/DLC DFB pro)

The Laser Configuration Section allows configuration of the laser heads. Depending on the laser type, some or all of these values can be changed.

NOTE !	The values entered in this window are applied immediately after entering. If you want to retain these values even after a reboot of the DLC pro, please click the **Save** button.

For TOPTICA laser heads please refer to the corresponding Production and Quality Control Data Sheet for the proper operating parameters.

CC Current Control

Maximum Current Input Field for maximum current. Parameter: laser1:dl:cc:current-clip

Use Tuning Clip Checking the box limits the laser diode current to the Maximum Tuning Current. In case this Maximum Tuning Current is lower than the entry in the **Maximum Current** field, this field changes to **Maximum Tuning Current** (display only).

CAUTION !	**Laser heads with Motor pro option**: Checking the **Use Tuning Clip** box in the CC Current Control section is **mandatory** before performing a motor scan. This avoids damage to the laser diode during a motor scan.

Set Current I_{set} Input Field for set current.

Maximum Voltage U_{max} Input Field for maximum voltage.

Polarity Checkbox Check when laser diode polarity is positive.

TC Temperature Control

Set Temperature T_{set}	Input Field for set temperature.
Save	Saves all relevant laser head operating parameters so that they are resumed at the DLC pro boot procedure.
Close	Closes the window without saving. The currently set values are only valid until the DLC pro is switched off.

> Menu > Device Configuration Laser Configuration Section

DLC TA pro/-AL and Seed Laser + BoosTA pro Combination

NOTE !	For a **DLC BoosTA pro** system, only amplifier operating parameters are available.

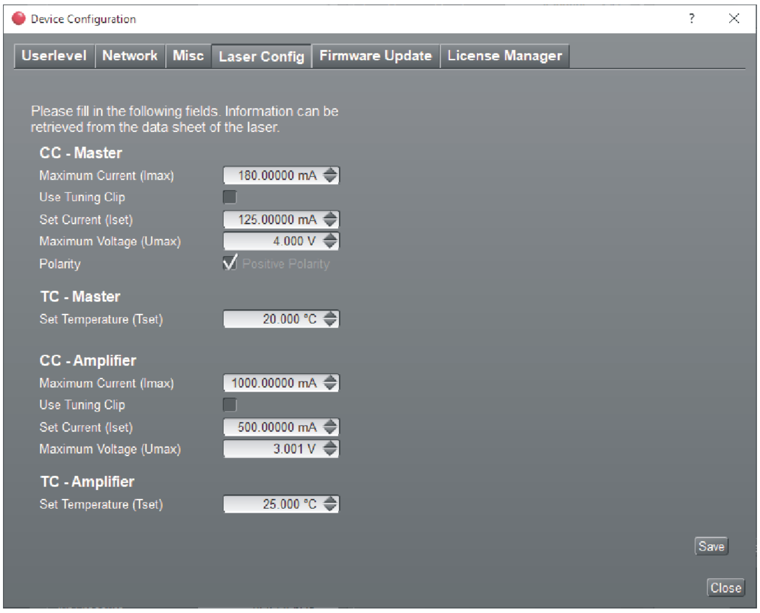


Figure 68 Device Configuration Window Laser Configuration Section (example DLC TA pro)

The Laser Configuration Section allows configuration of the laser head. Depending on the laser type, some or all of these values can be changed.

NOTE !	The values entered in this window are applied immediately after entering. If you want to retain these values even after a reboot of the DLC pro, please click the **Save** button.

For TOPTICA laser heads please refer to the corresponding Production and Quality Control Data Sheet for the proper operating parameters.

CC Current Control Master Settings for CC Master Oscillator.

Maximum Current Input Field for maximum current. Parameter: laser1:dl:cc:current-clip

Use Tuning Clip Checking the box limits the laser diode current to the Maximum Tuning Current. In case this Maximum Tuning Current is lower than the entry in the **Maximum Current** field, this field changes to **Maximum Tuning Current** (display only).

CAUTION ! **Laser heads with Motor pro option**: Checking the **Use Tuning Clip** box in the CC Current Control Master section is **mandatory** before performing a motor scan. This avoids damage to the laser diode during a motor scan.

Set Current I_{set} Input Field for set current.

Maximum Voltage U_{max} Input Field for maximum voltage.

Polarity Checkbox Check when laser diode polarity is positive.

TC Temperature Control Master Settings for TC Master Oscillator.

Set Temperature T_{set} Input Field for set temperature.

CC Current Control Amplifier Settings for CC Tapered Amplifier.

Maximum Current Input Field for maximum current.
Parameter: laser1:amp:cc:current-clip

Use Tuning Clip Checking the box limits the amplifier current to the Maximum Tuning Current. In case this Maximum Tuning Current is lower than the entry in the **Maximum Current** field, this field changes to **Maximum Tuning Current** (display only).

CAUTION ! **Laser heads with Motor pro option**: Checking the **Use Tuning Clip** box in the CC Current Control Amplifier section is **mandatory** before performing a motor scan. This avoids damage to the amplifier during a motor scan.

Set Current I_{set} Input Field for set current.

Maximum Voltage U_{max} Input Field for maximum voltage.

TC Temperature Control Amplifier Settings for TC Tapered Amplifier.

Set Temperature T_{set} Input Field for set temperature.

Save Saves all relevant laser head operating parameters so that they are resumed at the DLC pro boot procedure.

Close Closes the window without saving. The currently set values are only valid until the DLC pro is switched off.

> Menu > Device Configuration Firmware Update Section

NOTE !	For a step-by-step description of a firmware update via TOPAS DLC pro, please refer to section 10.17.2.

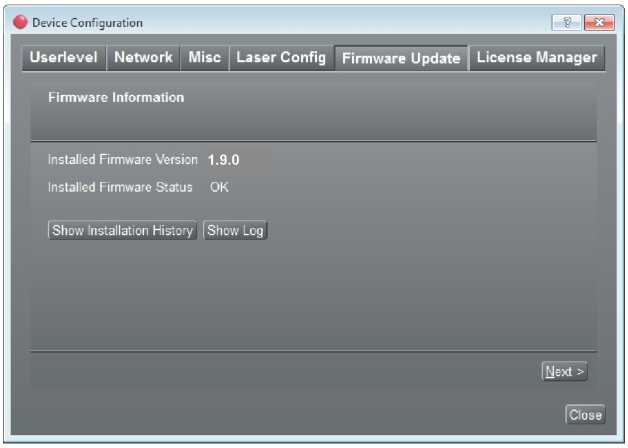


Figure 69 Device Configuration Window Firmware Update Section

Firmware Information	Displays information about the current firmware version and status.
Show Log	Displays a log file of the firmware installer.
Show Installation History	Displays the history of the installed firmware versions.
Next >	Opens the Archives window where firmware files to be installed can be added.

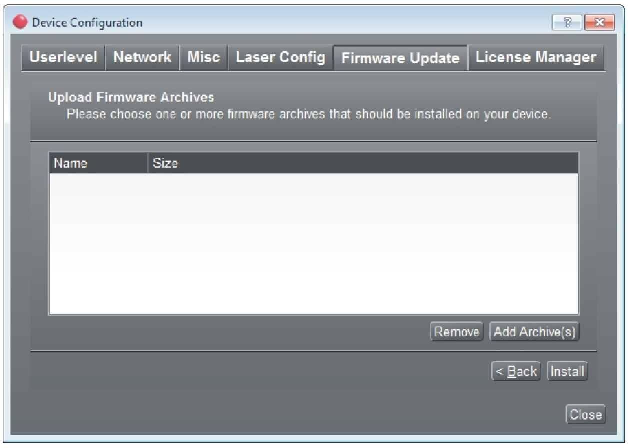


Figure 70 Firmware Update Archives Window

Add Archive(s)	Adds firmware files to the Archives window.
Remove	Deletes firmware files from the list in the Archives window.
Back	Closes the Archives window.
Install	Saves the selected firmware file to the DLC pro.

NOTE ! Please reboot the DLC pro to finish installation of the new firmware version.

Close	Closes the Device Configuration window.

> Menu > Device Configuration License Manager Section

NOTE !	For an example of a step-by-step description of the installation of a new option via TOPAS DLC pro please refer to section 10.19.

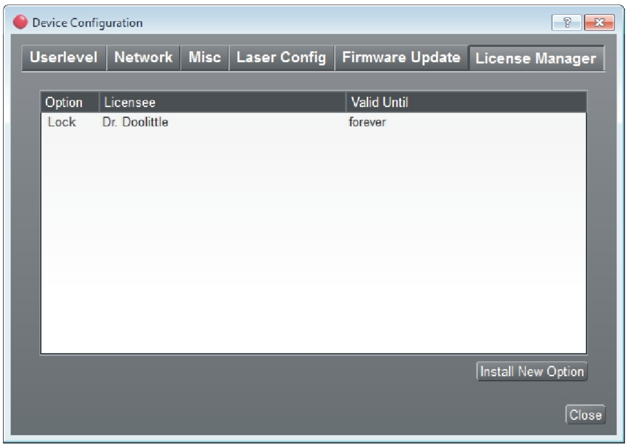


Figure 71 Device Configuration Window License Manager Section

A window shows details on options already installed on the DLC pro.

Install New Option Opens the License Key window. Please insert the license key provided by Toptica and click **OK** to install the new option on the connected DLC pro.

Close Closes the Device Configuration window.

> Menu > Save Configuration Saves the most important settings of the Params tab (e.g., settings for Scan/Lock mode, laser current and temperature settings).

NOTE !	The function of **Menu > Save Configuration** is equal to pressing the **Load/Save** button on the DLC pro front panel twice and to executing the command **laser1/2:save**.

> Menu > Configuration Manager The Configuration Manager window opens.

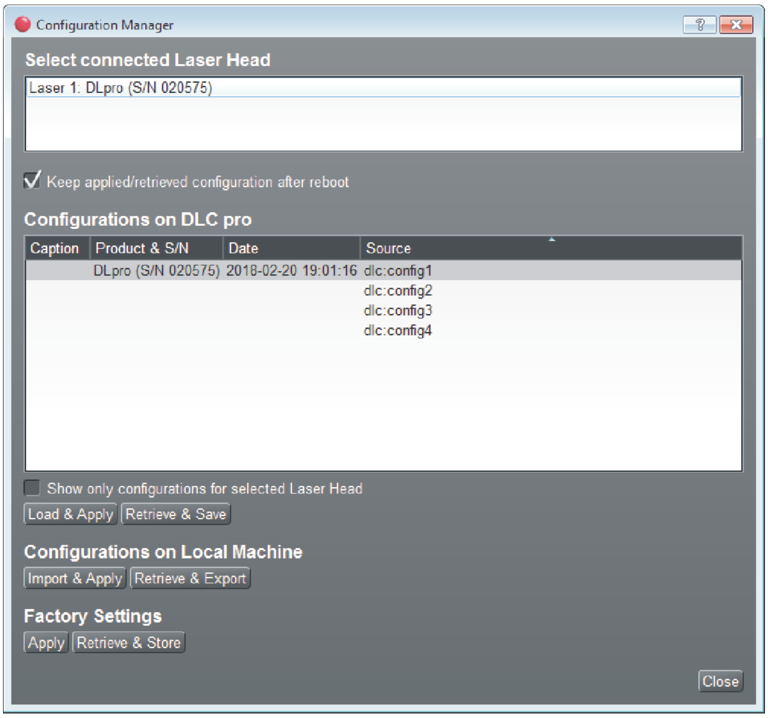


Figure 72 Configuration Manager Window

The Configuration Manger allows to save and load several device parameter configurations, which include laser head operation parameters as well as not laser head specific settings of the DLC pro, e.g., display settings. A configuration file contains the laser head type and its serial number and can only be loaded if this data matches the selected laser head.

The Configuration Manager window shows the connected laser heads and a list of all available configuration files on the DLC pro, a USB flash drive at the USB connector at the DLC pro front panel or stored on the control computer.

DANGER !	Always switch off the laser emission of the connected laser heads when handling configurations !

NOTE !	Click **Menu > Save Configuration** to have the last loaded/saved device parameter configuration resumed at the DLC pro boot procedure.

NOTE !	Servo positions used for the AutoAlign option (motorized mirrors) of the laser head are not stored in the configuration file.

Select connected Laser Head Select the laser head for which the device parameter configuration should be handled.

Keep applied/retrieved configuration after reboot When the box is checked, the last applied/retrieved configuration is used after the next boot procedure of the DLC pro.

Configurations on DLC pro	Lists all available device parameter configurations on the DLC pro and a USB flash drive at the USB connector at the DLC pro front panel. Click on the configuration to select it. The last used configuration is marked in gray.
Show only configurations for selected Laser Head	When the box is checked, only device parameter configurations which match the selected laser head are displayed.
Load&Apply	Clicking loads the selected device parameter configuration. A configuration file contains the laser head type and its serial number and can only be loaded if this data matches the selected laser head (**Select connected Laser Head**).

NOTE ! To be able to save a configuration, the USB flash drive needs a folder "\toptica". Configuration files (*.laserconf) must be located in the folder "\toptica" to be detected.

Retrieve&Save	Clicking saves the selected device parameter configuration for the selected laser head to the DLC pro or a USB flash drive.
Configurations on Local Machine	Allows access to device parameter configurations (*.laserconf) which are stored on the control computer.
Import&Apply	Clicking opens a dialog window to select a device parameter configuration. Click **Open** to import the configuration. A configuration file contains the laser head type and its serial number and can only be loaded if this data matches the selected laser head (**Select connected Laser Head**).
Retrieve&Export	Clicking opens a dialog window to enter a caption of the device parameter configuration. Click **OK** to confirm and open a dialog window to select a configuration file or to create a new file. Click **Save** to export the device parameter configuration for the selected laser head to the control computer.
Factory Settings	Allows to handle the factory settings for the selected laser head (**Select connected Laser Head**).
Apply	Clicking loads the parameter values from the factory settings.

NOTE ! Factory settings are certain laser head specific operation parameters, such as laser diode maximum voltages and currents, laser diode polarity, photo diode calibration data and other mostly laser safety related settings.
Please note that the factory settings may have been changed formerly by the user, e.g. after an exchange of the laser diode.

Retrieve&Store	User level MAINTENANCE required, otherwise not present (for changing the user level, please refer to section 6.11). Clicking reads out the parameter values in the factory settings and stores them into the EEPROM of the laser head.
Close	Closes the Configuration Manager window.

> Menu > Signal Displays > Signal Display

Adds the Signal Displays for laser 1/2 to the main area of the screen.

NOTE !	For showing the Lock-relevant functions of the **Signal Display**, a Lock option license is required. When a Lock option license is acquired, TOPTICA provides an option license key via e-mail or USB flash drive. The license key must be activated via the TOPAS DLC pro PC-GUI (please refer to section 10.19).

NOTE !	When you display **Signal Display** and **Parameter Trace** windows at the same time, you can display one window at full size in the front for better viewing. Do this by picking the window at the title bar and pulling it in the center of the right screen area. The window to be displayed in the front is then selected by buttons at the bottom of the right display area which are labeled accordingly. Each display window may also be moved to any screen position when picked at the title bar.

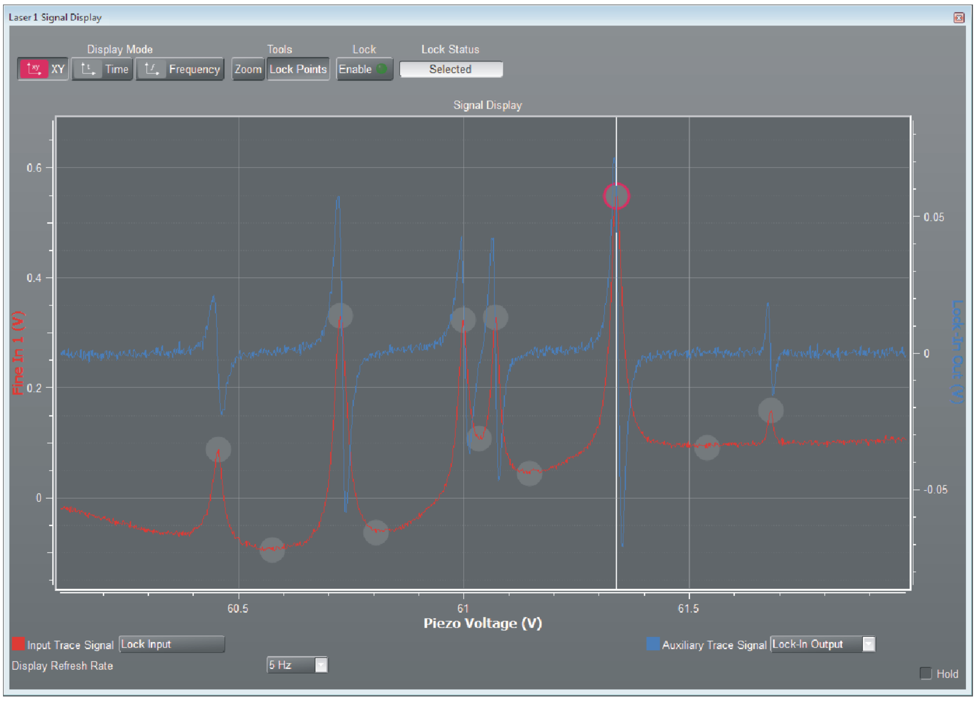


Figure 73 Signal Display showing the Lock Input signal (Input Trace Signal, red) and the Lock-In Output signal (Auxiliary Trace Signal, blue) for Top of Fringe locking and lockpoint candidates (example)

NOTE !	The signals displayed on the Signal Display are simultaneously shown on the touchscreen of the DLC pro.

The **Signal Display** displays various signals, e.g. for finding resonance frequencies, optimizing scans, locking and for characterizing the laser.

Turn the **Signal Display** on and off with the Signal Display entry in the Menu. The **Signal Display** offers three modes of operation: **XY**, **Time** and **Frequency**. In XY mode the signals (Y-direction) are plotted against the scan of the laser (X-direction), in time mode against time. Frequency mode shows a fast Fourier transform of the signal. It is possible to switch between these three modes with the corresponding buttons on the top of **Signal Display**. A click with the right mouse key on the **axis label** allows you to select the axis-scale.

Two tools are available: Select **Zoom** and use the mouse wheel to zoom in or out. Another option to zoom in is to hold the left key of the mouse and drag over the desired detail of the graphs from top left to bottom right. Dragging over the graphs from bottom right to top left undoes the last zoom. The display can be shifted right or left by holding the right mouse key. In XY mode, normally a signal is displayed depending on the laser frequency while the laser is scanned. When zooming or moving the displayed spectrum in this mode, the actual scan parameters (scan amplitude and scan offset) are modified.

Use the **Lock Points** Tool for showing and selecting lockpoints, etc. (for details please refer to section 6.15.1). Zooming and shifting the display is performed as described above in the **Zoom** section. Enable/disable the lock by clicking the **Lock Enable** button or by double-clicking on the desired lockpoint candidate. The **Lock Status** (only in XY mode) shows the actual status of the lock.

When the laser is locked, the **Signal Display** shows the Lock Input signal during the last scan before the lock was enabled (default black trace) and the actual Lock Input signal as a point cloud (default red) in red brackets (see Figure 74).

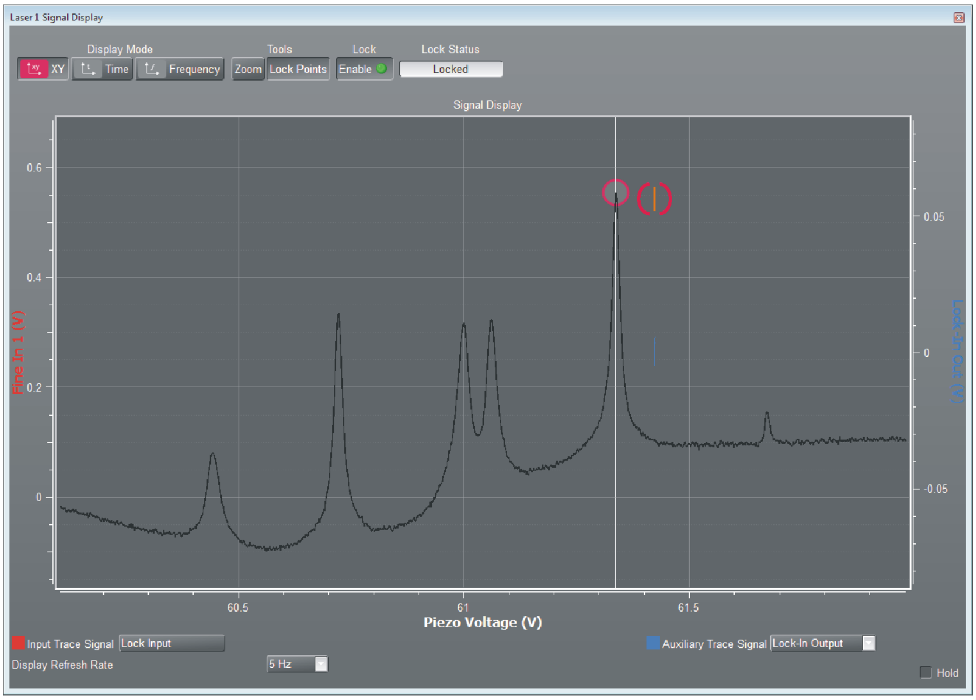


Figure 74 Signal Display when the laser is locked (example)

NOTE !	Due to the enabled lock, the scan is disabled. In XY mode the Lock Input signal now appears as a point cloud because the scan output (X-axis) remains constant and all Y-values are plotted against this constant X-value.

In case one of the used PID controller outputs is equal to the scan output, the X-value does not remain constant, reflecting the action of the PID controller. Depending on the required action of the PID controller to keep the lock stable, the point cloud may leave the displayed X-axis range. In this case a red arrow shows the direction to the point cloud. The red arrow also helps to judge if the laser is still locked. When the laser is out-of-lock, the red arrow will not point into the expected direction.

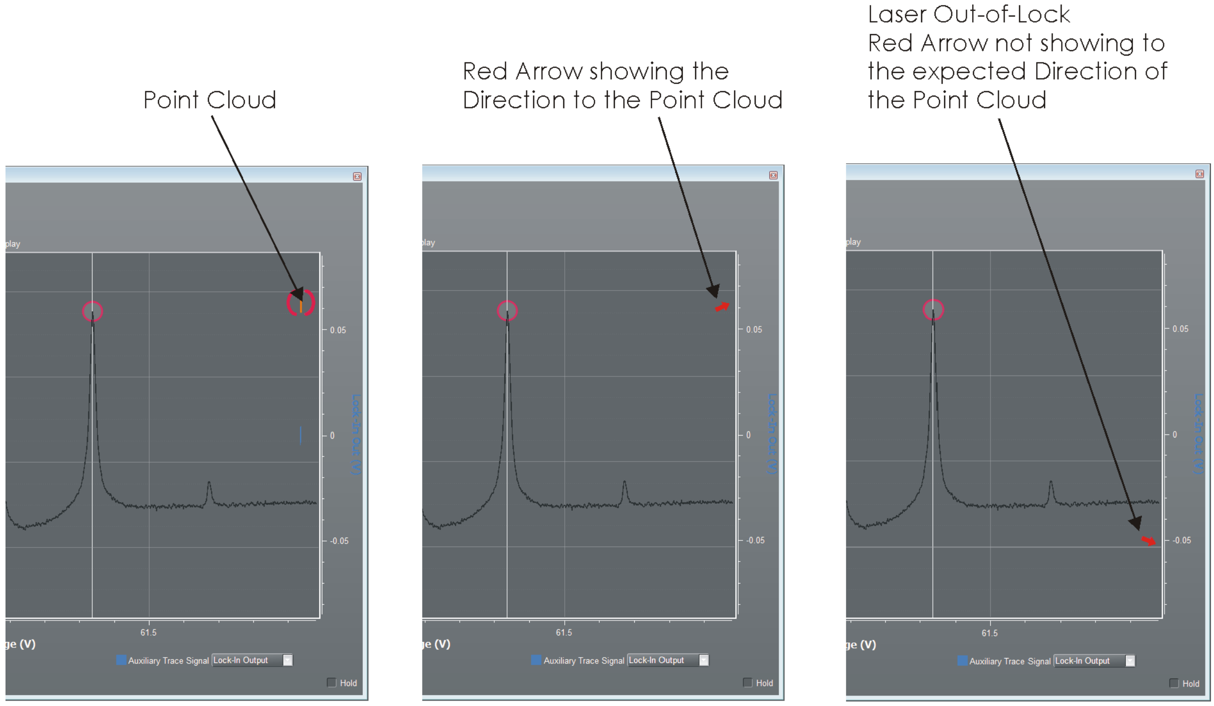


Figure 75 Red arrows showing the direction to the Lock Input signal point cloud

Right clicking in the graph area allows you to configure the graph appearance (color and thickness of traces, etc.) and to use the **Lock Candidate Filter** for deselecting unwanted lockpoints. The displayed signal can also be exported as an image. Configure scaling by right-clicking on the axis labels.

At the bottom of the **Signal Display**, you can select the display **Refresh Rate** as well as the **Auxiliary Trace Signal** that is displayed on the right Y-Axis. The **Input Trace Signal**, which is displayed on the left axis, is always the Lock Input signal: you can select it in the Scan & Lock tab (**Lock Settings > Lock Input Signal**). Click **Hold** to freeze the display image.

Display Mode

XY	Signals (Y-direction) are plotted against the scan of the laser (X-direction).
Time	Signals (Y-direction) are plotted against time (X-direction).
Frequency	Frequency mode shows a fast Fourier transform of the signals.

Tools

Zoom	Use the mouse wheel to zoom in or out. Another option to zoom in is to hold the left key of the mouse and drag over the desired area of the graphs from top left to bottom right. Dragging over the graphs from bottom right to top left undoes the last zoom.
Lock Points	Use this tool for showing and selecting lockpoints, etc. (please refer to section 6.15.1). When selected, the **Input Trace Signal** is fixed to the Lock Input signal.

Lock

Enable	Enables/disables the lock.

Lock Status — The **Lock Status** (only in XY mode) shows the actual status of the lock.

Selecting:	Lockpoint candidates are displayed.
Selected:	Lockpoint candidate is selected.
Locking:	Lock is enabled, lockpoint not reached, yet.
Locked:	Laser is locked to the selected lockpoint.
On Hold:	PID outputs are frozen.
Resetting:	PID output channels are reset to zero.
Reset:	PID output channels are on zero level.
Relocking:	A ReLock scan is performed.

NOTE ! When **Lock Without Lockpoint** in the Scan & Lock tab is checked, **Lock Enable** and **Lock Status** are present in every **Display Mode**.

Time Base (only Time mode)	The time base for the Signal Display can be adjusted.
Frequency Base (only in Frequency mode)	The frequency base for the Signal Display can be adjusted.
Display Refresh Rate	Select display refresh rate for the Signal Display.

NOTE ! The actual refresh rate may be limited by the **Scan Frequency** set in the SC Scan Control section of the Laser tab (see section 6.14.1), or the **ReLock Frequency** set in the ReLock section of the ReLock tab (see section 6.16). Keep that in mind when setting very low **Scan Frequency** or **ReLock Frequency** values.

Input Trace Signal	Select input channel for the input trace signal.
Auxiliary Trace Signal	Select input channel for the auxiliary trace signal.
Hold	Freezes the display image when the box is checked.

> Menu > Signal Displays > Wide Scan Display

Adds the Wide Scan Display window to the main area of the screen.

NOTE !	When you display **Wide Scan Display** and **Parameter Trace** windows at the same time, you can display one window at full size in the front for better viewing. Do this by picking the window at the title bar and pulling it in the center of the right screen area. The window to be displayed in the front is then selected by buttons at the bottom of the right display area which are labeled accordingly. Each display window may also be moved to any screen position when picked at the title bar.

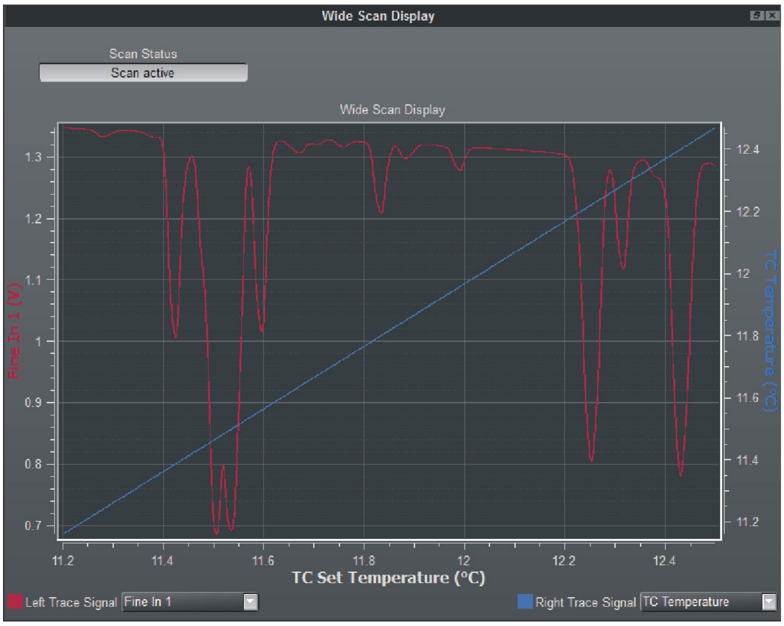


Figure 76 Wide Scan Display showing a molecular absorption spectrum (left/red curve) and the TC Temperature signal (right/blue curve)

NOTE !	The signals displayed on the Wide Scan Display are simultaneously shown on the touch-screen of the DLC pro. When **Scan Shape > Triangle** is selected in the Wide Scan section of the Laser tab (see section 6.14.1), do not use the screen display for analysis, as it shows artifacts. The full resolution of all recorded data points can be exported after right clicking in the graph area of the Wide Scan Display.

The **Wide Scan Display** displays various signals, e.g. for finding resonance frequencies over the entire tuning range of the laser diode.

Turn the **Wide Scan Display** on and off with the Wide Scan Display entry in the Menu. A click with the right mouse key on the **axis label** allows you to select the axis-scale.

Use the mouse wheel to zoom in or out. Another option to zoom in is to hold the left key of the mouse and drag over the desired detail of the graphs from top left to bottom right. Dragging over the graphs from bottom right to top left undoes the last zoom. The display can be shifted right or left by holding the right mouse key. Normally a signal is displayed depending on the laser frequency while the laser is scanned. The **Scan Status** shows the actual status of the wide scan.

Right clicking in the graph area allows you to configure the graph appearance (color and thickness of traces, etc.). The displayed signal can also be exported as an image. Configure scaling by right-clicking on the axis labels.

At the bottom of the Signal Display, you can select the **Left/Red Signal** (left Y-axis) and the **Right/Blue signal** (right Y-axis).

NOTE !	A selected signal is displayed not until after a start of a wide scan.

Scan Status	**Disabled**:	Wide scan is disabled.
	Setting Output Channel to start value:	Wide scan was initiated by the Play button, but has not started, yet. Temperature or wavelength is set to the **Start** value entered in the Wide Scan section of the Laser tab (see section 6.14.1).
	Scan Active:	Wide scan in progress.
	Resetting Output Channel:	Temperature or wavelength is set to the **Set** value entered in the Wide Scan section of the Laser tab (see section 6.14.1).
	Controlled by External Trigger:	**Input Trigger** is enabled and wide scan was initiated. The status message remains until the wide scan is stopped.

Notes on the Functionality of the Wide Scan:

The wide scan precisely scans a laser parameter and simultaneously acquires data on two input channels. It enables recording up to 5 million data points per channel in a scan. Depending on the laser type, users can decide to scan one of the following parameters:

- Set wavelength or piezo voltage for DLC CTL
- Laser diode temperature or current for DLC DFB pro
- Piezo voltage or laser diode current for DLC DL pro
- One of the analog outputs Out A or Out B for any of the above

This scan option also works for lasers that are part of a DLC TA pro/-AL or DLC DL-/TA-SHG/FHG pro system, then the available parameters for scanning are according to the seed lasers. The scan range is limited by the physical boundaries of the chosen parameter to be scanned. E.g. a wide scan of the CTL wavelength is limited by the minimum and the maximum wavelength of the CTL. A wide scan of the temperature of a DFB pro is limited by the tuning properties of the respective laser diode and/or the working range of the thermistor.

In Wide Scan mode, it is recommended not to change the **Set** value of the parameter to be scanned (see section 6.14.1) once the scan has started. For slowly changing parameters, like the laser temperature, please be patient while the laser tunes to the start point of the scan.

In general, the number of data points recorded will be much bigger than the ones displayed on the screen. In order to visualize narrow spectral features, the display actually shows an envelope graph which represents the minimum and maximum values of an interval by a data point each. As the visualization of up to 5 million data points requires quite a bit of computation, the response of the Wide Scan Display can be slower. If the full number of data points is not required, it is recommended to reduce the scan resolution by changing the parameter laser1:wide-scan:recorder-stepsize-set (Params tab, see section 6.24).

It is possible to zoom into the recorded data while the scan is still in progress. Use the **Full Range** button (see section 6.14.1) to return to the full scale display of the scan. A new scan will always start from the set limits, which may differ from the range displayed on the Wide Scan Display, in particular after a zoom.

Once a feature of interest has been found, one may wish to investigate it further, or lock the laser frequency to it. The **Center** button (see section 6.14.1) changes the **Set** value of the parameter to be scanned (e.g., the laser diode temperature, CTL wavelength, …) to the center of the currently zoomed window. Once the change has taken effect, it is possible to switch to Scan/Lock mode (see section 5.3), e.g. for investigating narrow features with a reduced/faster scan or to lock the laser.

Alternatively the **Zoom Range** button (see section 6.14.1) sets the **Start** and **End** values of the wide scan to the left and right borders of the current zoom. The wide scan can then be repeated more slowly and/or with higher resolution.

Note on Thermal Tuning of a DFB pro Laser:

The Wide Scan mode offers a very high temperature resolution: 1 bit corresponds to 1.4×10^{-6} K. The actual temperature resolution may differ, due to electronic noise and the properties of the TEC in the diode package. The effective temperature resolution is on the order of 50 µK.

The limits of a wide scan are ultimately given by the measurement range of the thermistor inside the laser head, which typically works from 2.2 °C to 51.8 °C.

The useable temperature range of a specific DFB laser depends on the characteristics of the respective diode: When the temperature is tuned, the gain of the semiconductor medium typically shifts about 4 times faster than the grating-defined lasing wavelength. This may cause the diode to jump into a “free-running” (i.e. no longer frequency-stabilized) operation mode at the gain maximum. These operation regimes are excluded by TOPTICA, by restricting the temperature range accordingly.

> Menu > Parameter Trace Adds the Parameter Trace window to the main area of the screen.

NOTE !	When you display **Signal Display** and **Parameter Trace** windows at the same time, you can display one window at full size in the front for better viewing. Do this by picking the window at the title bar and pulling it in the center of the right screen area. The window to be displayed in the front is then selected by buttons at the bottom of the right display area which are labeled accordingly. Each display window may also be moved to any screen position when picked at the title bar.

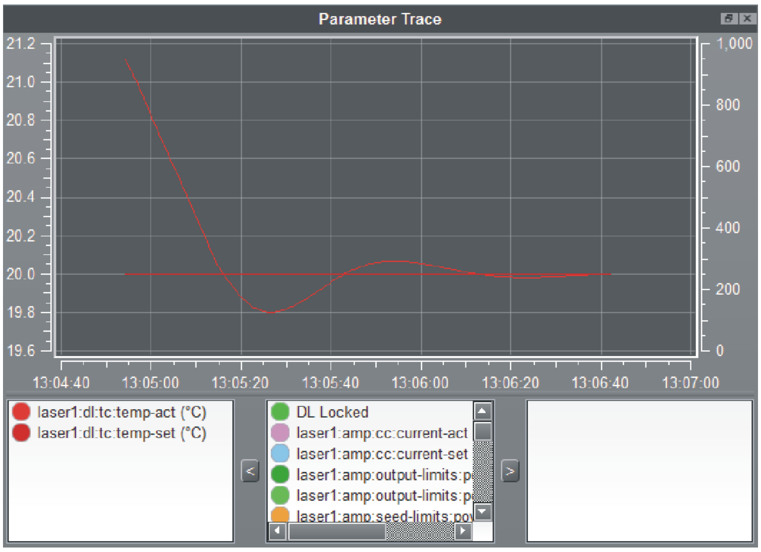


Figure 77 Parameter Trace Window

The Parameter Trace window displays user selectable parameters over time. You can turn this window on and off with the Parameter Trace entry in the Menu. Please note that the minimum sample interval is 0.5 seconds.

Select a parameter from the list in the center window below the display screen and click **<** or **>** to display it and to select whether the corresponding axis labelling is shown on the left or the right.

Click the right mouse key in the **display screen**, to access several useful functions such as customizing the display setup or exporting data. Click the right mouse key on the **axis label** to select the axis scale (y-axis) or the displayed time range (x-axis).

NOTE !	Please make sure that there is no automatic clock change of the control computer during a running measurement !

> Menu > Optimization Tools >Lock Wizard Starts a Lock Wizard session for Top of Fringe locking.

NOTE !	For using the Lock Wizard, a Lock option license is required. When a Lock option license is acquired, TOPTICA provides an option license key via e-mail or USB flash drive. The license key must be activated via the TOPAS DLC pro PC-GUI (please refer to section 10.19).

The Lock Wizard (only available for the Top of Fringe (Lock-In) lock type) is an interactive tool which helps to set-up a Top of Fringe lock. The tool consists of the Signal Display (see Figure 73) and a series of windows which guide you through the steps described in sections 5.3.10, 6.15.3 and 7.3.2. To ensure a convenient lock set-up, commands are executed automatically and individual parameters are set automatically, for others standard values are specified.

Next > /< Back	Buttons to navigate between the different lock instruction steps (windows), where different groups of lock-relevant parameters are specified.
Close	Closes the Lock Wizard session without saving parameters.
Finish	Only available in the last instruction window. Clicking saves the lock settings and closes the Lock Wizard session.

NOTE !	If the Lock Wizard does not complete successfully, or is interrupted, a special configuration, which is stored at the start of the Lock Wizard, is loaded.

> Menu > Optimization Tools > Bode Plots

Adds a display window for transfer functions of the PID controllers to the main area of the screen.

NOTE !	For displaying the Bode Plots, a Lock option license is required. When a Lock option license is acquired, TOPTICA provides an option license key via e-mail or USB flash drive. The license key must be activated via the TOPAS DLC pro PC-GUI (please refer to section 10.19).

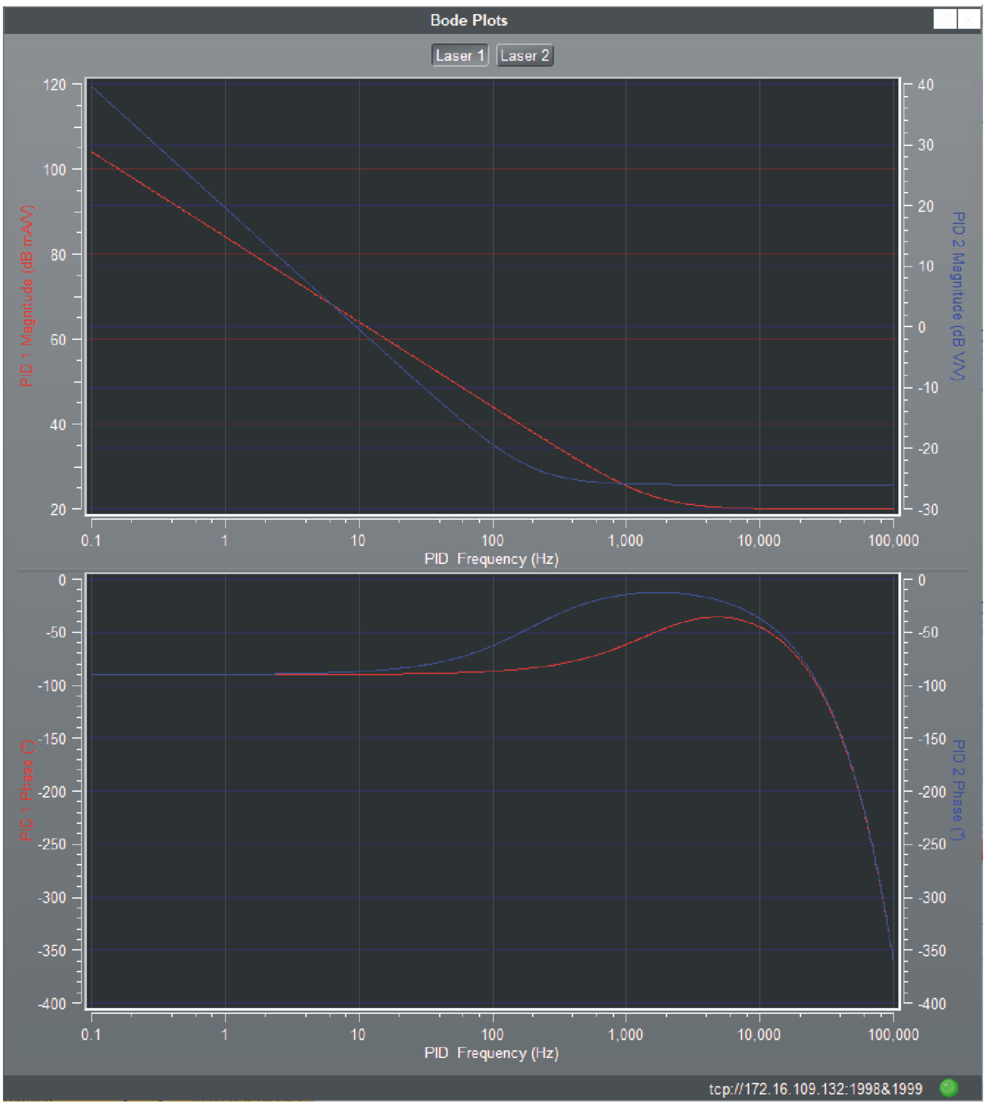


Figure 78 Bode Plots window (example DLC pro for Dual-Laser-Operation)

The depicted Bode Plots give information about the frequency-dependent transfer functions for the PID controllers of the DLC pro (provided with the lock option). The transfer functions will illustrate the gain settings of the PID controllers (overall, proportional, integral, differential, and cut-off frequencies).

The input signals of the transfer functions depend on the lock type. With Side of Fringe selected, the input is the Lock Input Signal while for Top of Fringe, the input is the Lock-In Output Signal, as shown in the TOPAS DLC pro PC-GUI.

The output signals of the transfer functions are the outputs of the corresponding PID controllers which are PID 1 and PID 2.

Magnitude and phase of these transfer functions are displayed over frequency in the upper and lower graph, respectively.

NOTE !	Be aware that parts of the system transfer function, such as piezo elements, will add to the PID controller transfer functions and may act as low-pass filters in the overall feedback loop.

> Menu > Optimization Tools > Motor Calibration Laser 1/2

Opens the Motor Calibration window to perform a wavelength calibration of the optional motorized wavelength control Motor pro.

NOTE !	The Motor Calibration Laser 1/2 menu entry is only available in user level MAINTENANCE and with the HighFinesse wavelength meter software installed.

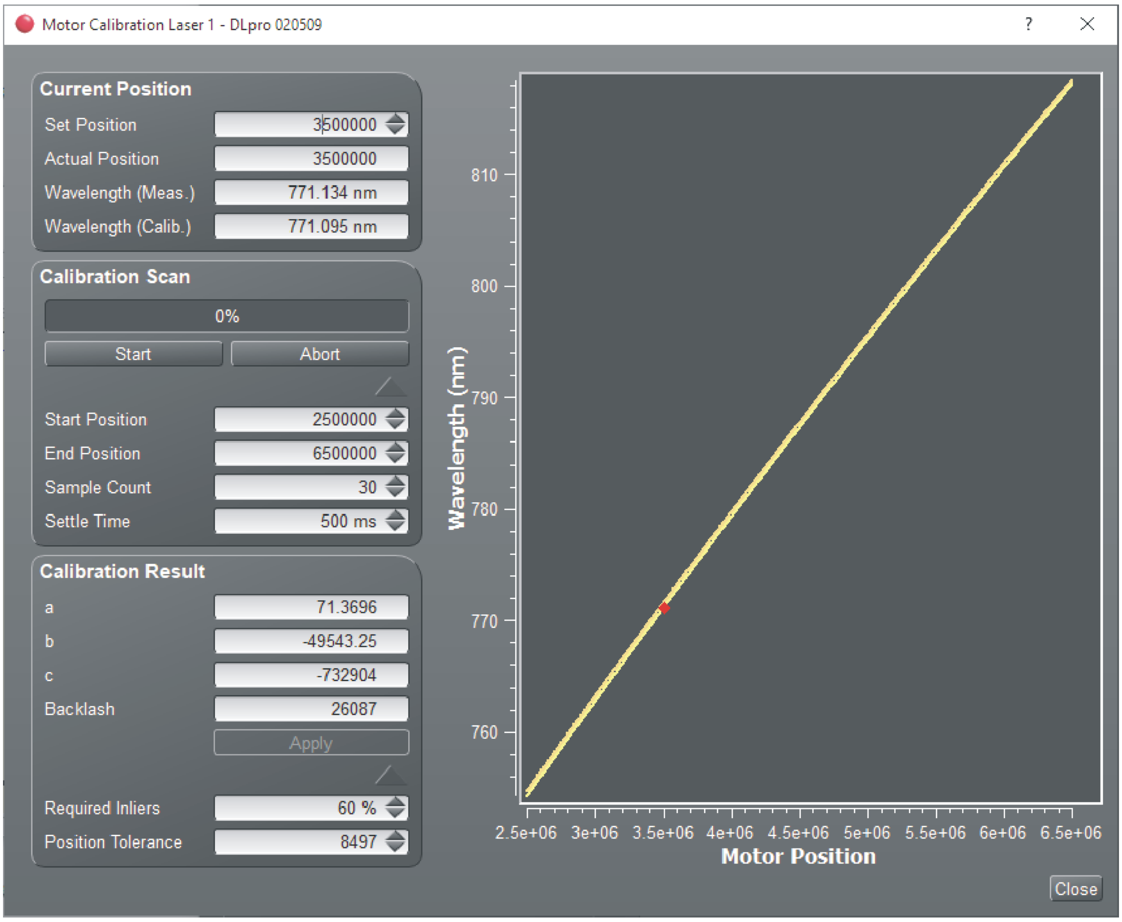


Figure 79 Motor Calibration window

For a detailed description of the operator controls and performing a wavelength calibration, please refer to the Motor pro manual.

> Menu > Communication Adds the Communication window to the main area of the screen.

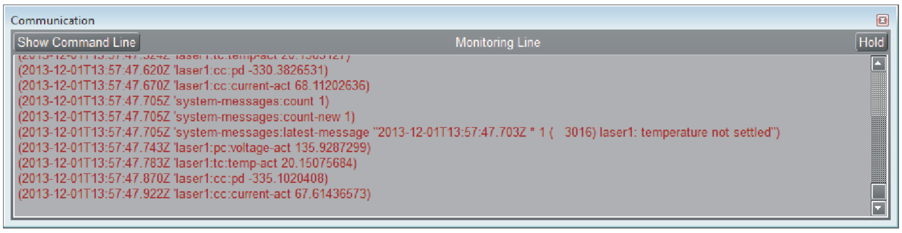


Figure 80 Communication Window

Communication Window Shows details on the communication between TOPAS DLC pro and the DLC pro.

Hold Freezes the display of the communication. Click **Hold** again to continue the display.

Show Monitoring Line/ Show Command Line Toggles between displaying the communication on the monitoring line or on the command line.

> Menu > About The About window opens, which provides information about the manufacturer, contact details, software version, etc.

> Menu > Exit Closes the TOPAS DLC pro software without saving the most important parameters set in the Params tab.

NOTE !	To store the configuration set in the Params tab, please use **Menu > Save Configuration**.

6.12 Menu (DLC DL-/TA-SHG/FHG pro)

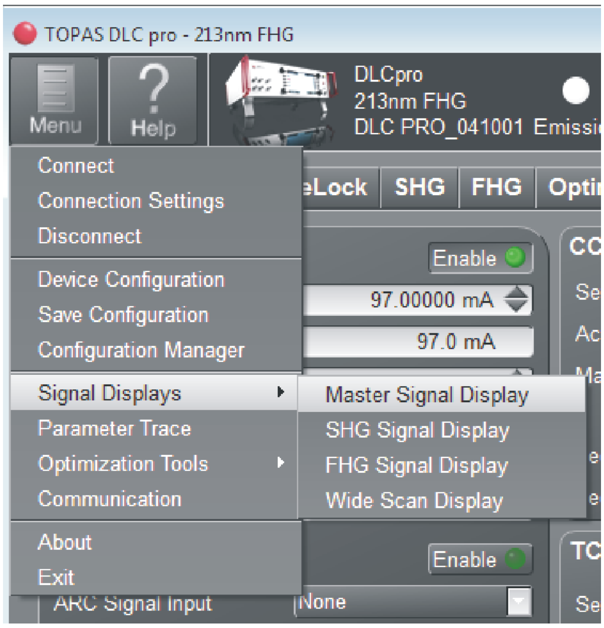


Figure 81 Menu (example DLC DL-/TA-FHG pro)

The standard TOPAS DLC pro menu is described in section 6.11. The DLC DL-/TA-SHG/FHG pro specific menu items are described below.

> Menu > Signal Displays > Master Signal Display

Adds the Signal Display window for the Master Oscillator of the DL-/TA-SHG/FHG pro laser head to the main area of the screen (please refer to the Signal Display description in section 6.11).

> Menu > Signal Displays > SHG Signal Display/FHG Signal Display

Adds the Signal Display window for the SHG/FHG cavity of the DL-/TA-SHG/FHG pro laser head to the main area of the screen.

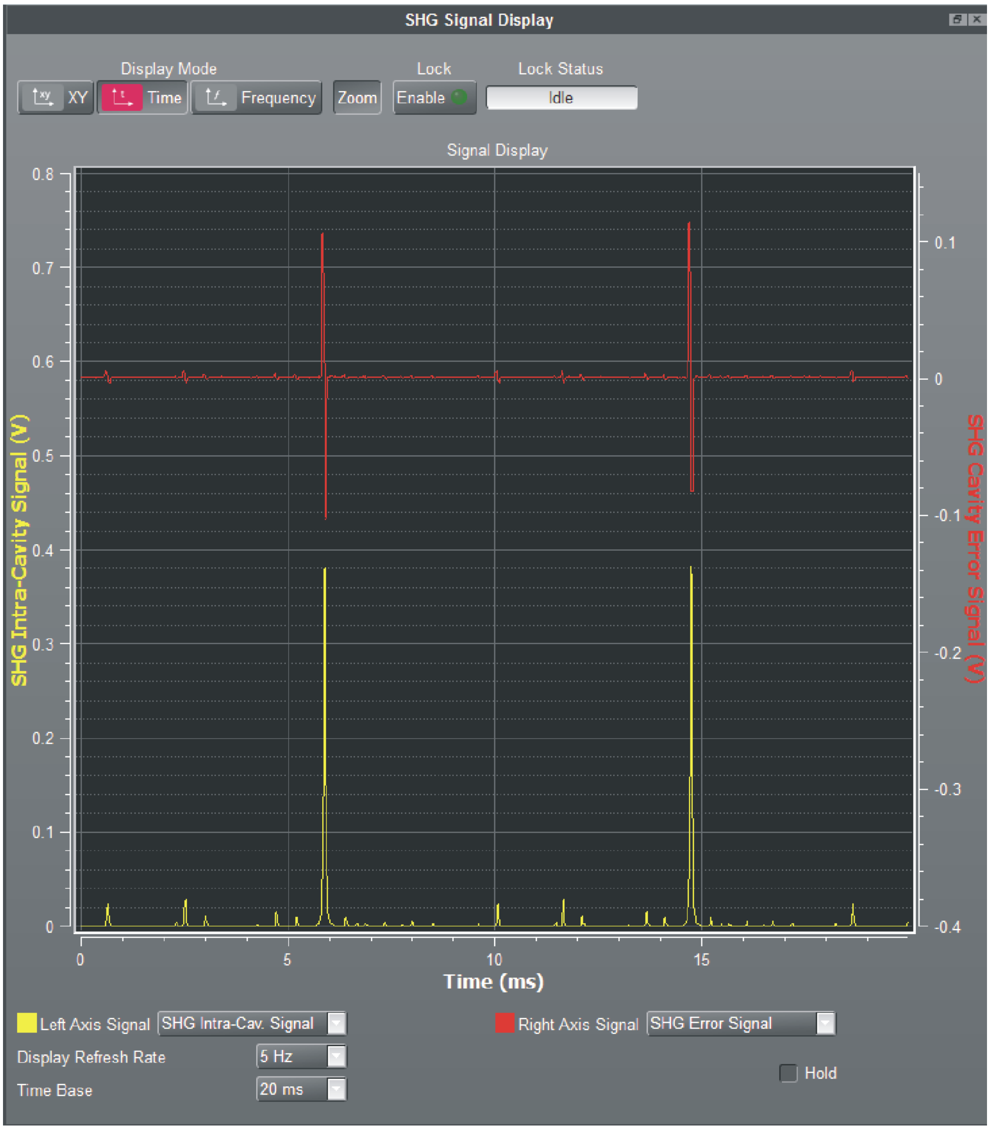


Figure 82 Example: SHG Signal Display (DLC DL-/TA-SHG pro) showing the SHG Intra-Cavity Signal (yellow trace) and the SHG Error Signal (red Trace)

Please refer to the Signal Display description in section 6.11. Note that the Lock Points tool is not available in the SHG/FHG Signal Display.

Lock

Enable Enables/disables the cavity lock.

Lock Status The **Lock Status** (only in XY mode) shows the actual status of the cavity lock.

Idle: Cavity scan disabled or cavity piezo is scanning.
Locking: Cavity lock is enabled, lock not reached, yet.
Locked: Cavity is locked.

Left Axis Signal Select input channel for the Left Axis signal.

Right Axis Signal Select input channel for the Right Axis signal.

> Menu > Signal Displays > Wide Scan Display

Adds the Wide Scan Display window for the Master Oscillator of the DL-/TA-SHG/FHG pro laser head to the main area of the screen (please refer to the Wide Scan Display description in section 6.11).

> Menu > Optimization Tools > Optimization Progress Monitor

Adds the Optimization Progress Monitor window to the main area of the screen (only available when the DL-/TA-SHG/FHG pro is equipped with the AutoAlign option (motorized mirrors)).

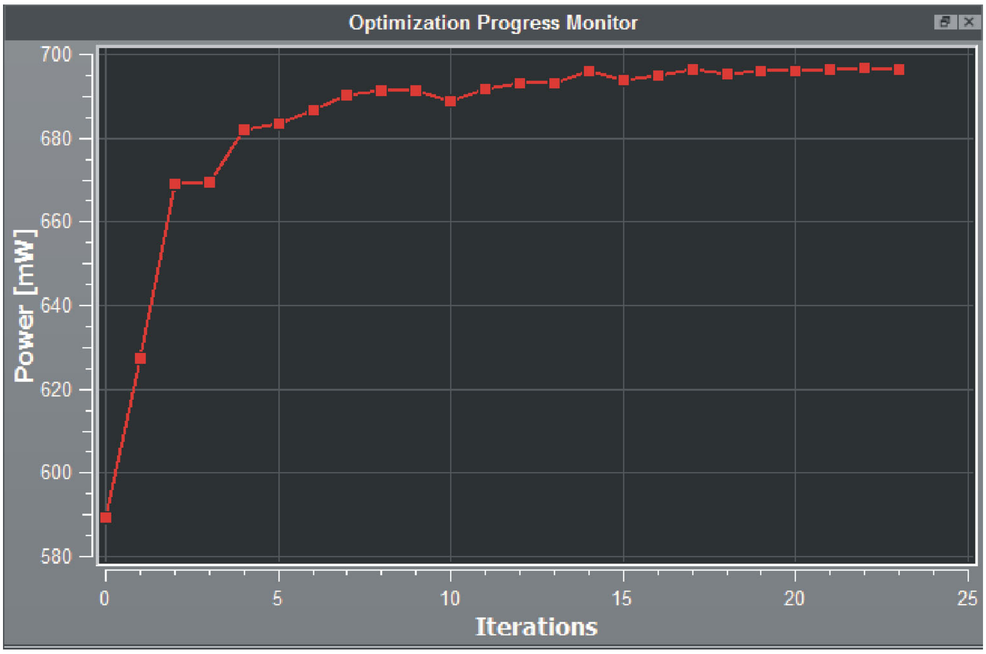


Figure 83 Optimization Progress Monitor window (DLC DL-/TA-SHG/FHG pro with AutoAlign option)

The Optimization Progress Monitor shows the progress of the power optimization procedure which is selected and started in the Optimization/Stabilization tab of the TOPAS DLC pro PC-GUI or in the Optimization/Stabilization sub menu which is available on the touchscreen after pressing the **Home** button. The optimization progress is displayed in different colors:

TA Power	red	(only DLC TA-SHG/FHG pro)
SHG Power	blue	
FHG Power	green	(only DLC DL-/TA-FHG pro)
Fiber Power	white	(only with option FiberMon)

> Menu > Optimization Tools > Bode Plots

Adds a display window for transfer functions of the PID controllers to the main area of the screen.

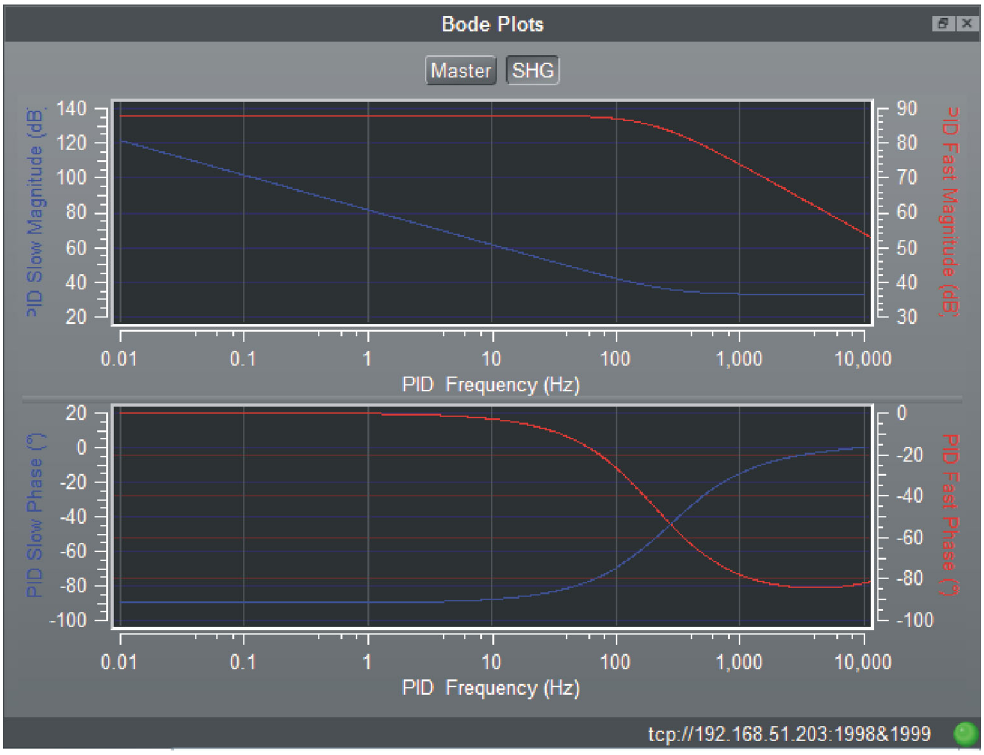


Figure 84 Bode Plots window (example DLC DL-/TA-SHG pro)

The depicted Bode Plots give information about the frequency-dependent transfer functions for the PID controllers of the DLC pro (provided with the lock option for the Master Oscillator) and of the SHG/FHG Cavity Lock paths. The transfer functions will illustrate the gain settings of the PID controllers (overall, proportional, integral, differential, and cut-off frequencies).

For the Master Oscillator lock - provided with the lock option - , the input signals of the transfer functions depend on the lock type. With Side of Fringe selected, the input is the Lock Input Signal while for Top of Fringe, the input is the Lock-In Output Signal, as shown in the TOPAS DLC pro PC-GUI. For the SHG/FHG cavity lock, the input is the SHG/FHG Error Signal.

The output signals of the transfer functions are the outputs of the corresponding PID controllers which are PID 1 and PID 2 for the Master Oscillator lock (**Master**) and PID Slow and PID Fast for the SHG/FHG cavity lock (**SHG/FHG**).

Magnitude and phase of these transfer functions are displayed over frequency in the upper and lower graph, respectively.

NOTE !	Be aware that parts of the system transfer function, such as piezo elements, will add to the PID controller transfer functions and may act as low-pass filters in the overall feedback loop.

NOTE !	While the slow SHG/FHG cavity piezo element has a responsivity of 300 nm per Volt, the fast SHG/FHG cavity piezo element changes the cavity's round-trip length by only 30 nm per Volt. Besides, the voltage of the fast SHG/FHG cavity piezo element passes an additional amplifier with a gain of 2. These factors will add to the magnitude of the corresponding transfer functions.

6.13 Help

Click to open a pdf version of this DLC pro manual.

6.14 Laser Tab

6.14.1 DLC pro for Laser Head DL pro

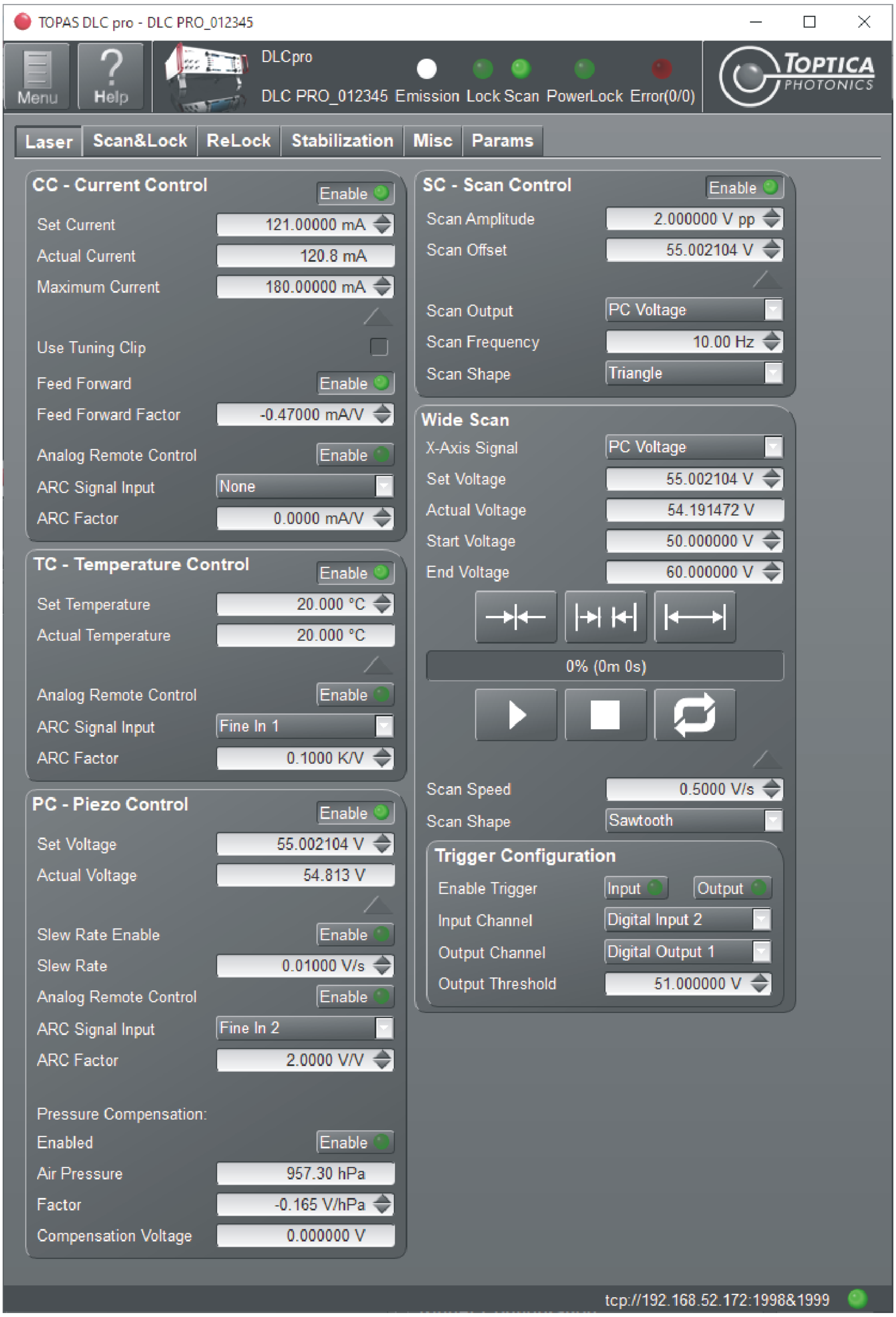


Figure 85 Laser tab (DLC DL pro)

CC Current Control

Enable	Activates/deactivates the Current Control.
Set Current	Input field for set current I_{set}.
Actual Current	Display field for actual current I_{act}. The actual current is measured with low accuracy for monitoring purposes and fault detection.

NOTE ! The Actual Current differs from the Set Current due to the Feed Forward and offsets added by PIDs.

Maximum Current	Input field for maximum current I_{max}.
Use Tuning Clip	Checking the box limits the laser diode current to the Maximum Tuning Current. In case this Maximum Tuning Current is lower than the entry in the **Maximum Current** field, this field changes to **Maximum Tuning Current** (display only).

CAUTION ! **Laser heads with Motor pro option**: Checking the **Use Tuning Clip** boxes for diode laser and amplifier (depending on the connected laser head) in the CC section(s) of the Laser tab (for amplifier see also section 6.14.6) is **mandatory** before performing a motor scan. This avoids damage to the laser diode and amplifier during a motor scan.

Click the triangle in the CC Section to access advanced setting options for the Feed Forward and Analog Remote Control of the laser frequency.

Feed Forward Enable	Activates/deactivates the Feed Forward, i.e. a change of the laser diode current proportional to the change of the piezo voltage due to the scan.
Feed Forward Factor	Scaling parameter of the Feed Forward in mA/V.
Analog Remote Control Enable	Activates/deactivates the Analog Remote Control. Please refer to section 10.10.1 for an example on how to configure the CC Analog Remote Control.
ARC Signal Input	Specify the BNC connector for the external remote control voltage.
ARC Factor	Specify the conversion factor for converting the remote control voltage [V] into a CC output offset [mA].

TC Temperature Control

Enable	Activates/deactivates the Temperature Control.
Set Temperature	Input field for set temperature T_{set}.
Actual Temperature	Display field for actual temperature T_{act}.

Click the triangle in the TC Section to access advanced setting options for the Analog Remote Control of the laser frequency.

Analog Remote Control Enable	Activates/deactivates the Analog Remote Control. Please refer to section 10.10.1 for an example on how to configure the TC Analog Remote Control.
ARC Signal Input	Specify the BNC connector for the external remote control voltage.
ARC Factor	Specify the conversion factor for converting the remote control voltage [V] into a TC output offset [K].

PC Piezo Control

Enable	Activates/deactivates the Piezo Control.
Set Voltage	Input field for a DC offset voltage which is applied to the piezo.

NOTE !	When the SC **Scan Output** (see below) is directed to **PC Voltage**, the value is identical to SC **Scan Offset**.

Actual Voltage	Display Field for internally measured voltage which is currently applied to the piezo. The actual piezo voltage is measured with low accuracy for monitoring and fault detection.

Click the triangle in the PC section to access advanced setting options.

Slew Rate Enable	Enable/Disable slew rate limiting feature. It allows to limit the rate of change of the output signal to the value set by **Slew Rate**
Slew Rate	Set slew rate (maximum rate of change) of PC output.
Analog Remote Control Enable	Activates/deactivates the Analog Remote Control. Please refer to section 10.10.1 for an example on how to configure the CC Analog Remote Control.
ARC Signal Input	Specify the BNC connector for the external remote control voltage.
ARC Factor	Specify the conversion factor for converting the remote control voltage [V] into a PC output offset [V].
Pressure Compensation Enable	Enable/Disable the air pressure compensation to improve the long term stability of the laser frequency.
Air Pressure	Shows averaged air pressure.
Factor	Factor for linear pressure compensation.

NOTE !	Please refer to section 10.11 for further information on the pressure compensation.

Compensation Voltage	Shows pressure compensation voltage.

SC Scan Control

NOTE !	For displaying a signal depending on the laser scan on the screen of your PC, please use the **Signal Display** on the main menu.

Enable Activates/deactivates the frequency scan of the laser.

NOTE !	Activating the scan is only possible when the laser is not locked. Please note that the **Scan Offset** is applied to the piezo even if the SC is disabled.

Scan Amplitude Peak-to-peak amplitude. The unit is dependent on the **Scan Output**.

Scan Offset DC signal level. The unit is dependent on the **Scan Output**.

Click the triangle below to access advanced setting options.

Scan Output Select output channel to which the generated signal is directed.
PC Voltage:
Scan signal is directed to the Piezo Control module and the piezo voltage is scanned.
CC Current:
Scan signal is directed to the Current Control module and the laser current is scanned.
Out A:
Scan signal is directed to the Out A BNC-connector on the DLC pro front panel.
Out B:
Scan signal is directed to the Out B BNC-connector on the DLC pro front panel.

Scan Frequency Set repetition frequency of the chosen waveform in Hz.

Scan Shape Select type of the generated waveform (sine or triangle). Default setting is triangle.

Wide Scan

X-Axis Signal Select X-axis signal for the Wide Scan Display (see section 6.11).
The X-axis signal is the parameter to be scanned. Available signals depend on the laser head type.

NOTE !	When Analog Remote Control (ARC) for the selected **X-Axis signal** is enabled in the corresponding sections of the Laser tab, the ramp of the wide scan is superimposed by the ARC signal. This may lead to distorted visualization at Wide Scan Display.

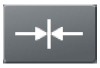
Set <value> Set value [mA, V, °C, nm] of the parameter to be scanned.

Actual <value> Actual value [mA, V, °C, nm] of the parameter to be scanned when wide scan is running.

Start <value> Start value [mA, V, °C, nm] of the parameter to be scanned.

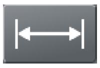
End <value> End value [mA, V, °C, nm] of the parameter to be scanned.

Buttons



Center: Click to set the **Set** value (e.g., the laser diode temperature) to the center value of the actual detail of the Wide Scan Display (X-axis). The display of **Actual** value will change accordingly.

Zoom Range: Select to set the **Start** and **End** value (e.g., the laser diode temperature) to the outer values of the actual detail of the Wide Scan Display (X-axis). The display of **Start** and **End** value will change accordingly.



Full Range: Click to scale the Wide Scan Display so that the entire wide scan from **Start** value to **End** value is displayed.

Play: Wide scan is initiated with the set **Scan Speed**.

Play Trigger: The icon in the Play button indicates that the wide scan is initiated by a input trigger signal and not by tapping the Play button (**Trigger Input** enabled).
After tapping the Play Trigger symbol, the **Start** <value> of the parameter to be scanned is accessed. The wide scan then is initiated with the set **Scan Speed** when a trigger signal is applied to the selected trigger **Input Channel**.
When the trigger signal is removed, the wide scan continues until the **End** <value> is reached. Tap the Stop symbol to discontinue the wide scan.

Stop: Wide scan is stopped.

Repeat: Wide scan is continuously repeated within the set values. The **Scan Shape** for a repeated wide scan can be selected in the respective pop-up menu.

Progress Bar — Displays the progress of the wide scan and the remaining time.

Scan Speed — Enter wide scan speed in [mA/s, V/s, K/s, nm/s].

NOTE !	A high **Scan Speed** together with a small laser1:wide-scan:recorder-stepsize-set (Params tab, see section 6.24) leads to a higher laser1:recorder:sampling-rate. At a sampling-rate above 100 kHz, dropouts during recording may occur.

Scan Shape — Select scan shape (triangle or sawtooth) for a repeated wide scan. Default setting is **Triangle**.
Sawtooth: Return to the start value is performed as fast as possible.
Triangle: Return to the start value is performed with **Scan Speed**.

Trigger Configuration

Enable Trigger Input/Output	Enable wide scan input or output trigger. **Input trigger:** Wide scan is initiated by an external trigger signal applied to Digital Input 2 or 3 of the Digital I/O connector on the MC+ module (see section 10.9.4). **Output Trigger:** At the **Output Threshold** of a wide scan a trigger signal is applied to Digital Output 1 or 3 of the Digital I/O connector on the MC+ module (see section 10.9.4).

NOTE !	Digital Output 1 or 3 must be configured for wide scan trigger in the Params tab (please refer to sections 9.2.3 and 6.24): The parameter io:digital-out1 or 3:mode must be set to 2.

Input Channel	Select input channel (pin of the Digital I/O connector on the MC+ module, see section 10.9.4) for input trigger.
Output Channel	Select output channel (pin of the Digital I/O connector on the MC+ module, see section 10.9.4) for output trigger.
Output Threshold	Output trigger threshold in [mA, V, K, nm]. Trigger output level is high if current value is above threshold value and low otherwise.

6.14.1.1 Synchronized Scanning of Lasers

At a DLC pro for Dual-Laser-Operation (see section 1.3) the scan of the two connected lasers can be synchronized. The settings for the synchronization can be performed in the Params tab of the TOPAS DLC pro PC-GUI (see section 6.24) or via software commands (see section 10.13).

laser-common:scan:sync-laser1/2	Select the lasers to be synchronized.
laser-common:scan:frequency	Enter the common scan frequency.
laser-common:scan:sync	When the command is executed, the scan generators of all selected lasers are set to the common scan frequency.
laser-common:scan:save	Save the scan-synchronization settings to be used after the next DLC pro boot procedure.

When the scan is enabled by clicking **Enable** in the SC Scan Control section of the Laser tab, the scans of the selected lasers then are started simultaneously and the lasers are scanned with the same frequency, and with zero relative phase-shift.

6.14.2 DLC pro for Laser Head DL pro FL with Intra-Cavity EOM

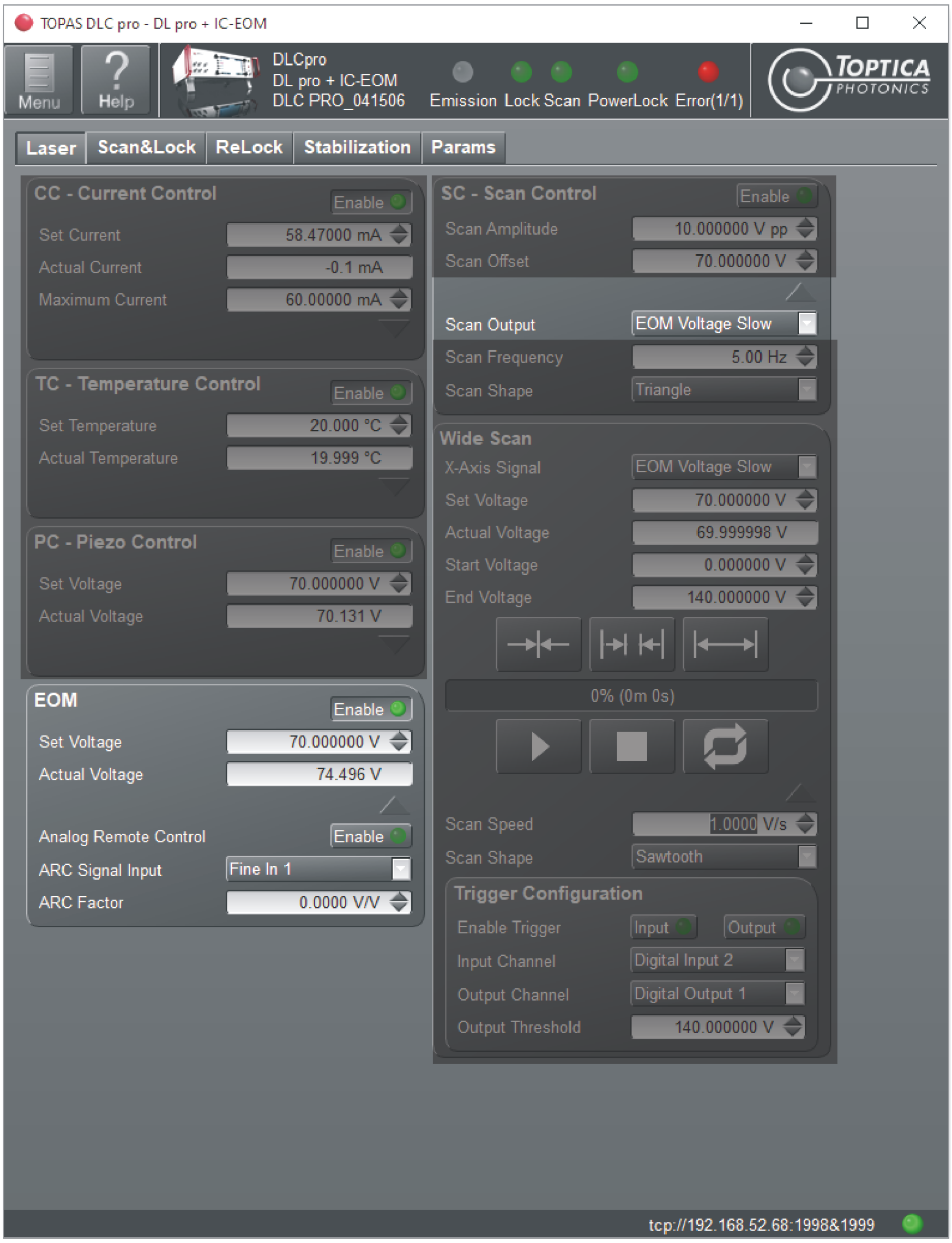


Figure 86 Laser tab (DLC DL pro FL with intra-cavity EOM)

As an option, an intra-cavity EOM can be integrated into the resonator of a DL pro laser head (DL pro FL). The voltage of the slow electrode of the intra-cavity EOM is controlled via one channel of a PC module. The operation and control of the respective laser head is unchanged and control for the slow electrode of the intra-cavity EOM is added in the EOM section of the Laser tab. For description of the operator controls, please refer to the Laser tab of the DL pro (see section 6.14.1).
Specific information on operation of the DL pro with intra-cavity EOM are noted below.

CAUTION !	Please refer to the DL/TA pro FL manual for details about how to connect and power up/down the laser head correctly.

EOM

Enable	Activates/deactivates the EOM slow control.
Set Voltage	Input field for a DC offset voltage which is applied to the slow electrode of the EOM.
Actual Voltage	Display Field for internally measured voltage which is currently applied to the slow electrode of the EOM. The actual EOM voltage is measured with low accuracy for monitoring and fault detection.

Click the triangle in the EOM section to access advanced setting options.

Analog Remote Control Enable	Activates/deactivates the Analog Remote Control. Please refer to section 10.10.1 for an example on how to configure the EOM Analog Remote Control.
ARC Signal Input	Specify the BNC connector for the external remote control voltage.
ARC Factor	Specify the conversion factor for converting the remote control voltage [V] into a PC output offset [V] for the intra-cavity EOM.

SC Scan Control

Click the triangle to access advanced setting options.

Scan Output	Select output channel to which the generated signal is directed. **EOM Voltage Slow:** Scan signal is directed to the Piezo Control module for the intra-cavity EOM and the voltage applied to the slow electrode of the intra-cavity EOM is scanned.

6.14.3 DLC pro for Laser Head DL pro with Motor pro Option

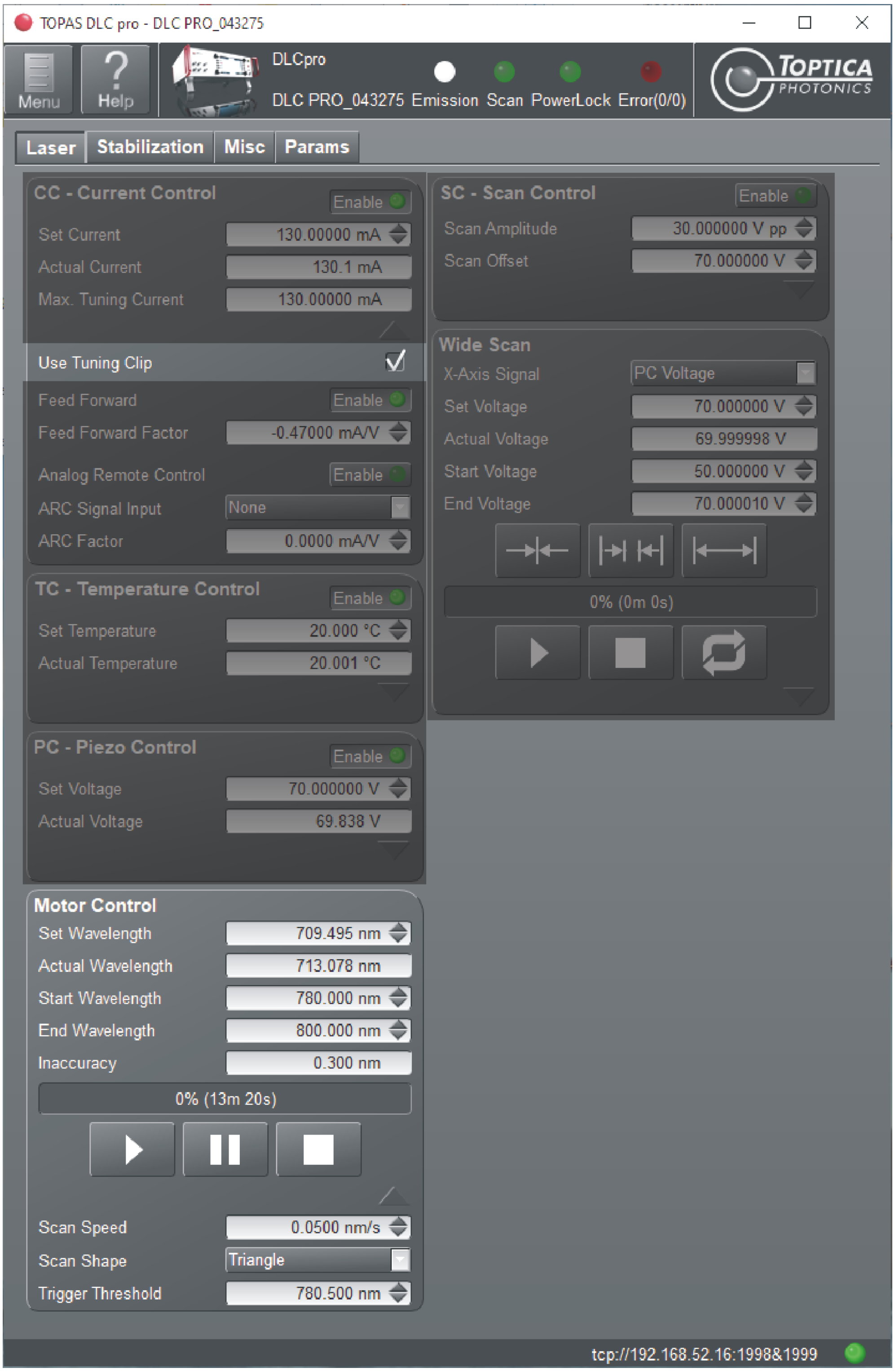


Figure 87 Laser tab (DLC DL pro with Motor pro option)

The Motor pro option for DL pro laser heads or DL pro Master Oscillators of amplified laser heads allows to quickly tune the laser to a new wavelength within its tuning range by moving the internal grating of the DL pro by a motor drive. Please refer to the DL pro laser head manual and the Motor pro manual for detailed description.

The operation and control of the laser head with Motor pro option is unchanged and control for the motor drive is added in the Motor Control section of the Laser tab. For description of the operator controls, please refer to the Laser tab of the DL pro (see section 6.14.1). Specific information on operation of the DL pro with Motor pro option are noted below.

Motor Control

NOTE !	All wavelengths in the Motor Control section are internally converted into motor step positions, so the wavelength accuracy mainly depends on the stored calibration data. Please refer to section 6.11 (**Menu > Optimization Tools > Motor Calibration Laser 1/2**) and to the Motor pro manual for instructions to perform a wavelength calibration.

Set Wavelength — Set desired target wavelength.

Actual Wavelength — Displays actual wavelength as calculated from the current motor position.

Start Wavelength — Start wavelength for a motor scan.

End Wavelength — End wavelength for a motor scan.

NOTE !	Please note that the motor drive can move the internal grating of the DL pro into positions, where the laser does not emit light. Please refer to the Production and Quality Control Data Sheet of the connected laser head for its wavelength range.

Inaccuracy — Displays the expected deviation of the **Actual Wavelength** from a measured wavelength, due to mechanical tolerances and other influences.

Buttons

Play: The **Start Wavelength** is accessed and the motor scan is initiated with the set **Scan Speed**.
After the scan is finished, the laser returns to the **Set Wavelength**.

CAUTION !	Checking the **Use Tuning Clip** boxes for diode laser and amplifier (depending on the connected laser head) in the CC section(s) of the Laser tab (see sections 6.14.1 and 6.14.6) is **mandatory** before performing a motor scan. Checking the box(es) reduces the laser diode (and amplifier) currents to the Maximum Tuning Currents to avoid damage to the laser diode (and the amplifier) during a motor scan.

Pause: Motor scan is paused. Tap **Play** to continue the motor scan.

Stop: Motor scan is stopped and the laser returns to the **Set Wavelength**.

Progress Bar Displays the progress of the Motor scan and the remaining time.

Scan Speed Enter Motor scan speed in [nm/s].

Scan Shape Select scan shape (triangle or sawtooth) for a repeated Motor scan. Default setting is **Triangle**.
Sawtooth: Return to the **Start Wavelength** is performed as fast as possible.
Triangle: Return to the **Start Wavelength** is performed with **Scan Speed**.

Trigger Threshold Enter output trigger wavelength [nm]. Trigger output level is high if **Actual Wavelength** is above threshold wavelength, and low if **Actual Wavelength** is below threshold wavelength. The trigger output is available at the Dig I/O D-Sub 15 HD connector at the Motor pro module (please refer to the Motor pro module for details).

6.14.4 DLC pro for DFB pro

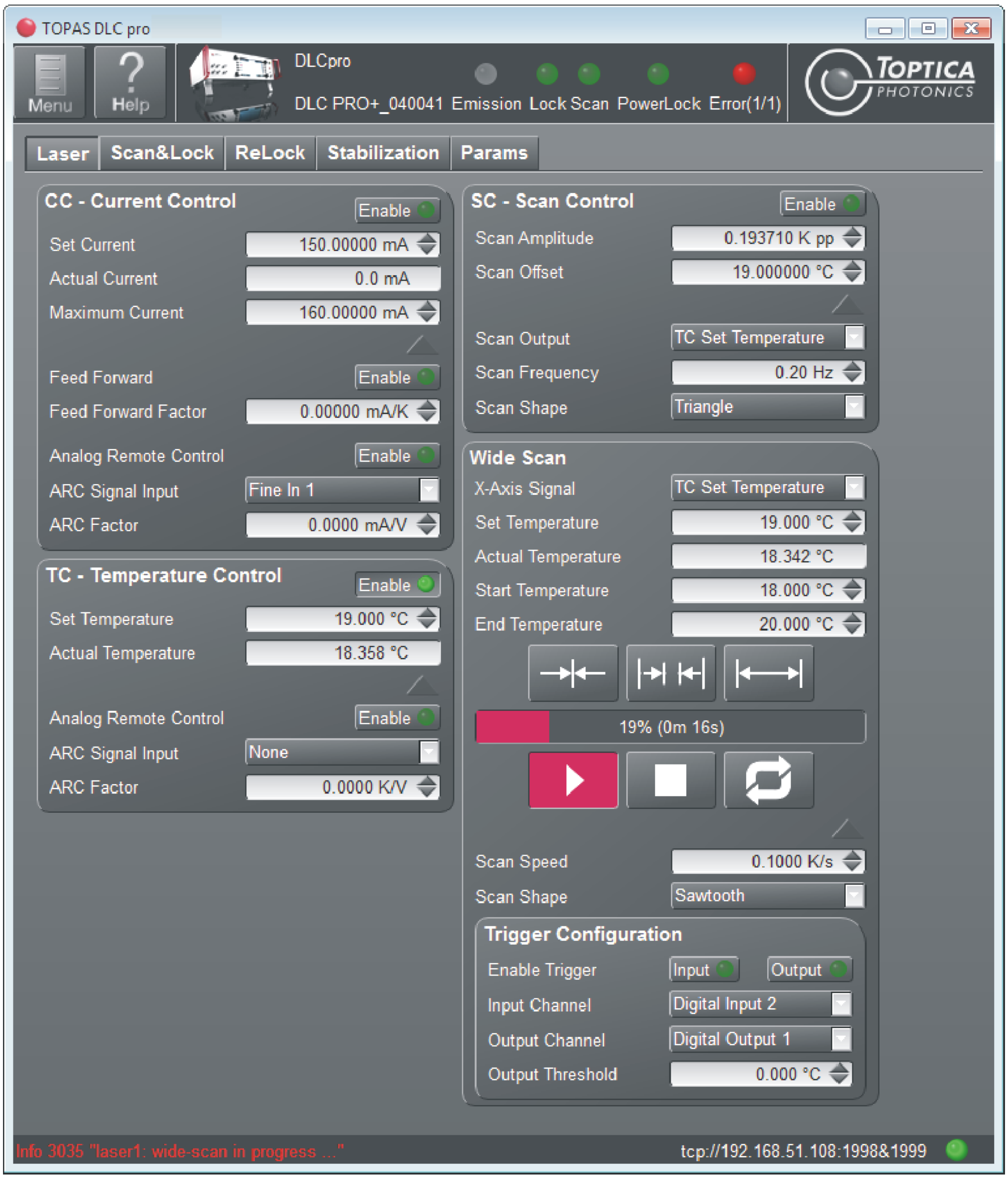


Figure 88 Laser tab (DLC DFB pro)

NOTE !	The DLC DFB pro Laser tab is present if a DFB pro laser head or a laser system with a DFB pro Master Oscillator is connected to the DLC pro.

The Laser tab comprises the operator controls for the DFB pro laser and the wide scan. As the DFB pro laser is operated like a DL pro laser head, please refer to section 6.14.1 for description of the basic CC-, TC, SC and Wide Scan operator controls. All DFB pro specific operator controls are described below.

CC Current Control

Feed Forward Factor	Scaling parameter of the Feed Forward in mA/K.

SC Scan Control

Scan Output	**TC Set Temperature** For DFB pro laser heads, **PC Voltage** is not available as output channel. When **TC Set Temperature** is selected, the scan signal is directed to the Temperature Control module and the laser diode temperature is scanned.

6.14.5 DLC pro for Laser Head CTL

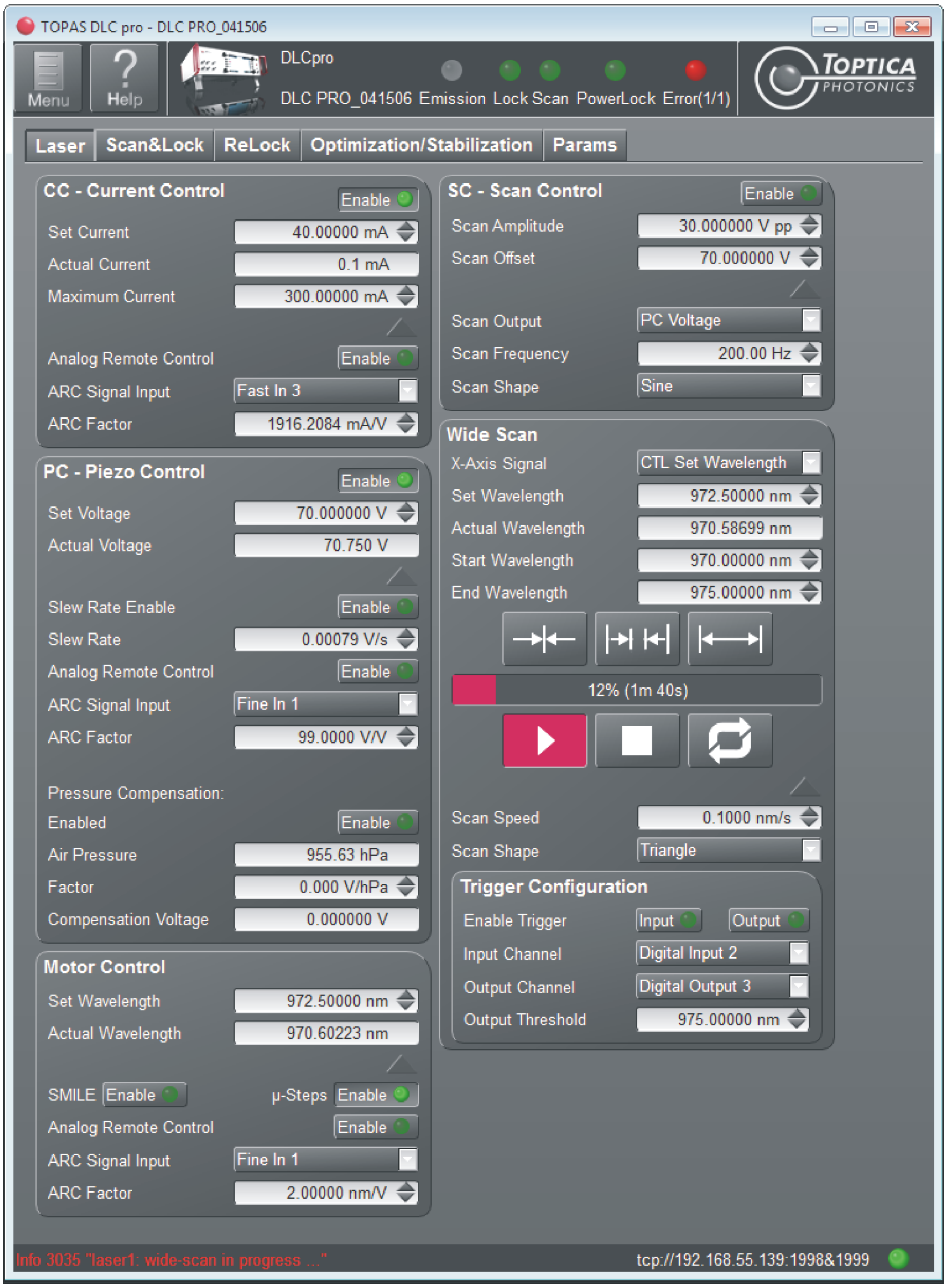


Figure 89 Laser tab (DLC CTL)

The Laser tab comprises the operator controls for the laser and the Motor Control section. As the laser is operated like a DL pro laser head, please refer to section 6.14.1 for description of the basic CC-, PC, SC and Wide Scan operator controls. All CTL specific operator controls are described below.

Motor Control

Set Wavelength	Input field for set wavelength.
Actual Wavelength	Display field for actual wavelength.
SMILE Enable	Enable the Single Mode Intelligent Loop Engine. For details please refer to the CTL manual.
μ-Steps	When enabled the scan motor is able to perform so-called microsteps (< 1 pm) while scanning. By default, these microsteps are enabled, but are automatically disabled for fast scans.
Analog Remote Control Enable	Activates/deactivates the Motor Analog Remote Control. Please refer to section 10.10.2 for an example on how to configure the Motor Analog Remote Control.
Input	Specify the BNC connector for the external remote control voltage.
Factor	Specify the input sensitivity factor for converting the remote control voltage [V] into a wavelength [nm].

6.14.6 DLC pro for Laser Head TA pro

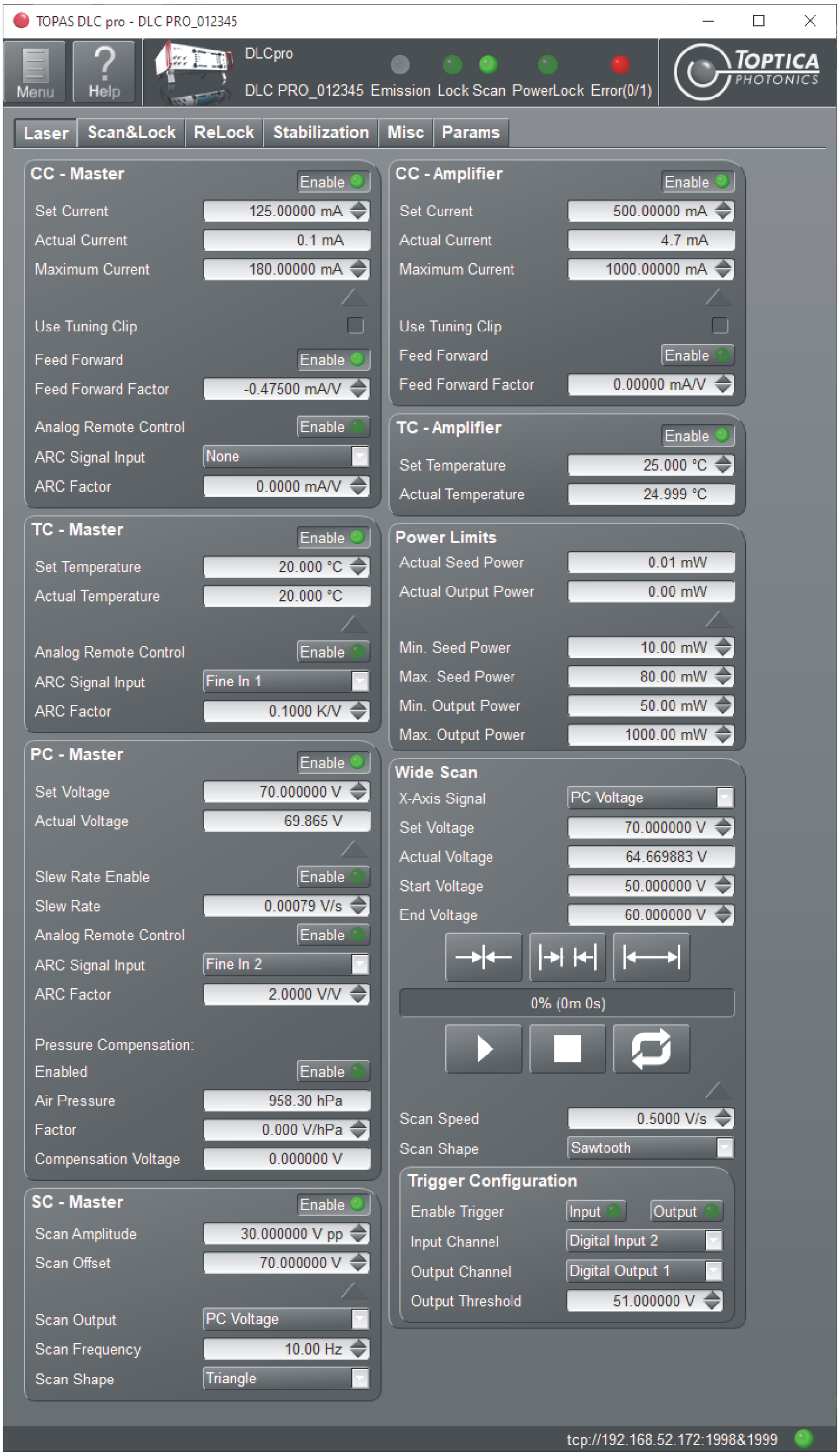


Figure 90 Laser tab (DLC TA pro)

The Laser tab comprises the operator controls for the TA pro Master Oscillator and the Tapered Amplifier. As the Master Oscillator is operated like a DL pro laser head, please refer to section 6.14.1 for description of the Master Oscillator operator controls. The Tapered Amplifier operator controls are described below.

CC Current Control Tapered Amplifier

Enable	Activates/deactivates the Current Control.
Set Current	Input field for set current I_{set}.
Actual Current	Display field for actual current I_{act}.

NOTE ! The Actual Current differs from the Set Current due to the Amplifier Feed Forward.

Maximum Current	Input field for maximum current I_{max}.
Use Tuning Clip	Checking the box limits the amplifier current to the Maximum Tuning Current. In case this Maximum Tuning Current is lower than the entry in the **Maximum Current** field, this field changes to **Maximum Tuning Current** (display only).

CAUTION ! **Laser heads with Motor pro option**: Checking the **Use Tuning Clip** box in the CC-Amplifier Current Control section is **mandatory** before performing a motor scan. This avoids damage to the amplifier during a motor scan.

Feed Forward Enable	Activates/deactivates the Amplifier Feed Forward, i.e. a change of the Tapered Amplifier current proportional to the change of the Master Oscillator piezo voltage due to the its scan.
Feed Forward Factor	Scaling parameter of the Amplifier Feed Forward in mA/V.

TC Temperature Control Tapered Amplifier

Enable	Activates/deactivates the Temperature Control.
Set Temperature	Input field for set temperature T_{set}.
Actual Temperature	Display field for actual temperature T_{act}.

Power Limits

Actual Seed Power	Display field for actual seed power.
Actual Output Power	Display field for actual output power at laser beam aperture of the TA pro.
Min. Seed Power	Input field for setting the minimum seed power.
Max. Seed Power	Input field for setting the maximum seed power.
Min. Output Power	Input field for setting the minimum output power at laser beam aperture of the TA pro.
Max. Output Power	Input field for setting the maximum output power at laser beam aperture of the TA pro.

6.14.7 DLC pro for Laser Head TA pro FL with Intra-Cavity EOM for Master Oscillator

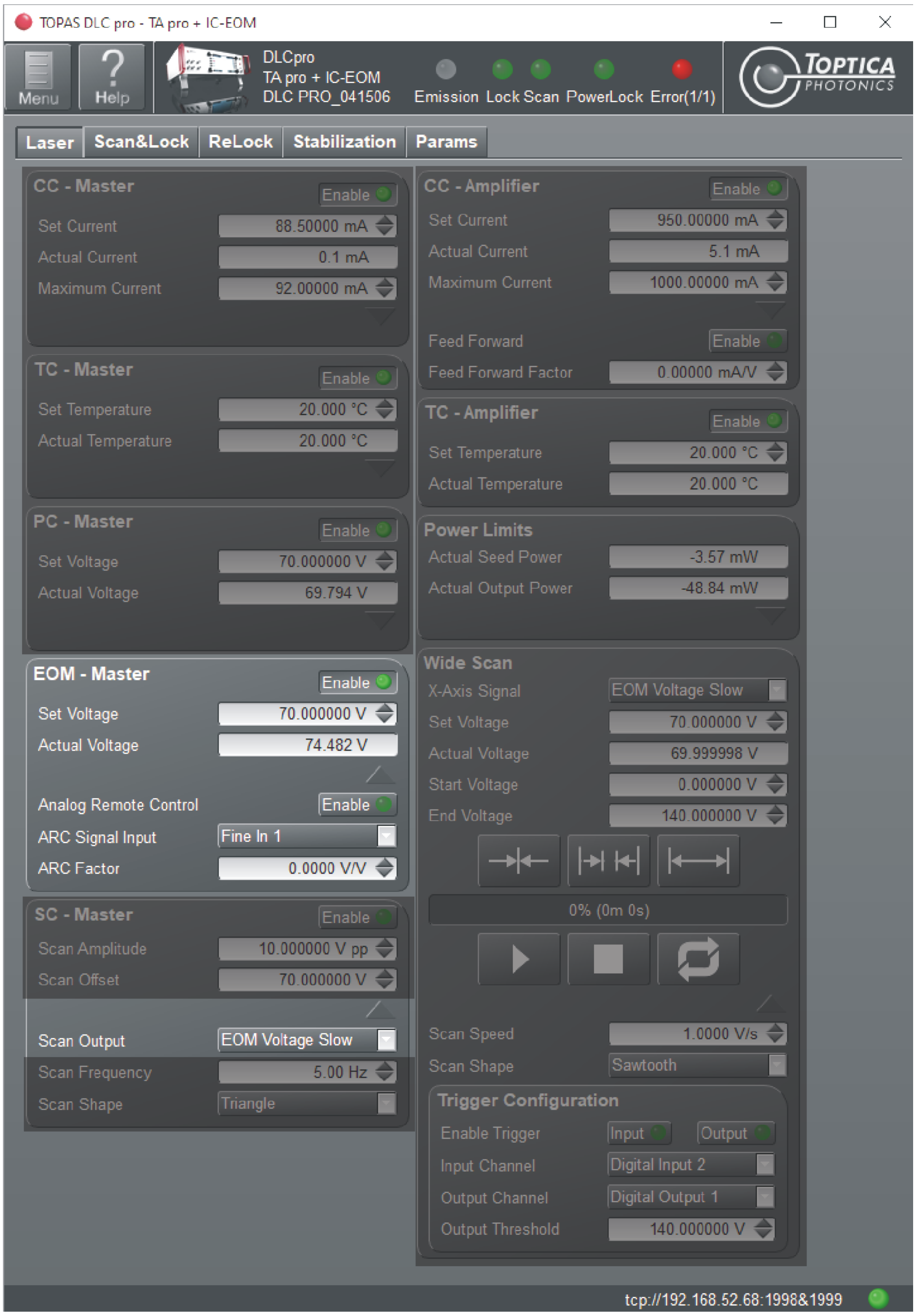


Figure 91 Laser tab (DLC TA pro FL with intra-cavity EOM for the Master Oscillator)

As an option, an intra-cavity EOM can be integrated into the resonator of the DL pro Master Oscillator in the TA pro laser head (TA pro FL). The voltage of the slow electrode of the intra-cavity EOM is controlled via one channel of a PC module. The operation and control of the respective laser head is unchanged and control for the slow electrode of the intra-cavity EOM is added in the EOM section of the Laser tab.

The TA pro Laser tab comprises the operator controls for the Master Oscillator and the Tapered Amplifier. As the Master Oscillator is operated like a DL pro laser head, please refer to section 6.14.1 for description of the Master Oscillator operator controls, and to section 6.14.2 for description of the intra-cavity specific operator controls. The Tapered Amplifier operator controls are described in section 6.14.6.

CAUTION !	Please refer to the DL/TA pro FL manual for details about how to connect and power up/down the laser head correctly.

6.14.8 DLC pro for TA pro AL

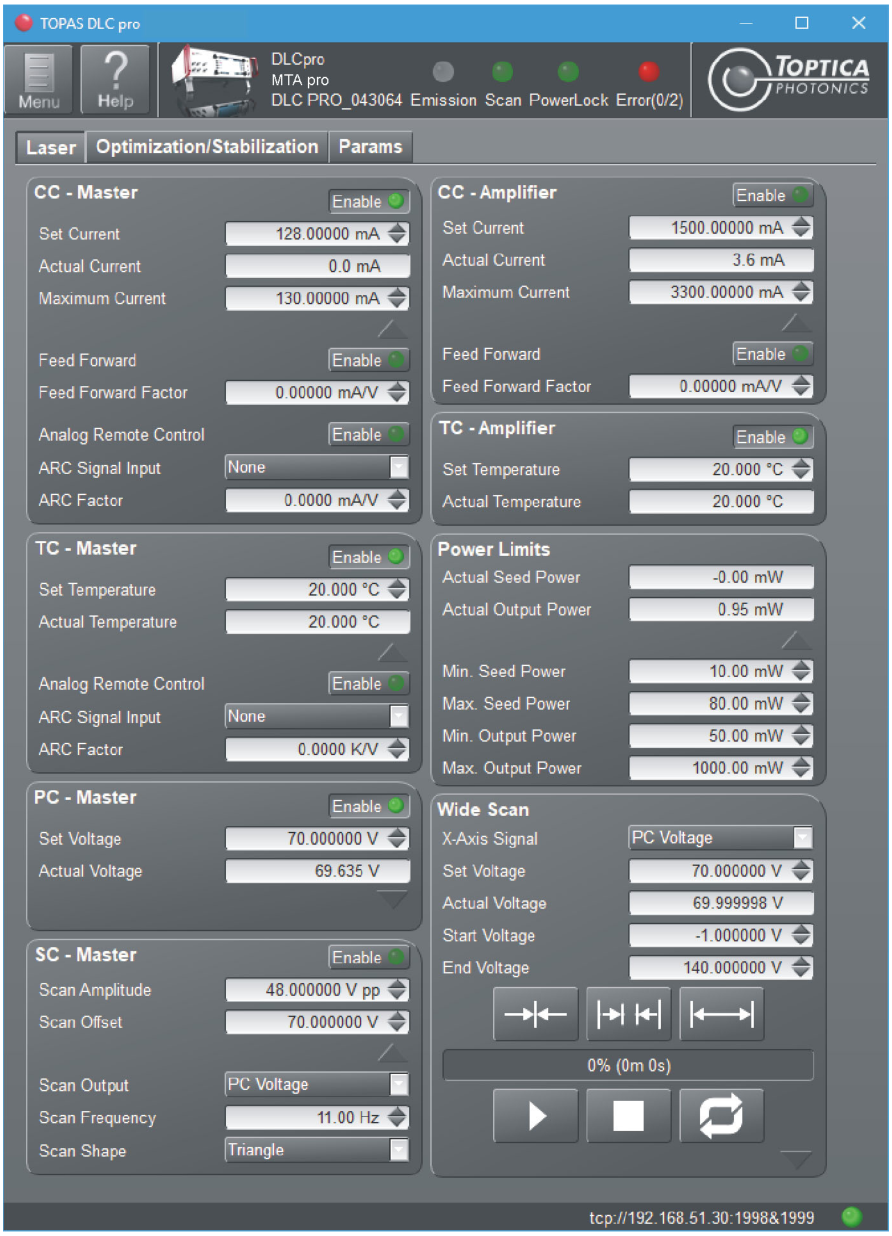


Figure 92 Laser tab (DLC TA pro AL, example one laser unit in TA pro configuration)

The Laser tab comprises the operator controls for the TA pro AL Master Oscillator (only DL pro and TA pro configuration) and the Tapered Amplifier (only TA pro and BoosTA pro configuration).

As the Master Oscillator is operated like a DL pro or DFB pro laser head, please refer to section 6.14.1 or section 6.14.4 for description of the Master Oscillator operator controls. The Tapered Amplifier operator controls are described in section 6.14.6.

6.14.9 DLC pro for Seed Laser + BoosTA pro Combinations

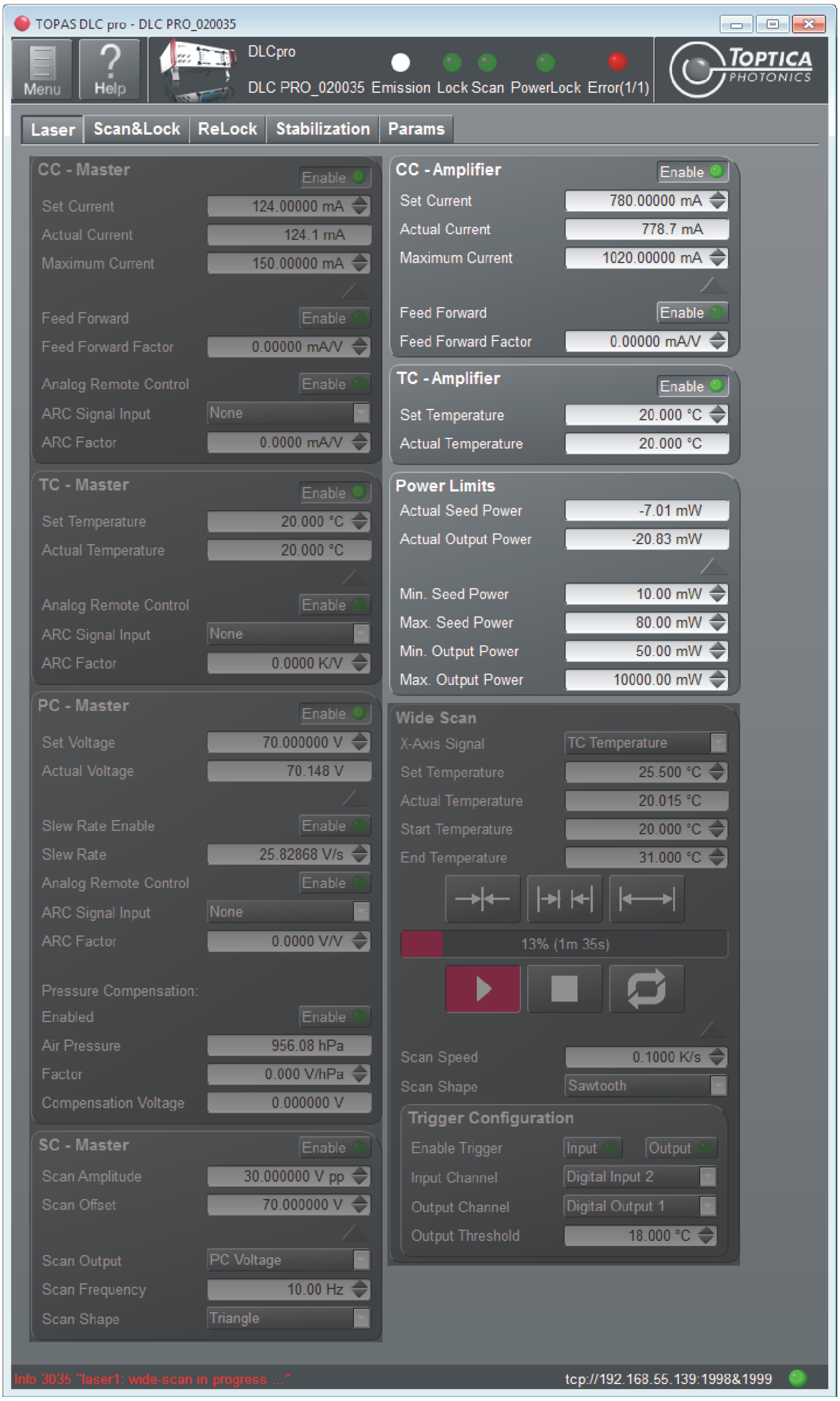


Figure 93 Laser tab seed laser + BoosTA pro combination (example DL pro seed laser)

In addition to a DL pro, DFB pro or CTL as seed laser head, a BoosTA pro tapered amplifier can be connected to the DLC pro, if at least one CC-5000 module is installed in the DLC pro laser driver electronics. In this seed laser + BoosTA pro combination, the operation and control of the respective seed laser head (Master Oscillator) is unchanged, and controls for the BoosTA pro are added in the Laser tab. For description of the operator controls, please refer to the Laser tab of the respective seed laser, and the Laser tab of the TA pro. Specific informations on seed laser + BoosTA pro combination are noted below.

NOTE !	**DLC BoosTA pro**: In case only a BoosTA pro laser head without a seed laser is connected to the DLC pro, only the BoosTA pro relevant operator controls are displayed.

Please refer to the BoosTA pro manual for details about how to connect and power up/down the laser heads correctly.

CC Current Control Tapered Amplifier

Feed Forward Enable Activates/deactivates the Amplifier Feed Forward, i.e. a change of the Tapered Amplifier current proportional to the change of the seed laser piezo voltage due to the its scan.

NOTE !	**CTL seed laser + BoosTA pro combination:** Do not use the amplifier feed forward as there is no power fluctuation to be compensated while scanning.

Power Limits

Actual Seed Power Display field for actual seed power.
Please refer to the BoosTA pro manual for information on installation and calibration of the seed power photo diode.

Actual Output Power Display field for actual output power at laser beam aperture of the TA pro.
Please refer to the BoosTA pro manual for information on installation and calibration of the amplified output power photo diode.

6.14.10 DLC pro for Laser Head DL-/TA-SHG/FHG pro

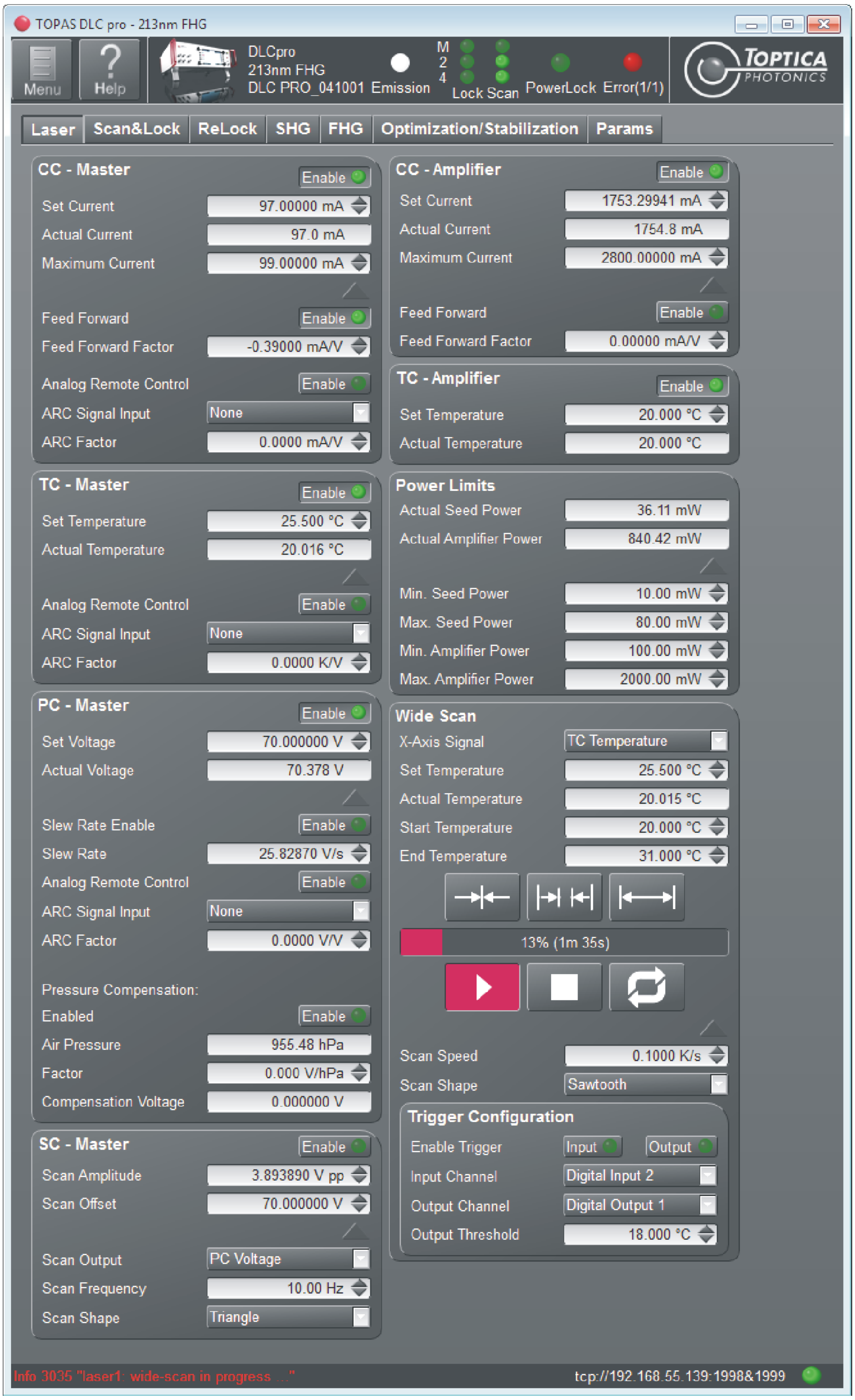


Figure 94 Laser tab (DLC TA-SHG/FHG pro, example DLC TA-FHG pro)

The Laser tab comprises the operator controls for the Master Oscillator and the Tapered Amplifier of the DL-/TA-SHG/FHG pro. Please refer to section 6.14.6 for description of the Master Oscillator and Tapered Amplifier operator controls, and to section 6.14.1 for description of the Wide Scan operator controls.

6.15 Scan & Lock Tab

NOTE !	To show and use the Scan & Lock tab, a Lock option license is required. When a Lock option license is acquired, TOPTICA provides an option license key via e-mail or USB flash drive. The license is unlimited in time but linked to the individual hardware of the DLC pro and cannot be used for other devices. The license key must be activated via the TOPAS DLC pro PC-GUI (please refer to section 10.19). If purchased along with the DLC pro, the licence is already installed. Otherwise a 30-day trail licence is provided on the USB flash drive in the Options Folder. **Dual-Laser-Operation**: With a single Lock option installed, in combination with the Dual-Laser-Operation upgrade, frequency locking of both lasers is possible.

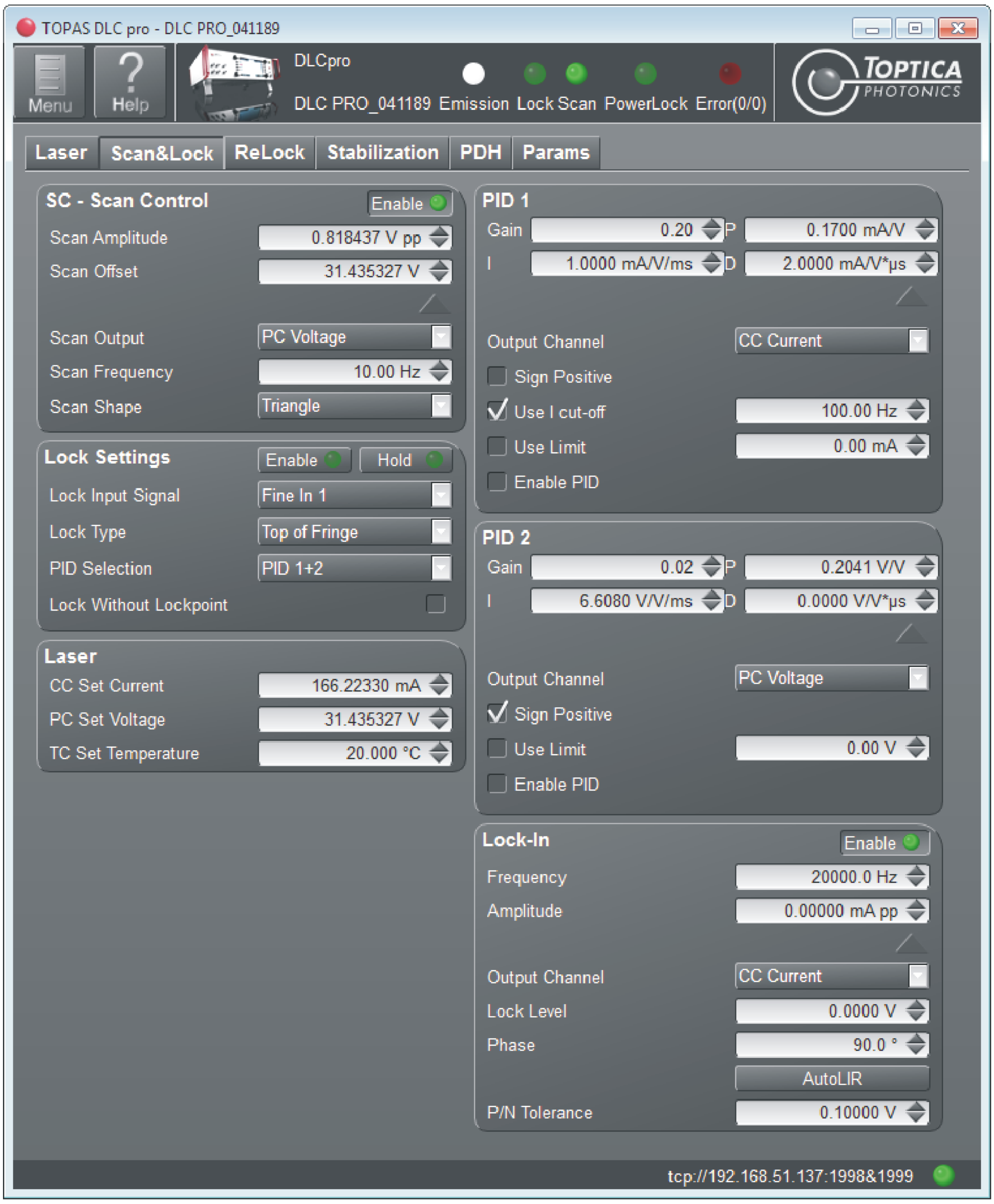


Figure 95 Scan & Lock tab (example DLC DL pro)

SC - Scan Control	For a full description, please refer to SC Scan Control in section 6.14.1.

Lock Settings

Enable	Locks/unlocks the laser to the selected lockpoint candidate.
Hold	Freezes the PID controller(s) output at the current value. When deselected by clicking again, the PID controller(s) continue to regulate starting with the value prior to the selection of **Hold**.
Lock Input Signal	Selection of the lock input signal. Chose the signal the DLC pro should be using to lock the laser. **Fine In 1/Fine In 2** BNC connector on DLC pro front panel. **Fast In 3/Fast In 4** BNC connector on DLC pro front panel. **PDH In 1/PDH In 2** **Only with PDH module**. SMB-connectors on PDH module panel.
Lock Type	Selection whether to lock to an edge or to an extremum of the input signal. **Top of Fringe**: LIR Lock to an extremum (requires modulation). **Side of Fringe**: Lock to an edge (slope). **Top of Fringe PDH**: **Only with PDH module**. PDH Lock to an extremum (requires modulation).

NOTE ! **Lock Type Top of Fringe:** Top of fringe locking is only possible without a FALC pro module (i.e., **None**) selected as **FALC Selection**.
Lock Type Top of Fringe PDH: If the PDH photo diode is DC-coupled, the **Lock Input Signal** can be derived by selecting **PDH In 1/PDH In 2** from the SMB-connectors on the PDH module.

Error Signal	**Only when Top of Fringe PDH as Lock Type and Fine In/Fast In as Lock Input Signal is selected.** Selection of the error signal generated by the PDH module. **PDH Error 1** Error signal at err/lo 1 connector of the PDH module. **PDH Error 2** Error signal at err/lo 2 connector of the PDH module.
Lock Without Lockpoint	Check box to select the Lock mode without lockpoint candidates. The lock is triggered in the middle of a rising scan ramp (equivalent to **Scan Offset**).
PID Selection	Selects the PID controllers for stabilizing the laser. Typically, PID 1 handles the high frequencies by controlling the laser current. PID 2 is responsible for the lower frequencies by controlling the piezo voltage. **None** **PID 1** **PID 2** **PID 1+2**

FALC Selection **Only when a FALC pro module is connected, and Top of Fringe as Lock Type is NOT selected.**
Selects the FALC pro module used for that is used for the fast control loop.
None
FALC 1
FALC 2

NOTE !	The DLC pro supports up to four FALC pro modules in a CAN link chain. Please note that only the two FALC pro modules with the lowest CAN Node IDs (see FALC pro manual) can be operated via **FALC Selection**. Additional FALC pro modules can be operated via the Params tab of the TOPAS DLC pro PC-GUI (see section 6.24, parameter falcX:...)

Set Level **Only when Side of Fringe as Lock Type is selected.**
Set lock level voltage for **Side of Fringe** lockpoint candidates.

Compensation Offset **Only when Side of Fringe as Lock Type is selected and FALC pro module is connected.**
Set compensation offset voltage for **Side of Fringe** lockpoint candidates.

Laser Parameters of the laser which can be modified for scanning and locking.

NOTE !	The Laser parameters correspond to the respective parameters in the Laser tab.

CC Set Current Input field for set current I_{set}.

PC Set Voltage Input field for a DC offset voltage which is applied to the piezo.
Not available for DLC DFB pro and laser systems with DFB pro Master Oscillator

TC Set Temperature Input field for set temperature T_{set}.

PID 1/PID 2 Typically, PID 1 handles the high frequencies by controlling the laser current. PID 2 is responsible for the lower frequencies by controlling the piezo voltage.

Gain Overall gain factor of the selected PID controller.

P Proportional gain of the selected PID controller.

I Integral gain of the selected PID controller.

D Differential gain of the selected PID controller.

Access advanced setting options by clicking the triangle below.

Output Channel Output channel that is controlled by the PID.
PC Voltage: The PID controls the piezo voltage.
TC Set Temperature:
(only DLC DFB pro and laser systems with DFB pro Master Oscillator)
For DFB pro laser heads, **PC Voltage** is not available as output channel. When **TC Set Temperature** is selected, the scan signal is directed to the Temperature Control module and the laser diode temperature is scanned.
CC Current: The PID controls the laser current.
Out A: PID output signal is directed to the Out A BNC-connector on the DLC pro front panel.
Out B: PID output signal is directed to the Out B BNC-connector on the DLC pro front panel.
EOM Voltage Slow (only laser systems with intra-cavity EOM):
The PID controls the voltage applied to the slow electrode of the intra-cavity EOM.

Sign Positive Checkbox to select positive polarity of the PID output in respect to the selected SC **Scan Output**. When selected, an increased PID controller output acts in the same direction as an increase of the **Lock Input Signal.**

Use I-cut-off (PID 1 only) Activated by the checkbox. Frequency in Hz below which the integral gain of the PID controller is limited. If PID 1 is used in parallel with PID 2 in a control system, I-cutoff prevents that the two PID loops accumulate offsets in different directions.

Use Limit Checkbox to define the symmetric maximum value which the PID controller can add or subtract to/from the offset of the piezo voltage or the laser current, depending on the selected PID **Output Channel.** Enter the maximum current, voltage or temperature in mA, V or °C into the Input Field**.**

Enable PID Checkbox to enable/disable the PID controller.

Lock-In Parameters for the Error signal generation required for the Top of Fringe lock type.

NOTE !	The **Lock-In** parameters are only displayed if Top of Fringe is selected as **Lock Type** in the **Lock Settings** section.

Enable Enables/disables the Error signal generation.

Frequency Modulation frequency in Hz. A good starting value for a modulation using the laser current is 20000 Hz.

Amplitude Modulation amplitude (pp: peak-to-peak); the unit depends on the selected **Lock-In Output Channel**:
PC Voltage: [V pp]
CC Current: [mA pp]

Status: 29.3.22

Access advanced setting options by clicking the triangle below.

Output Channel	Signal output to which the modulated signal is applied. **PC Voltage:** Modulated signal is applied to the piezo voltage. **TC Set Temperature:** **(only DLC DFB pro and laser systems with DFB pro Master Oscillator)** For DFB pro laser heads, **PC Voltage** is not available as output channel. When **TC Set Temperature** is selected, the scan signal is directed to the Temperature Control module and the laser diode temperature is scanned. **CC Current:** Modulated signal is applied to the laser current. **Out A:** Modulated signal is directed to the Out A BNC-connector on the DLC pro front panel. **Out B:** Modulated signal is directed to the Out B BNC-connector on the DLC pro front panel.
Lock Level	Offset (normally set to zero) for the PID controller used for the Top of Fringe lock type to compensate for spurious DC signals originated by the demodulation of the modulated input signal (in most cases due to an amplitude modulation component).
Phase	Relative phase (in °) between modulation and demodulation. Optimize the parameter (used for the Top of Fringe lock type) to get the Error signal as a derivative of the input signal. We suggest to turn-off the autoscaling of the signal during optimization.
AutoLIR	Clicking automatically determines and sets the **Phase** to get the Error signal as a derivative of the input signal.
P/N Tolerance	If the lockpoints at the extrema are not properly detected automatically, this behavior can be improved by adjusting the **P/N Tolerance** correctly for the signal and signal-to-noise ratio used.

6.15.1 Using the Lock Points Tool of the Signal Display for Locking

NOTE !	For showing the Lock-relevant functions of the **Signal Display**, a Lock option license is required. When a Lock option license is acquired, TOPTICA provides an option license key via e-mail or USB flash drive. The license key must be activated via the TOPAS DLC pro PC-GUI (please refer to section 10.19).

The Lock Points Tool in the Signal Display is used for showing and selecting lockpoints. The procedures for Side of Fringe and Top of Fringe locking with the PC-GUI is described in sections 6.15.2 and 6.15.3.

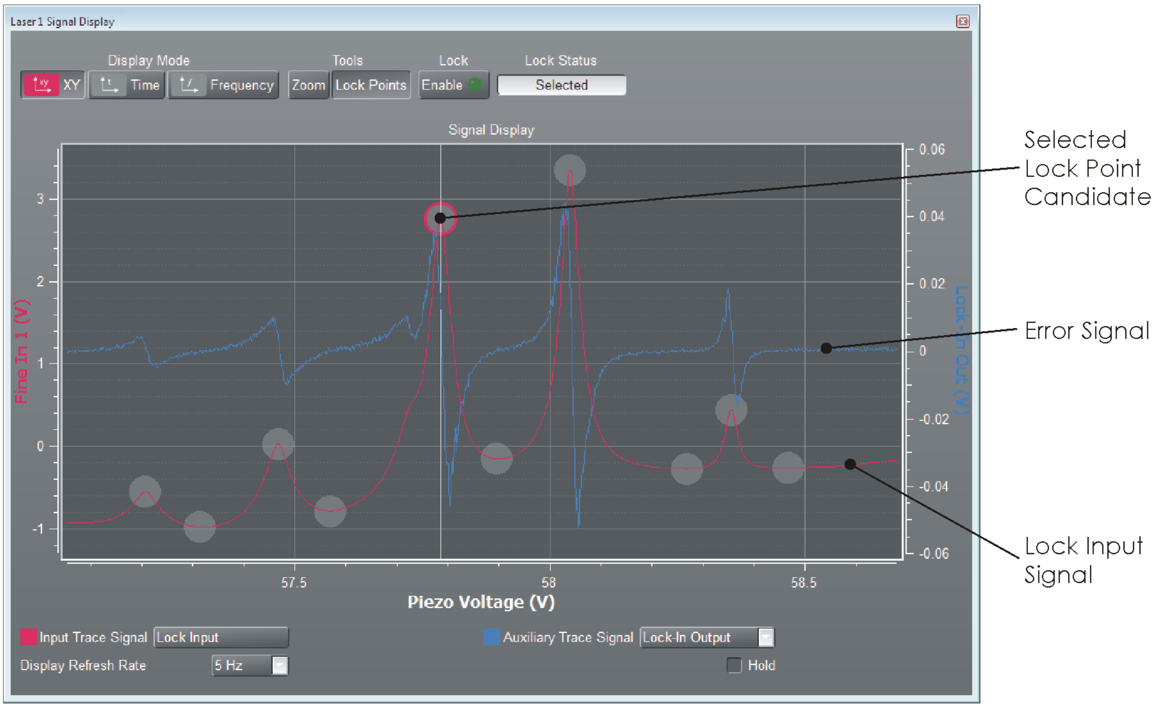


Figure 96 Lock Points tool of the Signal Display

For detailed information on the Signal Display, please refer to section 6.11.

- To specify the input signal to use for locking, select **Lock Input Signal** in the **Lock Settings** section of the Scan&Lock tab.
- With the Lock Points tool selected, the **Input Trace Signal** is fixed to **Lock Input**.
- To get the Error signal that is required for Top of Fringe locking, select **Auxiliary Trace Signal > Lock-In Output**. The laser is actually locked to the Lock-In Output signal.
- To display the lockpoint candidates, click **Lock Points**. Depending on the selected lock type (Side of fringe or Top of Fringe) the arrow inside the lockpoint candidate clearly shows its identity (see Figure 97.

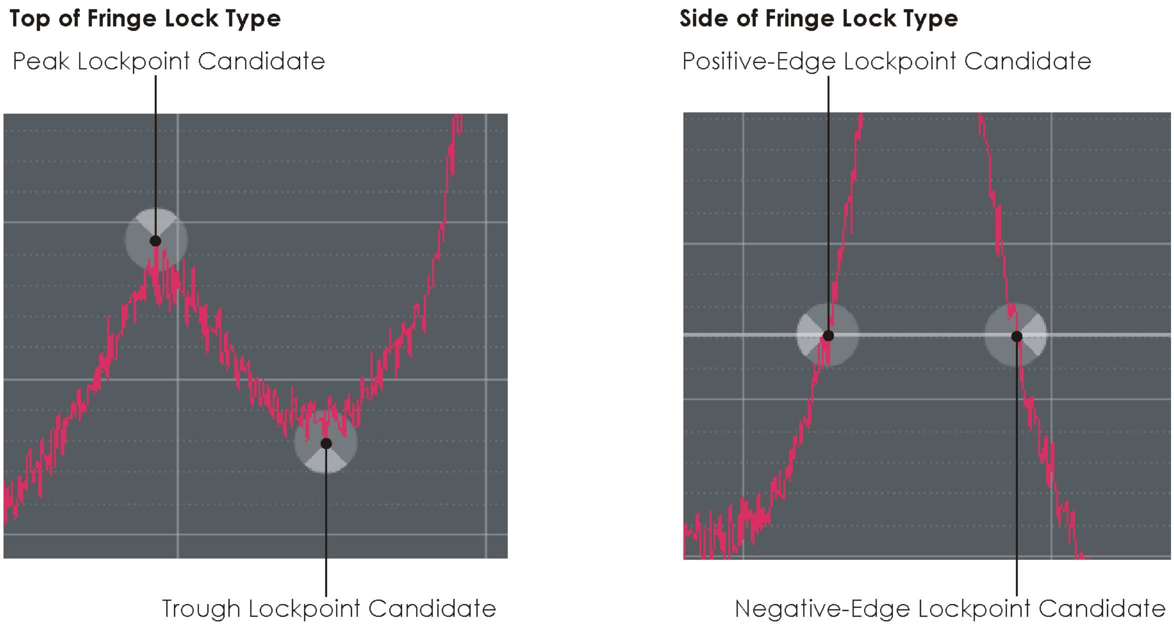


Figure 97 Identification of lockpoint candidate

- To deselect unwanted lockpoint candidates for a clearer view, use the **Lock Candidate Filter**: A right click in the graph area opens a menu. Select **Lock Candidate Filter** and configure the settings so that unwanted lockpoint candidates are not displayed.
- To lock the laser, select a lockpoint candidate and click **Lock Enable** on the Signal Display or click **Enable** in the **Lock Settings** section of the Scan&Lock tab. The lock can also be enabled by double-clicking on the desired lockpoint candidate.
- To unlock the laser, click **Lock Enable** on the Signal Display or click **Enable** in the **Lock Settings** section of the Scan&Lock tab. The lock can also be disabled by double-clicking somewhere in the Signal Display screen area.
- The **Lock Status** shows the actual status of the lock (please refer to section 6.11).
- To freeze the screen display, check the **Hold** checkbox.

6.15.2 Side of Fringe Locking with TOPAS DLC pro PC-GUI

NOTE !	For showing the Lock-relevant functions of the **Signal Display**, a Lock option license is required. When a Lock option license is acquired, TOPTICA provides an option license key via e-mail or USB flash drive. The license key must be activated via the TOPAS DLC pro PC-GUI (please refer to section 10.19).

Prerequisites:

- Experimental setup connected to the DLC pro (for details, see section 7.1):
- Control computer connected to the DLC pro (for details please refer to section 4.5.1).
- TOPAS DLC pro (PC-GUI) installed and started (for details please refer to section 6.2).
- Lock option license key activated via the TOPAS DLC pro PC-GUI (please refer to section 10.19).
- Lock Input signal connected to Fine In or Fast In (BNC-connectors on DLC pro front panel).
- Laser head connected to the DLC pro as described in section 4.5.3.

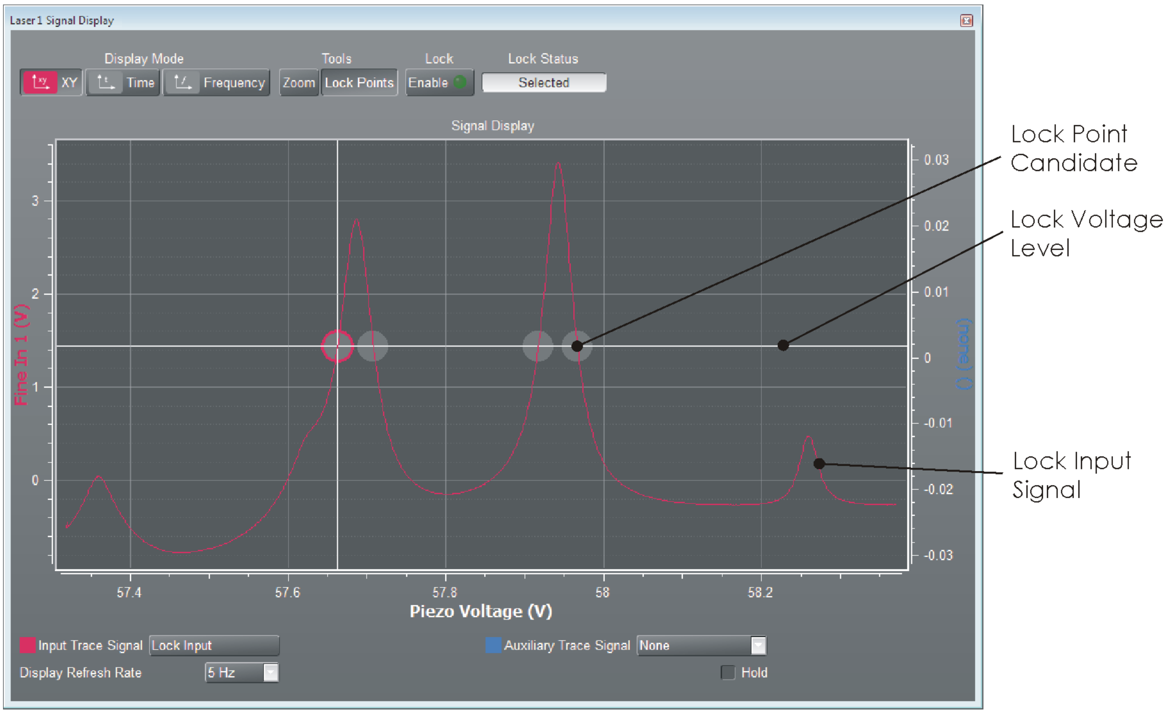


Figure 98 Signal Display showing the Lock Input signal (red) and lockpoint candidates for Side of Fringe locking.

1. Add the Signal Display to the main area of the screen (**Menu > Signal Display**) and select the **XY** display mode. Click on the **axis labels** with the right mouse key and select **Autoscale**.

2. Select the Scan&Lock tab.

3. Select the input channel of the Lock Input signal: **Lock Settings > Lock Input Signal**.
Choose the Lock Input signal to be shown on the Signal Display as a red trace (**Input Trace Signal**).

4. Select the Side of Fringe lock type: **Lock Settings > Lock Type > Side of Fringe**.

5. Select the PID controller(s) for regulating the lockpoint: **Lock Settings > PID Selection.**
Ensure that each PID output is configured correctly.

NOTE !	Typically, PID 1 handles the high frequencies by controlling the laser current. PID 2 is responsible for the lower frequencies by controlling the piezo voltage. If PID 1 is used in parallel with PID 2 in a control system, **I-cutoff** prevents that the two PID loops accumulate offsets in different directions.

6. Move and zoom the Lock Input signal and adjust the laser current (**Laser > CC Set Current**) until the desired lockpoint in the spectrum is clearly visible on the Signal Display.

7. Click **Lock Points** on the Signal Display to display the lockpoint candidates.

8. Set the desired lock level voltage in one of the following ways:
- Specify the **Set Level** in the **Lock Settings** section.
- Click to the desired voltage on the Signal Display.
- Move the horizontal gray line on the Signal Display to the desired voltage.

NOTE !	The current lock voltage level is displayed as a gray line on the Signal Display. Lockpoint candidates are displayed where the Lock Input signal crosses the lock voltage level line.

9. **Locking with lockpoint candidates:** Select the lockpoint by clicking the desired **lockpoint candidate**. For a clearer display, unwanted lockpoint candidates can be deselected either using the **Lock Candidate Filter** (right-click in the graph area) or in the Params tab (**laser 1 > dl > lock > candidate filter > positive-edge/negative-edge**).

Locking without lockpoint candidates: Check the box **Lock Without Lockpoint** in the Lock Settings section of the Scan & Lock tab. Move the spectrum on the Signal Display in x-direction so that the desired region to trigger the lock is located in the center.

10. Click **Lock Enable** on the Signal Display or click **Enable** in the **Lock Settings** section.
Locking with lockpoint candidates: The laser scans to the selected lockpoint. When the scan reaches the lockpoint, the scan stops, and the PID controller(s) switch on. The **Lock Status** shows the actual status of the lock (please refer to section 6.11).

Locking without lockpoint candidates: The laser scans to the center of the spectrum (**Scan Offset**). When the scan reaches this point, the scan stops, and the PID controller(s) switch on. The **Lock Status** shows the actual status of the lock (please refer to section 6.11).

11. Adjust the PID Gain settings and the advanced settings of the PID controller(s) to optimize the lock: **PID 1**, **PID 2**.
Please refer to section 8.3 for information on PID controller configuration and to section 6.15 for information on PID controller setting options.

6.15.3 Top of Fringe (Lock-In/PDH) Locking with TOPAS DLC pro PC-GUI

NOTE !	For showing the Lock-relevant functions of the **Signal Display**, a Lock option license is required. When a Lock option license is acquired, TOPTICA provides an option license key via e-mail or USB flash drive. The license key must be activated via the TOPAS DLC pro PC-GUI (please refer to section 10.19). **Only Top of Fringe (Lock-In)**: The Lock Wizard in the TOPAS DLC pro PC-GUI (**Menu > Optimization Tools > Lock Wizard**, see section 6.11) is an interactive tool which helps to set-up a Top of Fringe lock.

NOTE !	**If your DLC pro is equipped with a PDH module** (see section 9.2.9), you can also perform a Top of Fringe PDH lock, instead of the Lock-In procedure described in this section. In this case connect your experimental setup as shown in section 7.3.3 and follow the instructions below for Lock-In accordingly. Settings for the PDH module are performed in the PDH tab (see section 6.21). For an application example of a Top of Fringe PDH lock with high-finesse cavity, please refer to section 7.2.

NOTE !	**It is possible to route the Lock-In Error signal to the Out A/B BNC connectors** on the DLC pro front panel. Please use the Params tab to set the following parameters: io:out-a/b:external-input:signal = 30, io:out-a/b:external-input:factor = 1.0, and io:out-a/b:external-input:enabled = #t Choose io:out-a/b:linked-laser = 1/2 to select the Lock-In Error signal of laser 1 or laser 2. By routing the Lock-In Error signal to analog outputs, the signal resolution may be reduced. Please use the parameters io:out-a:external-input:factor or io:out-b:external-input:factor, respectively, in order to increase signal-to-noise.

Prerequisites:

- Experimental setup connected to the DLC pro (for details, see sections 7.3.2 or 7.3.3):
- Control computer connected to the DLC pro (for details please refer to section 4.5.1).
- TOPAS DLC pro (PC-GUI) installed and started (for details please refer to section 6.2).
- Lock option license key activated via the TOPAS DLC pro PC-GUI (please refer to section 10.19).
- **Only Lock-In**: Lock Input signal connected to Fine In or Fast In (BNC connectors on DLC pro front panel).
- **Only PDH Lock**: Lock Input signal connected to in 1 or in 2 (SMB connectors on PDH module panel).
- Laser head connected to the DLC pro as described in section 4.5.3.

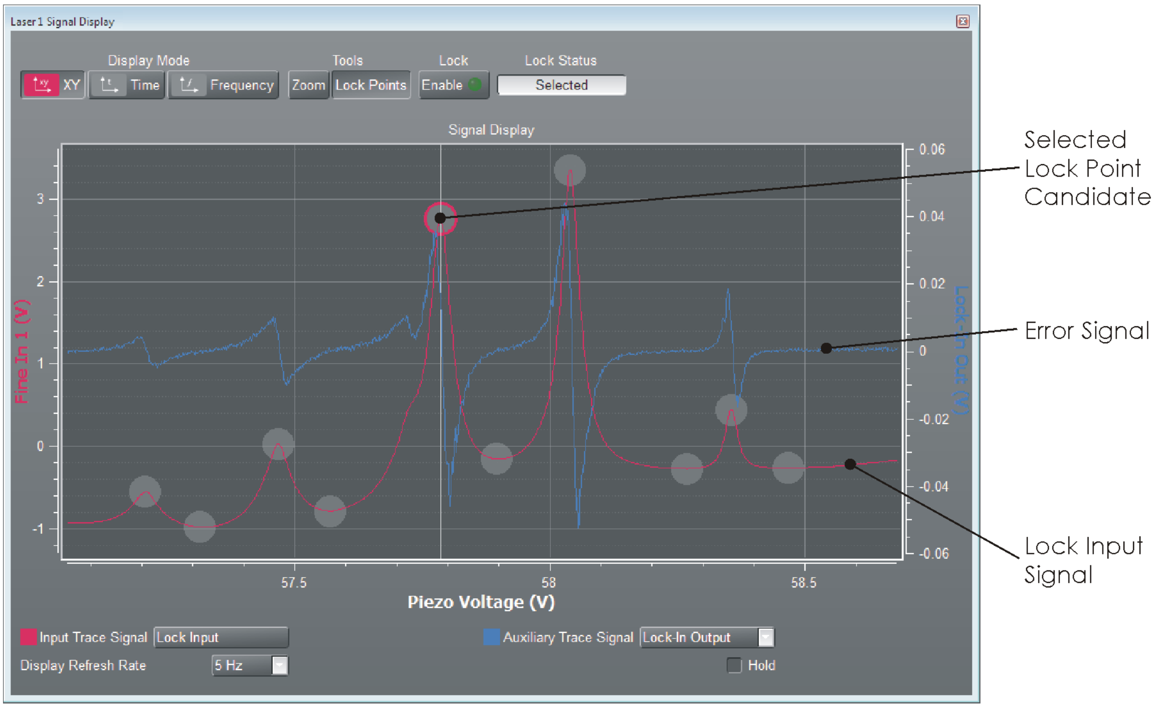


Figure 99 Signal Display showing lockpoint candidates for Top of Fringe locking

1. Add the Signal Display to the main area of the screen (**Menu > Signal Display**) and select the **XY** display mode. Click on the **axis labels** with the right mouse key and select **Autoscale**.

2. Select the Scan&Lock tab.

3. Select the input channel of the Lock Input signal: **Lock Settings > Lock Input Signal** depending on the desired **Lock Type** and the experimental setup.
Choose the Lock Input signal to be shown on the Signal Display as a red trace (**Input Trace Signal**).

4. Select the Top of Fringe lock type: **Lock Settings > Lock Type > Top of Fringe** or **Top of Fringe PDH**.

5. Select the PID controller(s) for regulating the lockpoint: **Lock Settings > PID Selection**.
Ensure that each PID output is configured correctly.

NOTE !	Typically, PID 1 handles the high frequencies by controlling the laser current. PID 2 is responsible for the lower frequencies by controlling the piezo voltage. If PID 1 is used in parallel with PID 2 in a control system, **I-cutoff** prevents that the two PID loops accumulate offsets in different directions.

6. Move and zoom the Lock Input signal and adjust the laser current (**Laser > CC Set Current**) until the desired lockpoint in the spectrum is clearly visible on the Signal Display.

7. Click **Lock Points** on the Signal Display to display the lockpoint candidates.

8. If necessary, switch on the Lock-In Error signal generation (**Lock-In, Enable**) and display the modulated/demodulated Error signal on the Signal Display: **Auxiliary Trace Signal > Lock-In Output**.

9. Select the signal output to which the Error signal modulation is applied: **Lock-In > Output Channel**. In case of **Lock Settings > Lock Type > Top of Fringe PDH** the Error signal modulation is always applied to the out 1/2 SMB-connectors at the PDH module.

10. Adjust the modulation frequency, modulation amplitude, lock level, and phase of the Error signal: **Lock-In > Frequency, Amplitude, Lock Level, Phase**.
Modify the demodulation phase (**Lock-In > Phase**) until the Error signal matches the derivative of the Lock Input signal and the Error signal runs in the correct direction through the signal extremum to which you want to lock:
- Lockpoint is in signal valley: rising flank of the Error signal (default color: blue).
- Lockpoint is on signal peak: falling flank of the Error signal (default color: blue).
This optimization may be eased by disabling auto scaling.

11. **Locking with lockpoint candidates:** Select a lockpoint by clicking the desired **lockpoint candidate**. For a clearer display, unwanted lockpoint candidates can be deselected either using the **Lock Candidate Filter** (right-click in the graph area) or in the Params tab (**laser 1 > dl > lock > candidate filter > top/bottom**).

NOTE !	If the lockpoints at the extrema are not properly detected automatically, this behavior can be improved by setting the **Peak/Noise Tolerance** in the **Lock Candidate Filter** of the Signal Display (Params tab parameter: **laser 1 > lock > candidate-filter > peak-noise-tolerance**) correctly for the signal and signal to noise ratio used. This parameter is 0 for automatic detection, and automatic detection does not always work perfectly. The parameter should be set to a value that is larger than the peak-to-peak noise and smaller than the peaks that the laser should be locked to. For a convenient parameter optimization it is recommended to use the TOPAS DLC pro PC-GUI where the parameter can be changed while the signal is displayed.

Locking without lockpoint candidates: Check the box **Lock Without Lockpoint** in the Lock Settings section of the Scan & Lock tab. Move the spectrum on the Signal Display in x-direction so that the desired region to trigger the lock is located in the center.

12. Click **Lock Enable** on the Signal Display or click **Enable** in the **Lock Settings** section.
Locking with lockpoint candidates: The laser scans to the selected lockpoint. When the scan reaches the lockpoint, the scan stops and the PID controller(s) switch on. The **Lock Status** shows the actual status of the lock (please refer to section 6.11).

Locking without lockpoint candidates: The laser scans to the center of the spectrum (**Scan Offset**). When the scan reaches this point, the scan stops, and the PID controller(s) switch on. The **Lock Status** shows the actual status of the lock (please refer to section 6.11).

NOTE !	The laser is actually locked to the Lock-In Error signal (0 V of the Lock-In Output signal). The Lock-In Error signal is the input signal for the PID controller(s).

13. Adjust the PID gain settings and the advanced settings of the PID controller(s) to optimize the lock: **PID 1**, **PID 2**.
Please refer to section 8.3 for information on PID controller configuration and to section 6.15 for information on PID controller setting options.

6.16 ReLock Tab

NOTE !	To show and use the ReLock tab, a Lock option license is required. When a Lock option license is acquired, TOPTICA provides an option license key via e-mail or USB flash drive. The license key must be activated via the TOPAS DLC pro PC-GUI (please refer to 10.19).

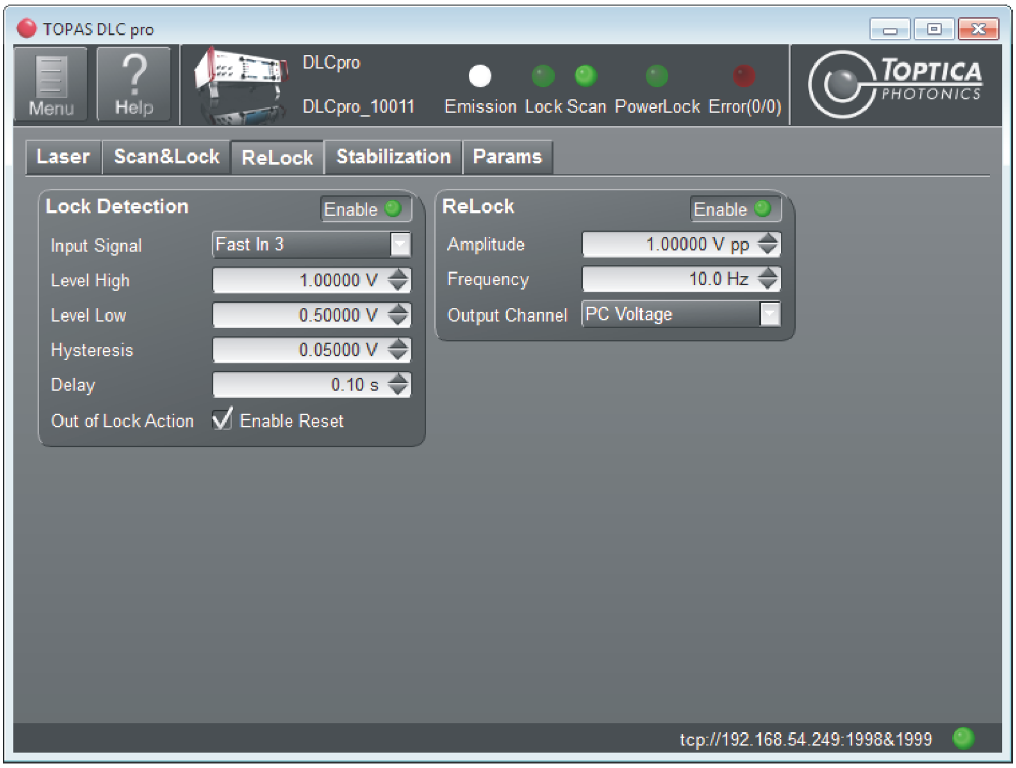


Figure 100 ReLock tab

Lock Detection This tab allows to set the parameters for the out-of-lock detection.

Enable Enables/disables the Out-of-lock detection.

Input Signal Select input signal for the ReLock window (Window Input signal).

Level High Upper voltage limit of the ReLock window.

Level Low Lower voltage limit of the ReLock window.

Hysteresis Tolerance between the out-of-lock voltage levels (**Level High** or **Level Low**) and the voltage levels which determine that the laser is in lock again (see section 5.3.11).

Delay Time between detection of the out-of-lock state and initialization of a reset/relock procedure.

Out-of-Lock Action Behavior of the PID controllers after the out-of-lock state was detected and the **Delay** time has passed.
Enable Reset:Check box to enable reset of all selected PID controllers.

ReLock

Enable	Enables/disables the ReLock scan.
Amplitude	ReLock scan amplitude. The unit depends on the selected **Output Channel**.
Frequency	ReLock scan frequency in [Hz].
Output Channel	Select Output channel of the ReLock scan. **PC Voltage:** Piezo voltage. **TC Set Temperature** **(only DLC DFB pro and systems with DFB pro Master Oscillator):** For DFB pro laser heads, **PC Voltage** is not available as output channel. When **TC Set Temperature** is selected, the scan signal is directed to the Temperature Control module and the laser diode temperature is scanned. **CC Current:** Laser current. **Out A:** ReLock output signal is directed to the Out A BNC-connector on the DLC pro front panel. **Out B:** ReLock output signal is directed to the Out B BNC-connector on the DLC pro front panel.

6.16.1 ReLock Configuration with TOPAS DLC pro PC-GUI

Prerequisites:

- The laser is ready to be locked (please refer to sections 6.15.2, 6.15.3).
- Signal Display added to the main area of the screen (**Menu > Signal Display**).
- A separate signal for out-of-lock detection (Window Input signal) is connected to Fine In or Fast In (BNC-connectors on DLC pro front panel).

1. Select the ReLock tab and select the **XY** display mode in the Signal Display.

2. Select the channel for the Lock Detection Input signal: **Lock Detection > Input Signal**.
Display the Lock Detection Input signal on the Signal Display: **Auxiliary Trace Signal.**

3. Define the limits of the ReLock window for out-of-lock detection: **Lock Detection > Level High**, **Level Low**, **Hysteresis** (please refer to section 5.3.11).

4. Define the delay between out-of-lock detection and reset/relock scan activation: **Lock Detection > Delay**.

5. Enable/disable the PID controller(s) reset: **Out-of Lock-Action Enable Reset** checkbox. The speed of the reset is dependent on the **Slew Rate** settings of the selected PID output channels.

6. Enable/disable the ReLock scan: **ReLock > Enable**.
Define amplitude, frequency, and output channel of the ReLock scan: **ReLock > Amplitude**, **Frequency**, **Output Channel**.

7. Enable/disable the out-of-lock detection: **Lock Detection > Enable**.

NOTE !	In case the **ReLock Frequency** is lower than the **Scan Frequency** set in the SC Scan Control section of the Laser tab (see section 6.14.1), the XY display mode of the Signal Display does not show a whole ReLock scan period. Use the Time display mode for proper display.

6.17 SHG Tab (DLC DL-/TA-SHG pro)

Figure 101 SHG tab (DLC DL-/TA-SHG pro)

Cavity Scan Settings SHG cavity scan settings.

Enable Enables/disables the SHG cavity scan.

Scan Amplitude Peak-to-peak scan amplitude in [V_{pp}].

Scan Offset DC signal level in [V].

Click the triangle below to access advanced setting options.

Scan Frequency Set repetition frequency in Hz.

TC Crystal	Settings for the SHG crystal temperature controller. Please note that the temperature gradient is limited to avoid damage of the crystal.
Enable	Activates/deactivates the crystal Temperature Control. **When TC Crystal is disabled, the crystal temperature is regulated to 25 °C.**
Set Temperature	Input field for set temperature T_{set}.
Actual Temperature	Display field for actual temperature T_{act}.

Cavity ReLock

Enable	Enables/disables the SHG ReLock.

Click the triangle below to access advanced setting options.

Settings	This tab allows to set the SHG ReLock parameters.
Input Signal	Select input signal for the ReLock window (Window Input signal). **SHG Intra-Cavity Signal:** Circulating fundamental power inside the SHG cavity. **Threshold** and **Hysteresis** are given in [V]. **SHG Power**: Harmonic output power of the SHG cavity. **Threshold** and **Hysteresis** are given in [mW].
Amplitude	ReLock scan amplitude in [V_{pp}].
Frequency	ReLock scan frequency in [Hz].
Lock Detection	This tab allows to set the parameters for the out-of-lock detection.
Threshold	Lower voltage/power limit of the ReLock window.
Hysteresis	Tolerance between the out-of-lock voltage/power level (**Threshold**) and the voltage/power level which determines that the laser is in lock again (please refer to the DL-/TA-SHG/FHG pro manual for ReLock configuration) Note that for the SHG cavity lock the Level High of the ReLock window does not need to be adjusted by the user.
Delay	Time between detection of the out-of-lock state and initialization of a reset/relock procedure.
Master	Parameters of the Master Oscillator which can be modified without the need to switch to the Laser tab.

NOTE ! The Master parameters correspond to the respective parameters in the Laser tab.

CC Set Current	Input field for set current I_{set} of the Master Oscillator in [mA].
PC Set Voltage	Input field for a DC offset voltage which is applied to the piezo of the Master Oscillator in [V].

Lock Settings

Enable Locks/unlocks the SHG cavity to a cavity resonance which is close to the central cavity piezo position (approx. 70 V piezo voltage).

General

PID Selection Selects the PID controllers for stabilizing the SHG cavity. Typically, **PID Slow** is responsible for the lower frequencies by controlling the slow cavity piezo. **PID Fast** handles the higher frequencies by controlling the fast cavity piezo. **P Analog** is used to lock the Master Oscillator frequency onto the cavity length via the modulation input of the Master Oscillator.

NOTE ! Please note that the laser must be configured for P Analog adjustment. Please refer to the DL-/TA-SHG/FHG pro manual for details.

None
PID Slow
PID Slow + Fast
PID Slow + P Analog
PID Slow + Fast + P Analog

Set Level Set lock level voltage for the SHG cavity lock Error signal.

Click the triangle below to access advanced setting options.

PDH Photo Diode Gain Gain of the Pound-Drever Hall photo diode in [V/V].

Cavity Feed Forward Enable Activates/deactivates the SHG cavity Feed Forward, i.e. the slow cavity piezo voltage follows the Master Oscillator piezo voltage to support faster scan speeds in locked operation.

Cavity Feed Forward Factor Scaling parameter of the SHG cavity Feed Forward in [V/V].

Local Oscillator

Enable Enables/disables the local oscillator of the SHG cavity lock. The local oscillator operates at a frequency of 25 MHz.

Amplitude Local oscillator amplitude in [V_{pp}].

Phase Relative phase between modulation and demodulation in [°]. Optimize the parameter to get the Error signal as a derivative of the input signal.
We suggest to turn off autoscaling of the signal during optimization.

AutoPDH Starts an algorithm which finds the optimum phase between the photo diode signal and the local oscillator.

PID Slow/PID Fast	PID controllers as selected in **PID Selection**.
Gain	Overall gain factor of the PID controller.
P	Proportional gain of the PID controller in [V/V].
I	Integral gain of the PID controller in [V/V/ms].
D	Differential gain of the PID controller in [V/V x µs].
Use I-cut-off (PID Fast only)	Activated by the checkbox. Frequency in Hz below which the integral gain of the PID controller is limited. If PID Fast is used in parallel with PID Slow in a control system, I-cutoff prevents that the two PID loops accumulate offsets in different directions.
P Analog	As selected in **PID Selection**. P Analog is used to lock the Master Oscillator frequency onto the cavity length via the modulation input of the Master Oscillator.

NOTE !	Please note that the laser must be configured for P Analog adjustment. Please refer to the DL-/TA-SHG/FHG pro manual for details.

P	Proportional gain of the analog feedback path to the Master Oscillator in [V/V].

6.18 FHG Tab (DLC DL-/TA-FHG pro)

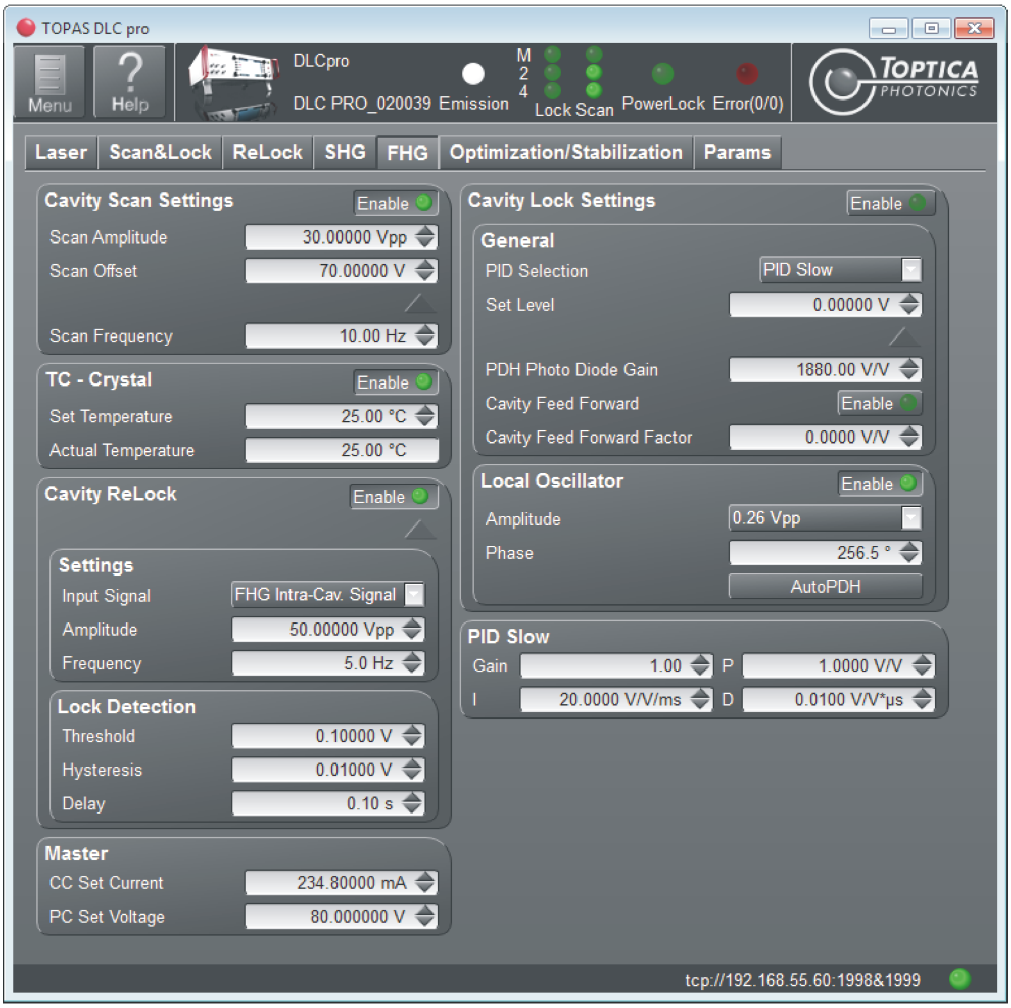


Figure 102 FHG tab (DLC DL-/TA-FHG pro)

The FHG tab for control of the FHG Stage is equivalent to the SHG tab which is described in section 6.17. Please note that P Analog is not available.

6.19 OPO Tab (DLC TOPO)

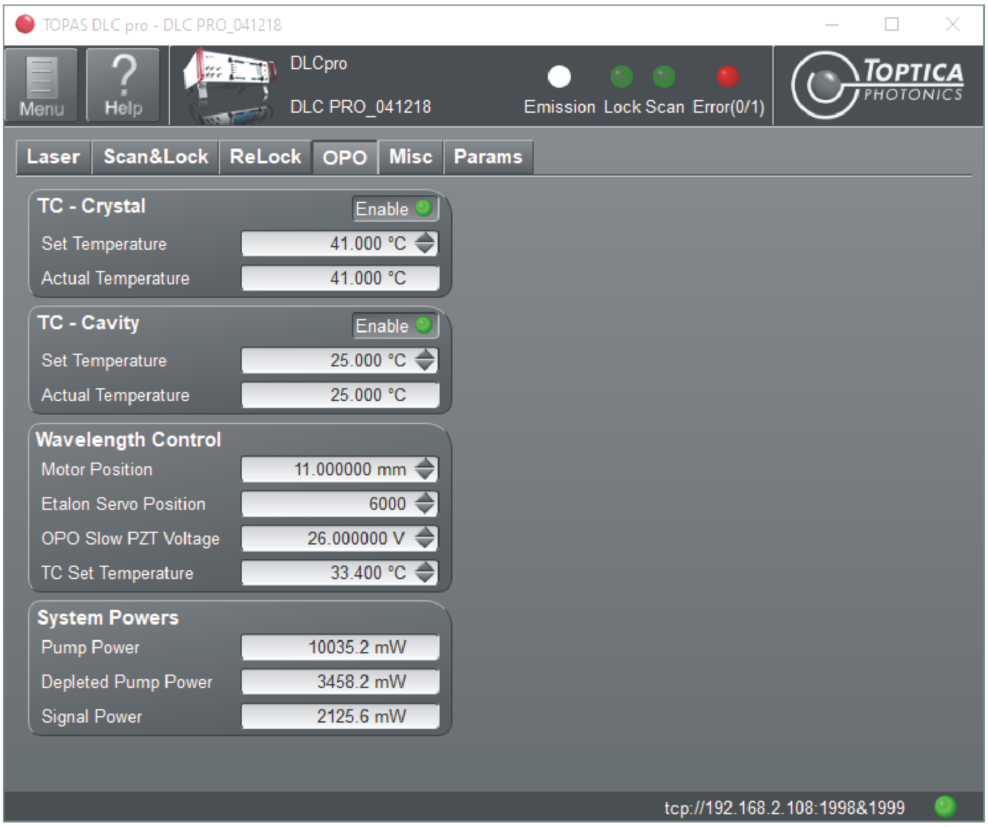


Figure 103 OPO tab (DLC TOPO)

TC Crystal
Settings for the TOPO crystal temperature controller. Please note that the temperature gradient is limited (1 K/min) to avoid damage of the crystal.

Enable
Activates/deactivates the crystal Temperature Control.
When enabled, the crystal temperature is regulated to the **Set Temperature**. When disabled, the crystal temperature is regulated to the idling temperature of 35 °C.

Set Temperature
Input field for the crystal set temperature.

Actual Temperature
Display field for actual crystal temperature.

TC Cavity — Settings for the TOPO cavity Temperature Control.

Enable — Activates/deactivates the cavity Temperature Control. When enabled, the cavity temperature is regulated to the **Set Temperature**.

Set Temperature — Input field for cavity set temperature.

Actual Temperature — Display field for actual cavity temperature.

Wavelength Control — Settings for TOPO output wavelength control.

Motor Position — Intracavity crystal position with a resolution of 40 nm over a 0 - 17.5 mm range.

> **NOTE !** Adjustments smaller than 100 nm do not cause any noticeable changes in wavelength or power of the DLC TOPO laser system.

Etalon Servo Position — The etalon motor moves in 10-step increments, with each increment giving 20 arc-minutes of resolution (range: 4000 - 8000).

OPO Slow PZT Voltage — Intracavity piezo (PZT) voltage in the range of 0 - 140 V.

TC Set Temperature — Input field for DFB pro BFY pump laser temperature.

> **NOTE !** The external fiber amplifier of the DLC TOPO laser system requires 2 - 5 mW of input power. To make sure that the DFB pro BFY pump laser output is inside this range, the **CC Set Current** in the Laser tab should never be changed from the factory setting (see *DFB CC Set Current* in section 02 of the DLC TOPO Production and Quality Control Data Sheet). Consequently, please use CC Analog Remote Control of the DFB pro BFY current only for locking purposes, and do not use the Feed Forward feature, as this also affects the laser diode current.

System Powers

Pump Power — Display of the pump power measured by the power monitoring unit inside the TOPO laser head.

Depleted Pump Power — Display of the depleted pump power measured by the power monitoring unit inside the TOPO laser head.

Signal Power — Display of the signal power measured by the power monitoring unit inside the TOPO laser head.

> **NOTE !** For details on the power monitoring units and the required alignment and calibration procedures, please refer to the TOPO laser head manual.

6.20 Optimization/Stabilization Tab

NOTE !	For details of the power stabilization, please refer to section 5.3.6.

6.20.1 DLC pro for Laser Head DL pro

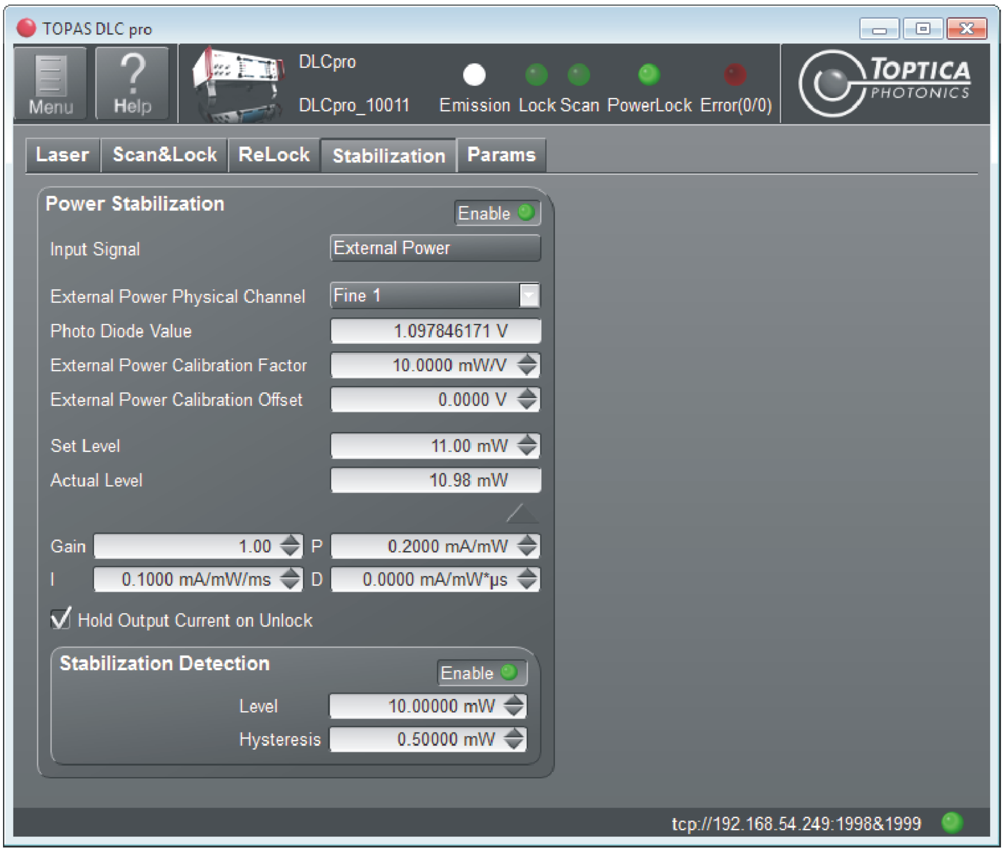


Figure 104 Stabilization tab (DLC DL pro)

The Stabilization tab comprises the operator controls for the DL pro power stabilization. Please refer to section 6.20.5 for a description of the basic operator controls. The specific operator controls for stabilization on **External Power** are described below. For an example on how to configure an external power stabilization, please refer to section 5.3.6.1 and follow the instructions accordingly.

Power Stabilization	Settings for the laser power stabilization.
Enable	Enables/Disables the laser power stabilization (PowerLock). The indicator shows the status of the PowerLock. **Dark green:** PowerLock disabled. **Yellow:** - PowerLock enabled, but power is not stabilized, locking procedure is in progress. - **Actual Current** not sufficient for reaching the desired power **Set Level**. **Light green:** PowerLock enabled and power is stabilized.
Input Signal	Selects which monitor photo diode is used for the power stabilization. **External Power**: External photo diode connected to one of the four DLC pro front panel BNC-connectors Fine/ Fast In.
External Physical Channel	Select the BNC-connector on the DLC pro front panel for connection of the external photo diode.
Photo Diode Value	Displays the photo diode voltage applied to the **External Physical Channel** [V].
External Power Calibration Factor	Enter the calibration factor for the external power.
External Power Calibration Offset	Enter the calibration offset for the external power.

6.20.2 DLC pro for Laser Head TA pro

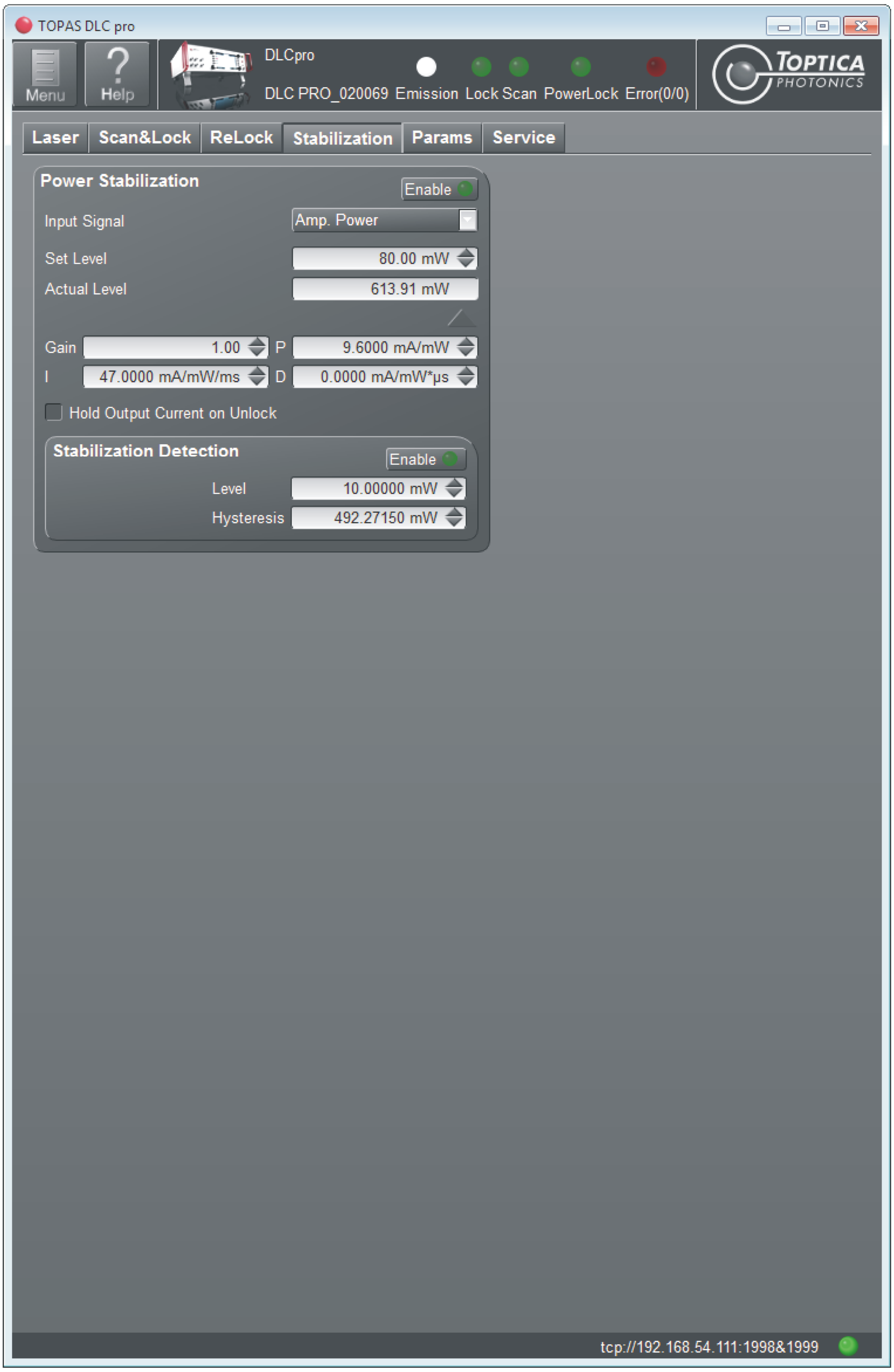


Figure 105 Stabilization tab (DLC TA pro)

The Stabilization tab comprises the operator controls for the TA pro power stabilization. Please refer to section 6.20.5 for a description of the operator controls.

6.20.3 DLC pro for Laser Head TA pro AL

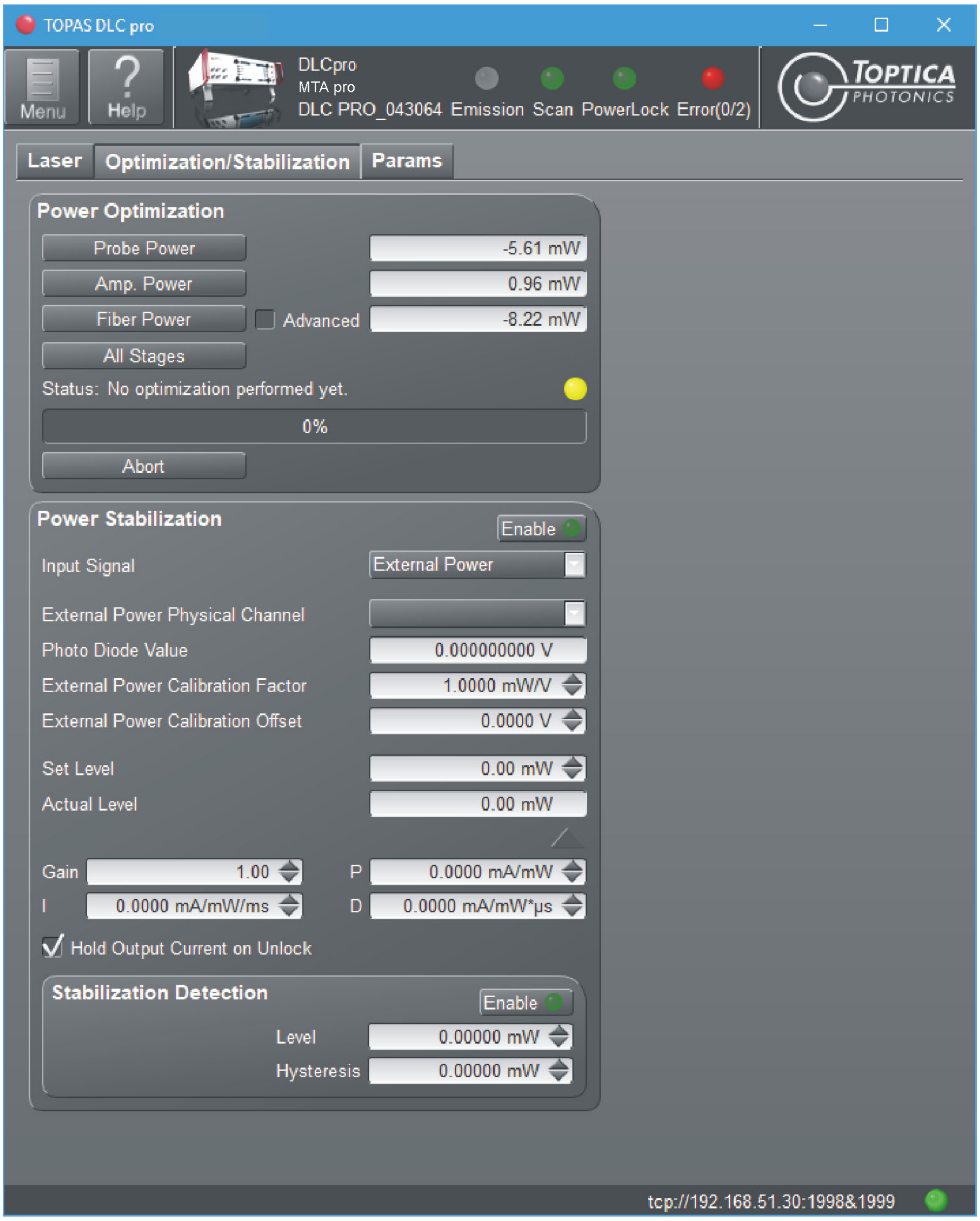


Figure 106 Stabilization tab (DLC TA pro AL, example one laser unit in TA pro configuration)

The Optimization/Stabilization tab comprises the operator controls for the TA pro AL optimization and power stabilization routines.

Power Optimization

This section allows to start various procedures for power optimization. Please note that, depending on the individual TA pro AL configuration, some optimization features may be not available.
The process of the selected optimization procedure can be displayed on the **Optimization Progress Monitor** which is available in the TOPAS DLC pro Menu.

Probe Power

Only available with DLC TA pro AL laser in DL pro and TA pro configuration. Clicking starts the optimization procedure for the probe laser beam power.

Amp. Power

Only available with DLC TA pro AL laser in TA pro and BoosTA pro configuration. Clicking starts the optimization procedure for the Tapered Amplifier power.

Fiber Power

Only available with DLC TA pro AL laser in TA pro and BoosTA pro configuration. Clicking starts the optimization procedure for the fiber output power.

Advanced Checkbox

When selected, a combination of optimization algorithms is performed. For details, please refer to the TA pro AL manual.

All Stages

Clicking starts the available optimization procedures in a preset sequence:
1. Probe Power optimization
2. Amp. Power optimization
3. Fiber Power optimization

Status

Text and indicator provide additional information about the algorithm state.

Abort

Stops a running optimization process.

Power Stabilization

Settings for the laser power stabilization.

Enable

Enables/Disables the laser power stabilization (PowerLock). The indicator shows the status of the PowerLock.

Dark green:	PowerLock disabled.
Yellow:	- PowerLock enabled, but power is not stabilized, locking procedure is in progress. - **Actual Current** not sufficient for reaching the desired power **Set Level**.
Light green:	PowerLock enabled and power is stabilized.

Input Signal

Selects which monitor photo diode is used for the power stabilization. The available selection is dependent on the TA pro AL configuration.

DL pro configuration
External Power: External photo diode connected to one of the four DLC pro front panel BNC-connectors Fine/Fast In. Laser diode current is controlled.

TA pro/BoosTA pro configuration
External Power: External photo diode connected to one of the four DLC pro front panel BNC-connectors Fine/Fast In. Amplifier current is controlled.
Amp. Power: TA output photo diode is used for stabilization. Amplifier current is controlled.

External Physical Channel	Select the BNC-connector on the DLC pro front panel for connection of the external photo diode.
Photo Diode Value	Displays the photo diode voltage applied to the **External Physical Channel** [V].
External Power Calibration Factor	Enter the calibration factor for the external power.
External Power Calibration Offset	Enter the calibration offset for the external power.
Set Level	Set lock level power for the power stabilization in [mW].
Actual Level	Displays the current power of the selected **Input Signal**.
Gain	Overall gain factor of the power stabilization PID controller.
P	Proportional gain of the power stabilization PID controller in [mA/mW].
I	Integral gain of the power stabilization PID controller in [mA/mW/ms].
D	Differential gain of the power stabilization PID controller in [mA/mW x µs].
Hold Output Current on Unlock	If checked, the current of the component used for the power stabilization will stay at its present value when the power stabilization is disabled. If not checked, the current is set to the value before the power stabilization was enabled.
Stabilization Detection	Settings for a detection when the power stabilization is suspended.
Enable	Enables/disables the power stabilization detection
Level	Power limit below which the power stabilization is suspended.
Hysteresis	Tolerance between **Level** and the actual laser power level above which the power stabilization is resumed.

6.20.4 DLC pro for Laser Head CTL

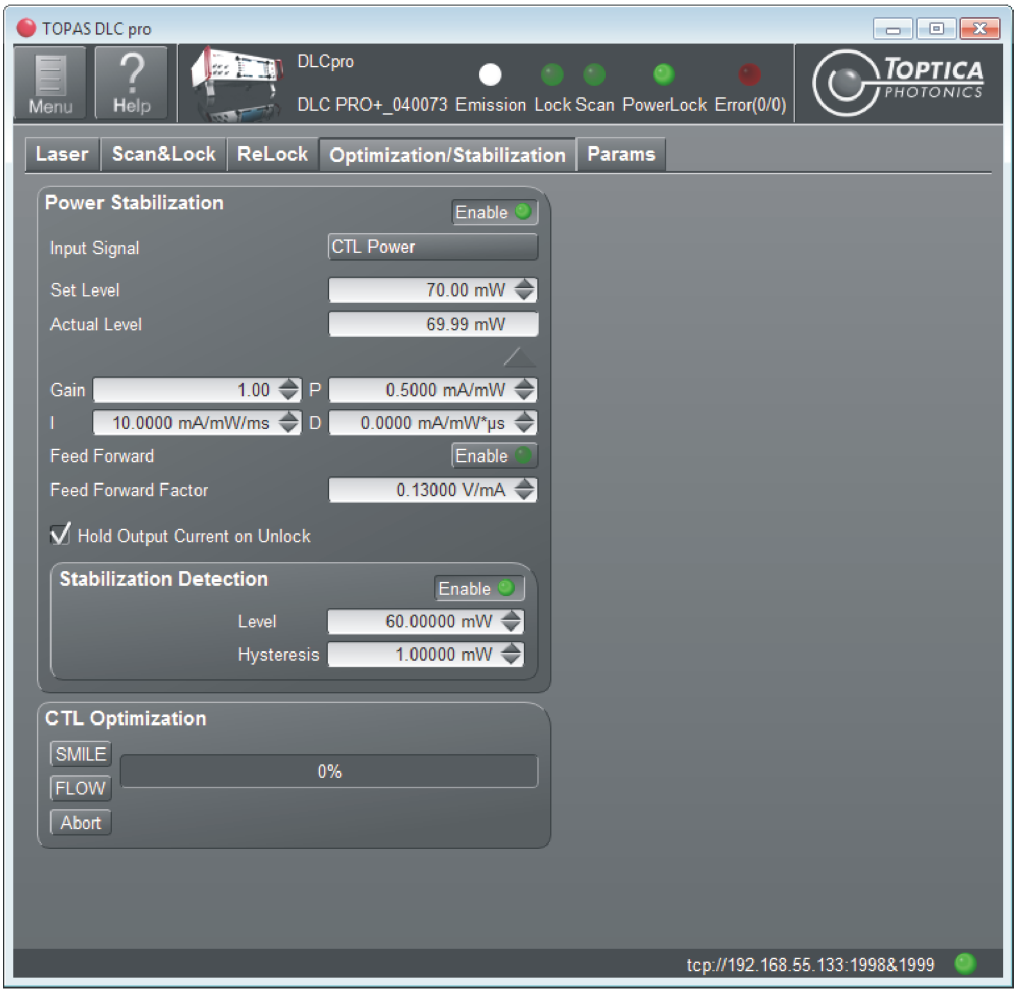


Figure 107 Optimization tab (DLC CTL)

The Optimization/Stabilization tab comprises the operator controls for the CTL power stabilization and the optimization routines. Please refer to section 6.20.5 for a description of the basic power stabilization operator controls. The CTL specific power stabilization and optimization operator controls are described below.

Power Stabilization Selects which monitor photo diode is used for the power stabilization.

Enable Enables/Disables the laser power stabilization (PowerLock). The indicator shows the status of the PowerLock.

Dark green: PowerLock disabled.

Yellow: - PowerLock enabled, but power is not stabilized, locking procedure is in progress.
- **Actual Current** not sufficient for reaching the desired power **Set Level**.

Light green: PowerLock enabled and power is stabilized.

Input Signal **CTL Power** CTL output power.

Feed Forward Enable/disable the power stabilization Feed Forward. When enabled, the piezo voltage is changed proportional to a laser diode current change. This results in a higher wavelength stability when the **Feed Forward Factor** is set properly.

Feed Forward Factor Enter the power stabilization Feed Forward factor. To set the **Feed Forward Factor**, couple the laser beam into a wavelength meter. Set the **Feed Forward Factor** so that a wavelength change during a change of the power stabilization **Set Level** is minimized. Reasonable values are 0 .. 1 V/mA.

CTL Optimization

SMILE Clicking **SMILE** initiates an optimization of SMILE parameters (takes about 1 minute). For details please refer to the CTL manual.

FLOW Clicking **FLOW** minimizes the lasing threshold for a number of different wavelengths (takes about 5 minutes). After FLOW has completed successfully, the optimization of SMILE parameters is automatically performed. For details please refer to the CTL manual.

Abort Click **Abort** to stop the optimization. The previous SMILE/FLOW parameter values are resumed.

Progress Bar The progress bar indicates the status of the optimization.

NOTE !	An error message appears, if SMILE or FLOW optimization is not possible. Potential reasons are active power stabilization, an active motor scan, or enabled ARC for the motor.

6.20.5 DLC pro for Laser Head DL-/TA-SHG/FHG pro

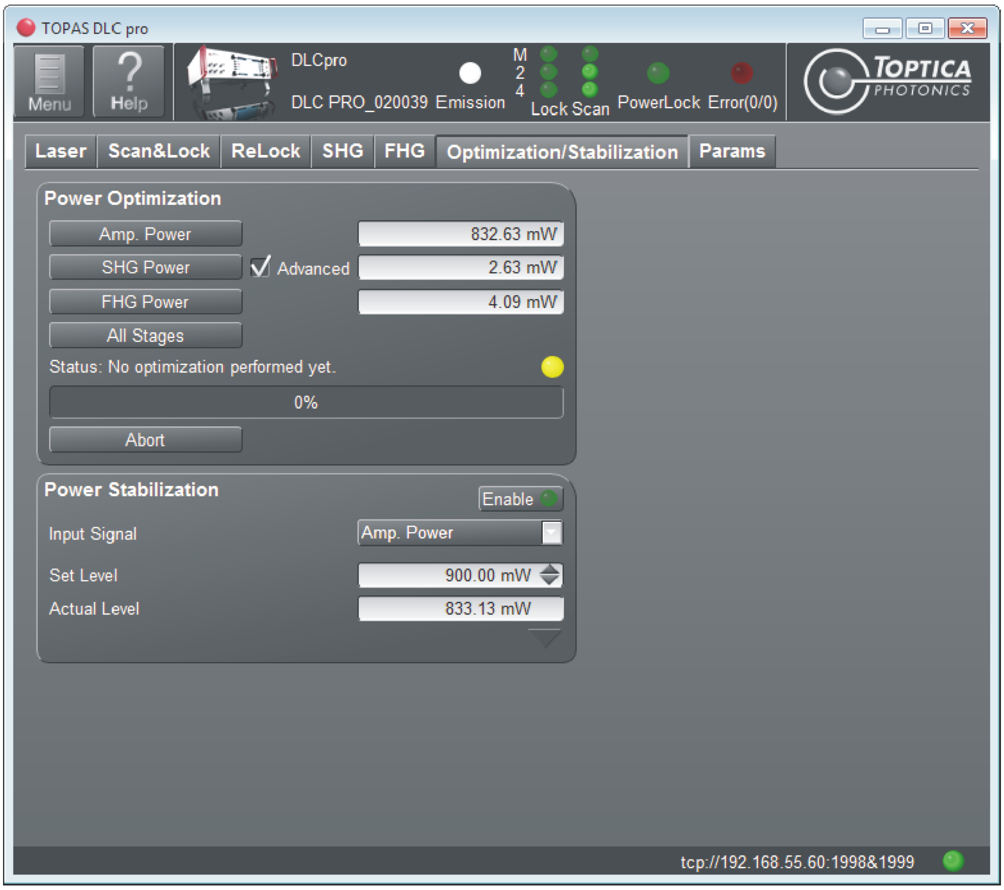


Figure 108 Optimization/Stabilization tab (example DLC DL-/TA-FHG pro)

The Optimization/Stabilization tab allows access to various optimization and stabilization procedures. The Optimization tab is only available with the AutoAlign option (motorized mirrors). The Stabilization tab is only available with TA-SHG/FHG pro laser systems as the Tapered Amplifier power is used for stabilization.

Power Optimization

Only with AutoAlign option. This section allows to start various procedures for power optimization. Please note that, depending on the individual DLC DL-/TA-SHG/FHG pro set-up, some optimization features may be not available.
The process of the selected optimization procedure can be displayed on the **Optimization Progress Monitor** which is available in the TOPAS DLC pro Menu.

Amp Power

Clicking starts the optimization procedure for the amplifier power (only DLC TA-SHG/FHG pro).

SHG Power

Clicking starts the optimization procedure for the SHG power.

Advanced Checkbox

The advanced option allows a more sophisticated algorithm which may achieve higher SHG power levels.

FHG Power

only DLC DL-/TA-FHG pro
Clicking starts the optimization procedure for the FHG power.

Fiber Power	Clicking starts the optimization procedure for the fiber power (available only with option FiberMon).
All Stages	Clicking starts the available optimization procedures in a preset sequence: 1. TA Power optimization (only DLC TA-SHG/FHG pro) 2. SHG Power optimization (**SHG Advanced** algorithm if selected) 3. FHG Power optimization (only DLC DL-/TA-FHG pro) 4. Fiber Power optimization (only with option FiberMon)
Status	Text and indicator provide additional information about the algorithm state.
Abort	Stops a running optimization process.
Power Stabilization	Settings for the laser power stabilization.
Enable	Enables/Disables the laser power stabilization (PowerLock). The indicator shows the status of the PowerLock. **Dark green:** PowerLock disabled. **Yellow:** - PowerLock enabled, but power is not stabilized, locking procedure is in progress. - **Actual Current** not sufficient for reaching the desired power **Set Level**. **Light green:** PowerLock enabled and power is stabilized.
Input Signal	Selects which monitor photo diode is used for the power stabilization. **External Power**: External photo diode connected to one of the four DLC pro front panel BNC-connectors Fine/ Fast In. Please refer to section 6.20.1 for input channel selection and calibration options. **Amp. Power:** TA output photo diode. **SHG Power:** SHG output photo diode. **FHG Power:** FHG output photo diode (only DLC TA-FHG pro). **Fiber Power:** Fiber monitor photo diode (only with option FiberMon).
Set Level	Set lock level power for the power stabilization in [mW].
Actual Level	Displays the current power of the selected **Input Signal**.
Gain	Overall gain factor of the power stabilization PID controller.
P	Proportional gain of the power stabilization PID controller in [mA/mW].
I	Integral gain of the power stabilization PID controller in [mA/mW/ms].
D	Differential gain of the power stabilization PID controller in [mA/mW x µs].

Hold Output Current on Unlock	If checked, the current of the component used for the power stabilization will stay at its present value when the power stabilization is disabled. If not checked, the current is set to the value before the power stabilization was enabled.
Stabilization Detection	Settings for a detection when the power stabilization is suspended.
Enable	Enables/disables the power stabilization detection
Level	Power limit below which the power stabilization is suspended.
Hysteresis	Tolerance between **Level** and the actual laser power level above which the power stabilization is resumed.

6.21 PDH Tab

NOTE !	To show and use the PDH tab, a PDH module must be installed at your DLC pro. When the PDH module is acquired, TOPTICA also provides relevant software to update your DLC pro. Please refer to section 10.3 for a step-by-step description on how to install the PDH module. If purchased along with the DLC pro, the PDH module and the software is already installed.

NOTE !	To use the PDH module for Top of Fringe PDH locking (Scan & Lock tab, see section 6.15.3), a Lock option license is required. The PDH module itself can be used without Lock option license. The Error signals are applied to the SMB-connectors of the PDH module (rear side of the DLC pro) and can be used together with an external controller.

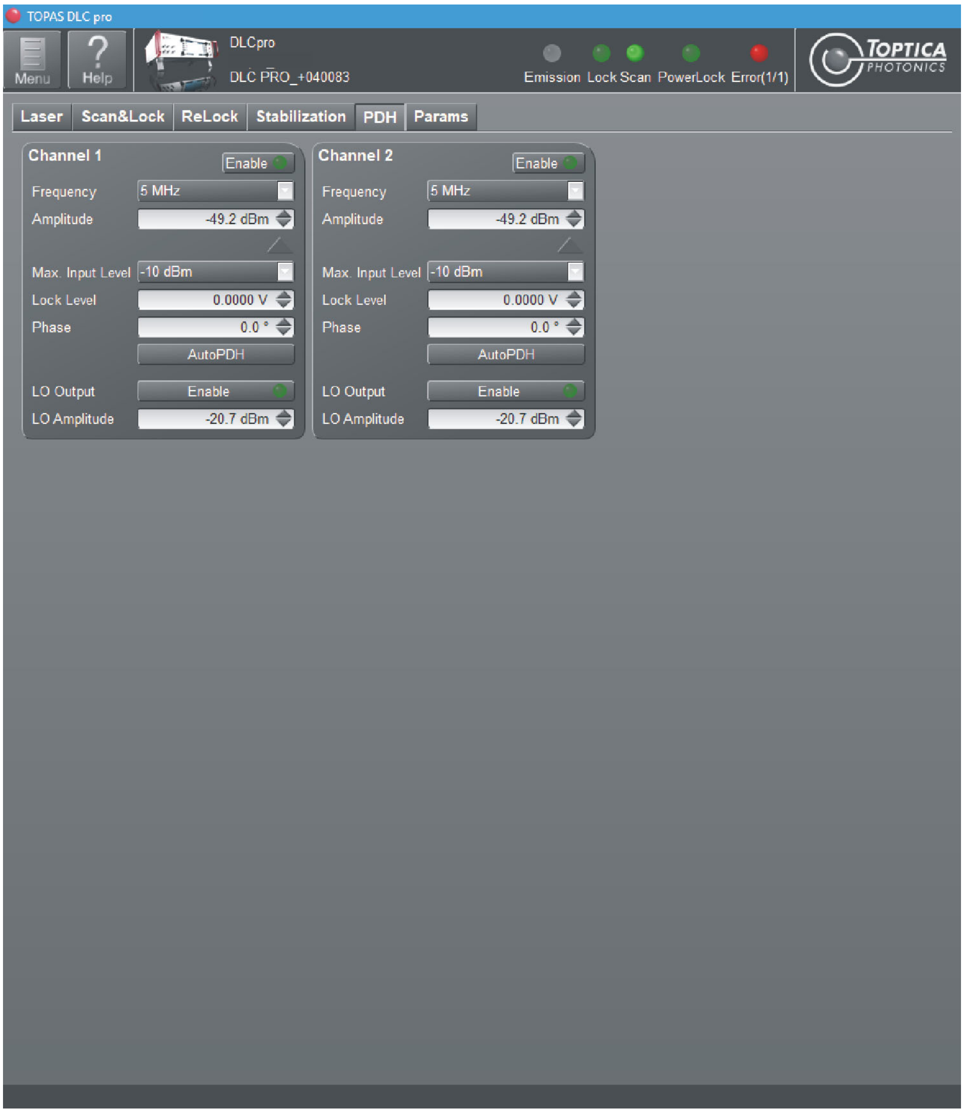


Figure 109 PDH tab

The PDH tab allows to configure the PDH module and is only available with a PDH module installed at your DLC pro.

Channel 1 Settings for channel 1 of the PDH module.

Enable Enable or disable PDH modulation and demodulation signal generation.

Frequency Select PDH modulation frequency.

Amplitude Enter PDH modulation amplitude.

Click the triangle below to access advanced setting options.

Max. Input Level Select the maximum RF input level expected at the in 1 connector of the PDH module.
-10 dBm: Signal level valid up to -10 dBm
0 dBm: Signal level valid up to 0 dBm
+10 dBm: Signal level valid up to +10 dBm

Lock Level Set level for the DLC pro internal PID controller used for the Top of Fringe PDH lock type.

Phase Enter the phase difference between PDH modulation and demodulation signal.

AutoPDH Starts an algorithm which finds the optimum phase between the photo diode signal and the local oscillator.

LO Output Enable or disable output of the LO signal instead of the error signal at the err/lo 1 connector of the PDH module.

LO Amplitude Enter the LO Amplitude.

NOTE !	When **LO Output** is enabled, the **LO Amplitude** can be set as desired. This may affect the error signal generated by the PDH module. If you wish to output the demodulation signal and ensure optimum error signal quality at the same time, set **LO Amplitude** to 8.8 dBm.

Channel 2 Settings for channel 2 of the PDH module.
Please refer to the descriptions of **Channel 1** for information.

6.22 FALC Tab

NOTE !	**For FALC pro module operation, System Software 5.9.1 or higher and Firmware 2.2.0 or higher are required. The MC+ module must be of hardware version 1V09 or higher.**

NOTE !	To show and use the FALC tab, a FALC pro module must be connected to your DLC pro. When the FALC pro module is acquired, TOPTICA also provides relevant software to update your DLC pro. Please refer to the FALC pro manual for detailed information on connecting the FALC pro module and configurating the CAN bus connection. If purchased along with the DLC pro, the software is already installed. However, the CAN bus connection must be configured according to the individual setup for FALC pro single use, or FALC pro use in a CAN link chain (see FALC pro manual for detailed information).

NOTE !	To use the FALC pro module together with the DLC pro Lock option, a Lock option license is required. For DLC pro systems purchased without the DLC pro Lock option, a 30-day trial license is provided on the USB flash drive with the DLC pro software. Please refer to section 10.19 for activating the license key. The FALC pro module itself can be used without Lock option license. Please refer to the FALC pro manual for detailed information.

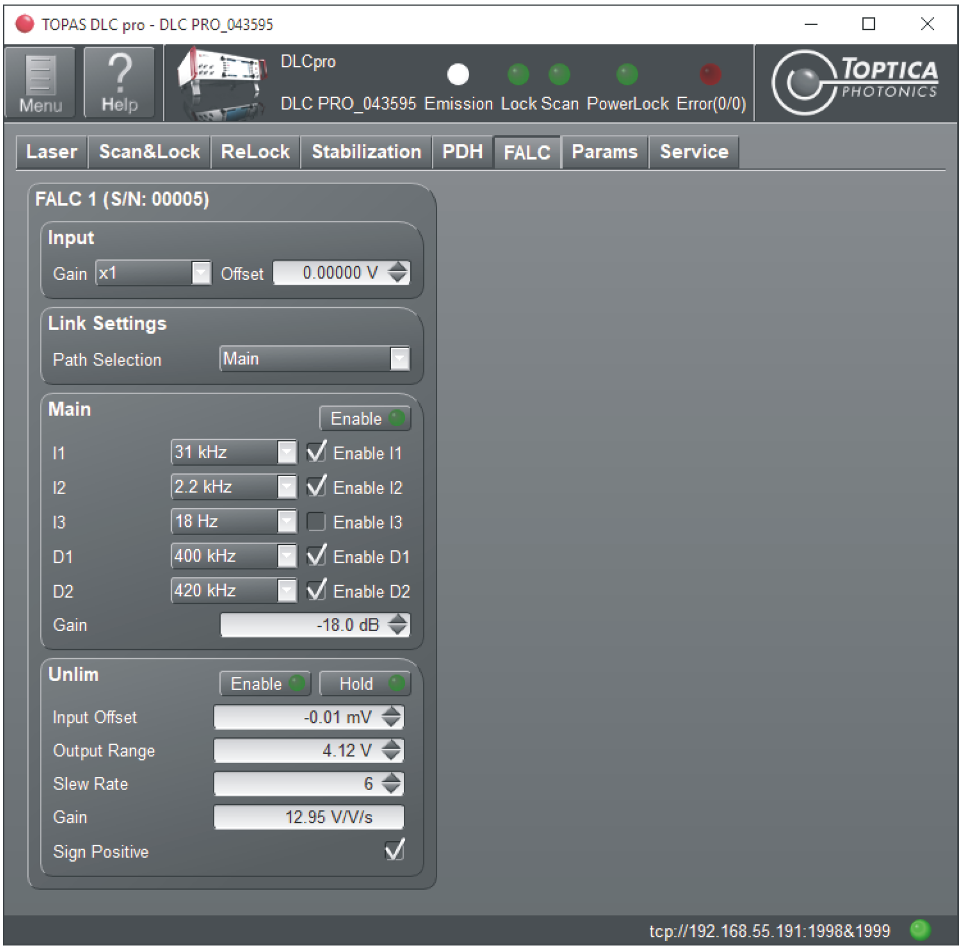


Figure 110 FALC tab

The FALC tab allows to configure the regulator of the FALC pro module and is only available with a FALC pro module connected to your DLC pro. The FALC tab does not depend on which front panel is mounted to the FALC pro module. Please refer to the FALC pro manual for detailed information on the module.

Input

Gain	Specify the input gain factor of the input signal. Available values are 1 and 5.
Offset	Compensates an offset of the input signal in [V].

Link Settings	**Only with DLC pro Lock option.**
Path Selection	Specify the branch(es) that are controlled by the DLC pro Lock option.

Main

Enable	Activates/deactivates the main circuit branch.
Enable Checkboxes	Check the respective box to enable the filter element in the main circuit branch.
I1	Specify the left corner frequency of the I1-integrating filter element.
I2	Specify the left corner frequency of the I2-integrating filter element.
I3	Specify the left corner frequency of the I3-integrating filter element.
D1	Specify the left corner frequency of the D1- differentiating filter element.
D2	Specify the left corner frequency of the D2- differentiating filter element.
Gain	Output gain value [dB] of the main circuit branch.

Unlim

Enable	Activates/deactivates the Unlim integrator branch.
Hold	Enables/Disables the update of the Unlim integrator output value. If enabled, the output value is frozen to the value in the moment the hold status is initiated.
Input Offset	Compensates an offset between the input of the Unlim integrator and the FALC pro internal error signal in [mV].
Output Range	Maximum absolute voltage [V] of the Unlimited integrator output signal.
Slew Rate	Specify the slew rate setting of the Unlim integrator [1 .. 12].
Gain	Indication of the resulting integrator gain [V/V/s] that is specified by the **Output Range** and the **Slew Rate**.
Sign Positive	Checkbox to select the sign (behavior) of the Unlim integrator. **Checked**: Output signal is in phase with the Error Output of the FALC pro module. **Unchecked**: Output signal is inverted with respect to the Error Output.

6.23 Misc Tab

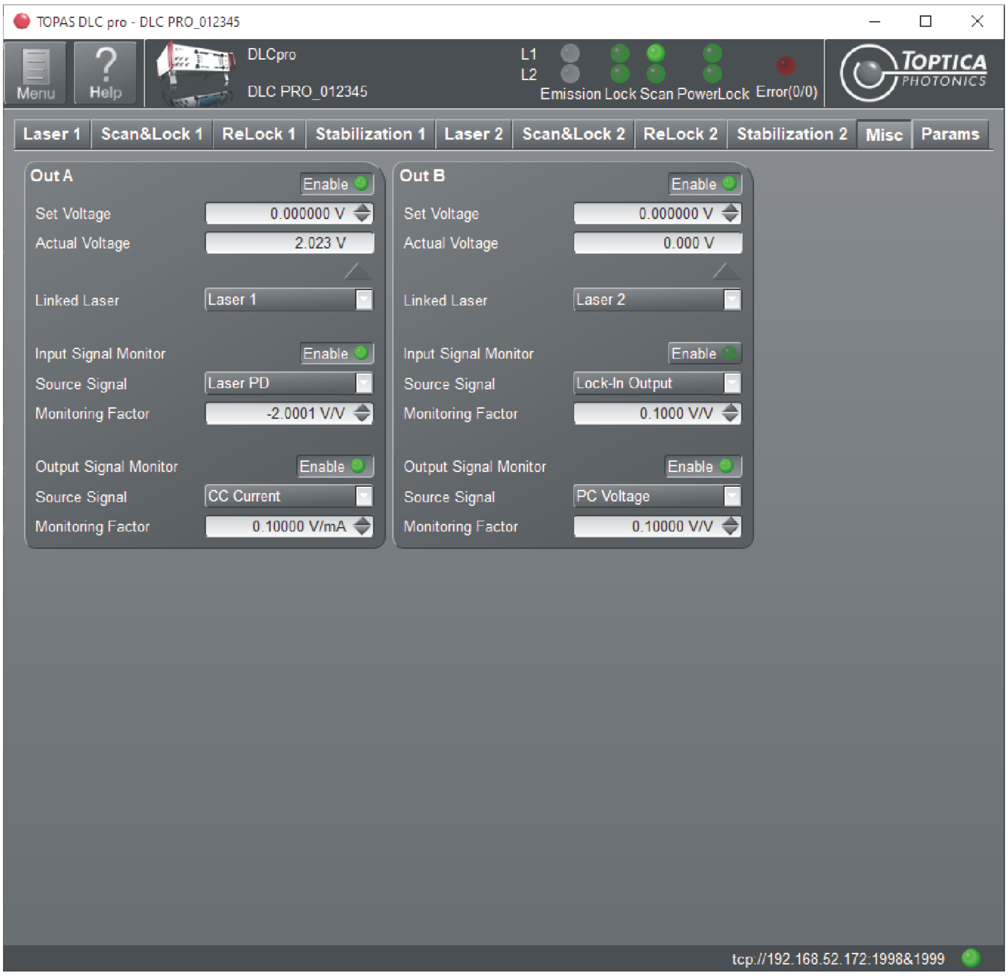


Figure 111 Misc tab (example)

The Misc tab allows to configure the voltages applied to the Out A and Out B BNC-connectors on the DLC pro front panel (see Figure 5). It is possible to control the DC voltage level and to route certain DLC pro internal signals to the BNC outputs, e.g. for monitoring on an external oscilloscope. The signals available for monitoring depend on the laser head type in use and are grouped into two disjoint signal types, reflecting the way their data streams are handled by the DLC pro signal processing unit.

- "Input Signals" are data streams resulting from periodical readout and post-processing of analog-to-digital converters. Examples are the voltage measured at the "Fine 1/2" BNC connectors on the DLC pro front panel, the "TC Temperature" measured inside DFB pro laser heads or the demodulated "Lock-In Output" of the built-in DLC pro lock-in amplifier (if the DLC pro Lock Option is installed).

- "Output Signals" are data streams generated by the DLC pro signal processing unit for controlling physical actuators. Examples are the "CC Current", "PC Voltage" or even the "Out A" or "Out B" voltages themselves.

You can think of Out A (and Out B) as an "adder", summing up a constant DC value, data from an "Input Signal" and data from an "Output Signal" to generate a resulting data stream which is then translated into a voltage, finally getting applied to the BNC-connector.

NOTE !	In case you did configure Out A or B as the output channel for the scan generator on the Laser tab or one of the PID regulators on the Scan&Lock tab, the outputs of these components will be added to the resulting data stream as well.

Please note that the **Input Signal Monitor** and the **Output Signal Monitor** differ in the way their stream data gets added. While for "Input Signals" their full value gets added directly as soon as monitoring is enabled, for "Output Signals" only changes of the data get added. That means that the voltage of Out A/B will not change immediately when the **Output Signal Monitor** is enabled. The value of the selected output channel first needs to vary in order to lead to a change of the Out A/B voltage.

Out A/Out B
Sections to configure the output applied to the Out A and Out B BNC-connectors on the DLC pro front panel (see Figure 5).
Click **Enable** to activate the voltage output at the respective BNC-connector. When the output is disabled, the output voltage is 0 V.

Set Voltage
Input field for a DC offset voltage applied to the output BNC-connector.

NOTE !	In case Out A/B is selected as the **Scan Output** channel (e.g. in the Laser tab), changes of the **Scan Offset** will immediately change the **Set Voltage**.

Actual Voltage
Display of the actual voltage applied to the output BNC-connector. The displayed voltage is internally calculated by the DLC pro.

NOTE !	In case Out A/B is selected as the signal output in any other tab of the TOPAS DLC pro PC-GUI or a context parameter menu of the touchscreen user interface, this also affects the **Actual Voltage** value.

Click the triangle below to access advanced setting options.

Linked Laser
Only available with Dual-Laser Operation.
Choose the desired laser for **Source Signal** selection.

Input Signal Monitor
Click **Enable** to output signals which are fed to the DLC pro from connected devices.

Source Signal
Available signals are dependent on the Linked Laser head.
Select signal type to be output at the BNC-connector.

Monitoring Factor
Enter factor to be multiplied with the **Source Signal** value. The resulting voltage is added to the **Set Voltage** and applied to the output BNC-connector. This can be useful to scale-down signals so that the output range of - 4 V..+ 4 V is met.

Output Signal Monitor	Click **Enable** to output signals which are generated by the DLC pro.

NOTE ! When **Output Signal Monitor** is enabled, not the absolute value but only changes of the **Source Signal** value affect the **Actual Voltage**.

Source Signal	**Available signals are dependent on the Linked Laser head.** Select signal type to be output at the BNC-connector.
Monitoring Factor	Enter factor to be multiplied with the changes of the **Source Signal** value. The resulting voltage is added to the **Set Voltage** and applied to the output BNC-connector. This can be useful to scale-down signals so that the output range of - 4 V..+ 4 V is met.

NOTE ! **We recommend to enable the Input/Output Signal Monitors only when required.** When configuring the **Input/Output Signal Monitors**, always make sure that the settings suit the experimental setup and that the selected **Linked Laser does not interfere with selections in other tabs** ! This is especially important when external devices are connected to the Out A/Out B BNC-connectors.

6.24 Params Tab

NOTE !	For normal operation, all relevant parameters are set in the relevant sections of the TOPAS DLC pro PC-GUI. To enable the user to change parameters that are not accessible via any predefined screens, review the complete set of the DLC pro parameters in the Params tab. For a detailed description of the parameters and associated codes, please refer to the Remote Command Reference for TCP/IP and USB. This document is available as a pdf file in the Documentations folder on the software USB flash drive supplied with the DLC pro.

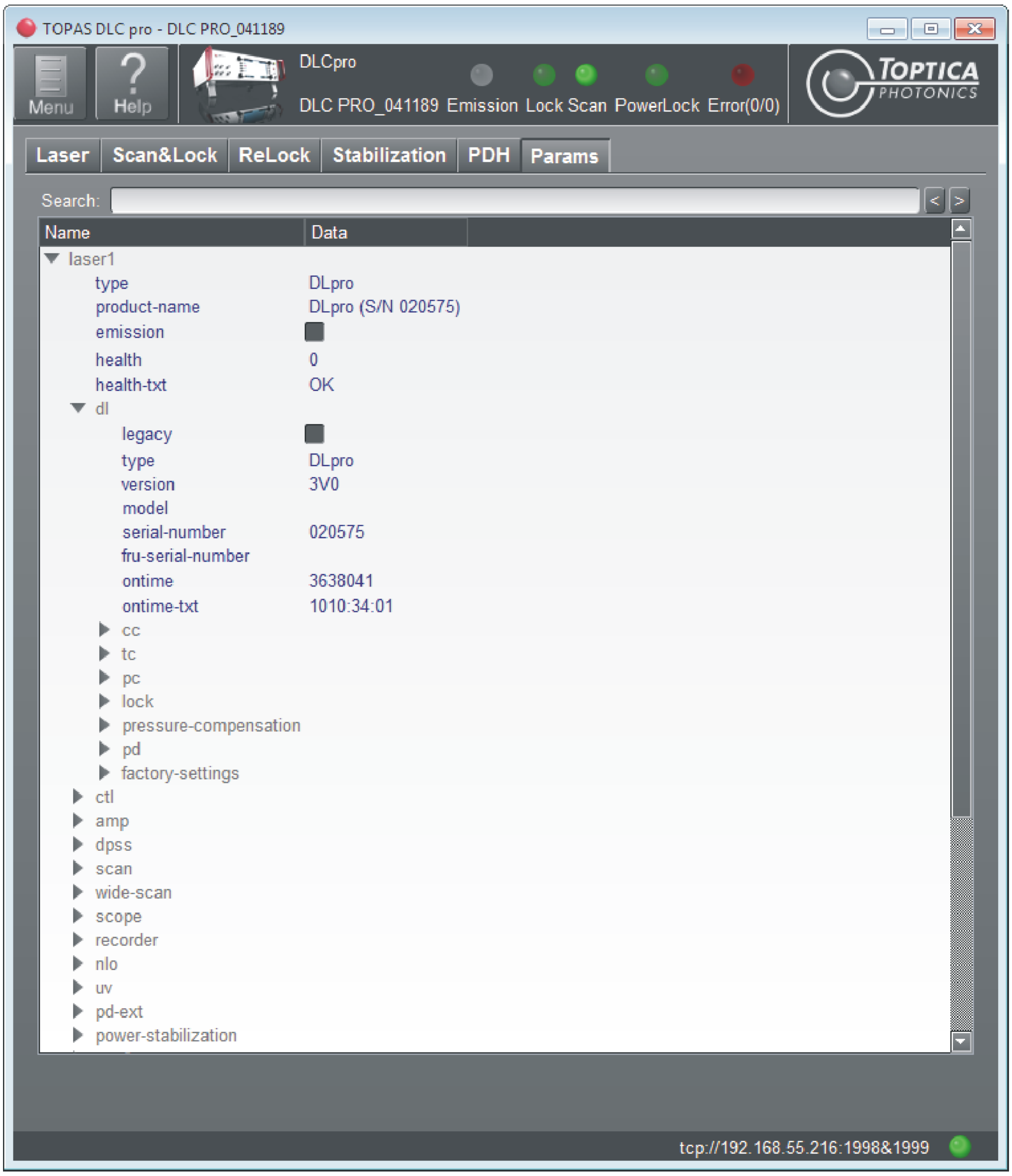


Figure 112 Params tab (example)

A complete list of the accessible parameters is displayed in the Params tab (parameter tree). The parameters are sorted according to functional units. Some parameters can be set directly in the tree after clicking on the value, others are display only.

Along with the parameters a number of commands are accessible in the Params tab. They are displayed in orange and after clicking them, a button appears which allows to execute the command. An example for such a command is the command laser1:save which stores the most important settings in the Params tab to the flash memory of the DLC pro in order to operate the laser with those settings after the next boot procedure of the DLC pro. Please note that some of the commands require a certain user level and are not visible if they cannot be executed.

To save the most important settings in the Params tab to the flash memory of the DLC pro, select **Menu > Save Configuration** or execute the command laser1:save.

NOTE !	The function of **Menu > Save Configuration** is equal to pressing the **Load/Save** button on the DLC pro front panel twice and to executing the command laser1/2:save.

7 Application Examples

NOTE !	To utilize the DLC pro Lock function modes, a Lock option license is required. When a Lock option license is acquired, TOPTICA provides an option license key via e-mail or USB flash drive. The license is unlimited in time but linked to the individual hardware of the DLC pro and cannot be used for other devices. The license key must be activated via the TOPAS DLC pro PC-GUI (please refer to section 10.19). If purchased along with the DLC pro, the licence is already installed. Otherwise a 30-day trail licence is provided on the USB flash drive in the Options Folder. **Dual-Laser-Operation**: With a single Lock option installed, in combination with the Dual-Laser-Operation upgrade, frequency locking of both lasers is possible.

NOTE !	The application examples below describe step-by-step the operation via the touchscreen interface. All examples can also be performed using the TOPAS DLC pro PC-GUI.

There are numerous different schemes to stabilize the frequency of lasers (e.g., to atomic or molecular resonances as well as cavities). The Lock function modes of the DLC pro are designed to cover a large range of locking scenarios. This section describes step-by-step how to perform some of the most common schemes with the DLC pro.

NOTE !	This section assumes that the user has some basic knowledge of the laser system and the electronics involved. For further information, see the laser head manual and the respective sections of the DLC pro manual.

7.1 General System Setup

The general setup to stabilize the frequency of lasers via the DLC pro is shown in Figure 113. All locking schemes are based on a spectroscopic or cavity signal (Lock Input signal) provided by the experimental setup which serves as a reference. The Scan/Lock mode of the DLC pro supplies the scan functionality to find resonances and potential lockpoints. It is also capable of utilizing the scan response as the Error signal and provides the controllers for the feedback loops. Moreover, the DLC pro can generate an Error signal by means of a frequency modulation/demodulation technique called *Lock-In* or *Pound-Drever-Hall*. Furthermore, the touchscreen and the TOPAS DLC pro PC-GUI support both user-friendly and intuitive access to all lock parameters. The integrated frequency analysis (Frequency display mode) allows you to optimize the controllers for advanced applications.

This section introduces the common setup with a DLC DL pro laser system for different lock scenarios.

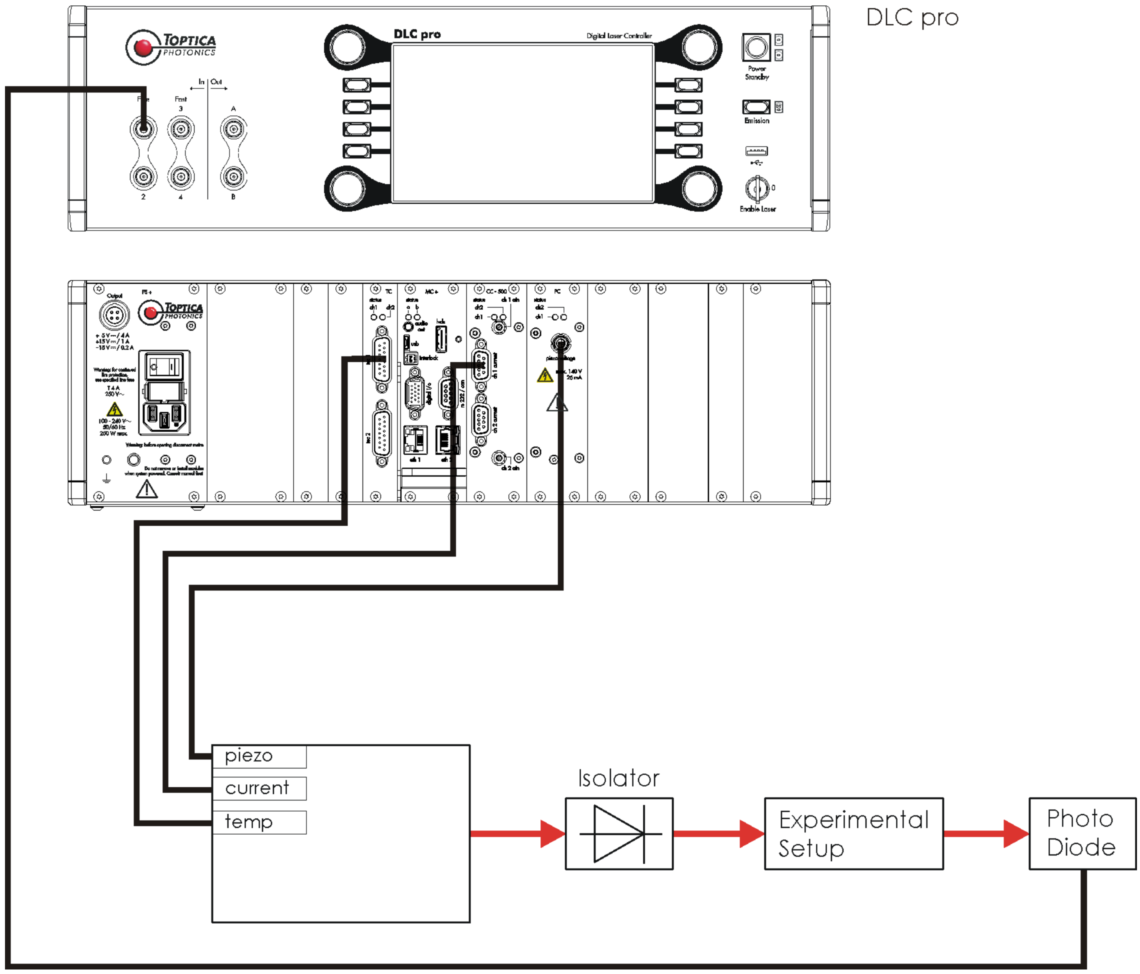


Figure 113 Typical setup for a frequency lock of a TOPTICA diode laser head via the DLC pro

The signal from a photo diode is fed into one of the Input BNC-connectors on the DLC pro front panel. The two PID controllers act on the grating piezo via the PC module and on the laser diode current via the CC module.

Initial Setup:

CAUTION !	Make sure that the laser current is switched off while installing the experimental setup. Ensure proper (personal) grounding while handling the laser head (e.g., when connecting cables).

1. Make sure that the laser head is properly connected to the TC, CC, and PC modules on the rear panel of the DLC pro. In the application examples, a DL pro extended-cavity diode laser (ECDL) is assumed. The same setup can work equally well with the DL 100 and can be translated to other diode based laser systems like the Tapered Amplifier (DLC TA pro), the Continuously Tunable Laser (DLC CTL), and the frequency-converting laser systems (DLC DL-/TA-SHG/FHG pro). The corresponding connections of the DL 100 laser head are labeled as follows:

DL pro	DL 100	Comment
mod DC	curr. mod.	DC-coupled current feedback is used for the fast feedback in addition to the slow feedback to the piezo.
mod AC	bias-t	AC-coupled fast current feedback can optionally be used for feedback or modulation at high frequencies in the MHz range or to apply the modulation frequency independently from the current feedback.

2. The output of the photo detector is connected to one of the **Fine/Fast In** BNC-connectors on the DLC pro front panel. Using the Fine connectors is recommended. For the BNC-connector specifications, please refer to section 4.3.

CAUTION !	On the Home screen, tap **Laser Config** and check the maximum current setting I_{max} of the CC module to prevent damage to the laser diode.

DANGER !	Do not look into the laser beam as the output can exceed the limits for class 1 specified by US laws 21 CFR 1040.10 and 2 CFR 1040.11 and the Laser Safety Standard EN 60825-1:2014. Take precautions to eliminate exposure to a direct or reflected beam.

3. Switch on the laser by pressing the **Emission** button. After a few minutes, the laser will stabilize thermally. Switch to Scan/Lock mode and select the Scan function mode.
You can adjust the laser frequency to the desired resonance using several methods with increasing precision:

- Coarse tuning in the 0.1 nm range is usually only required for the initial setup and can be achieved by modifying the angle of the grating with the fine-thread screw (please refer to the laser head manual).
- Adjust the **Set Current** I_{set} (and if necessary the **Set Temperature** T_{set}) at the rotary knobs to tune the frequency and achieve single-mode operation of the laser.
- The built-in piezo allows mode hop-free scanning of the laser over several 10 GHz. The DLC pro generates the scan signal that drives the piezo using the PC module as a high-voltage amplifier. The output is the sum of the **Scan Amplitude** and the **Scan Offset**.

4. Adjust the settings for the scan signal generation via the rotary knobs and touch gestures or in the context parameter menu after pressing the **Parameter** button in Scan/Lock mode:

Parameter	Description	Value to set to[a]
Scan > Scan Shape	Shape of the scan ramp	Triangle
Scan > Scan Frequency	Frequency of full scan (back and forth)	10 Hz
Scan Amplitude (Rotary Knob)	Scan amplitude peak-peak	10 V[b]
Scan Offset (Rotary Knob)	Scan offset	dependent on the laser
Scan > Scan Output	Output to which the scan signal is added	<PC Voltage>
Feed Forward > Feed Forward Factor	Current ramp applied to the laser diode	- 1 mA/V

a. The numerical values are guidelines and depend on the individual setup.
b. The scan amplitude can be enlarged or reduced to correspond to the application.

Table 1 DLC pro scan control settings

Obtain the maximum scan range of the DLC pro in the following way:

5. Set **Scan Offset** to 69.5 V.

6. Set **Scan Amplitude** to 141 V.
The scan control can now access the full output range (-1 .. +140 V).

7. You can analyze all the relevant signals via the touchscreen. However, the Digital I/O Connector of the MC+ module provides a digital trigger output (TTL-compatible) that can be used for monitoring signals on an external oscilloscope (for details please refer to section 9.2.3).

Now, all the hardware is set up, and the laser system can be completely controlled by the DLC pro.

7.2 PDH Lock with Cavity

7.2.1 Utilizing the DLC pro Lock Option

This section describes the laser frequency stabilization to a cavity.

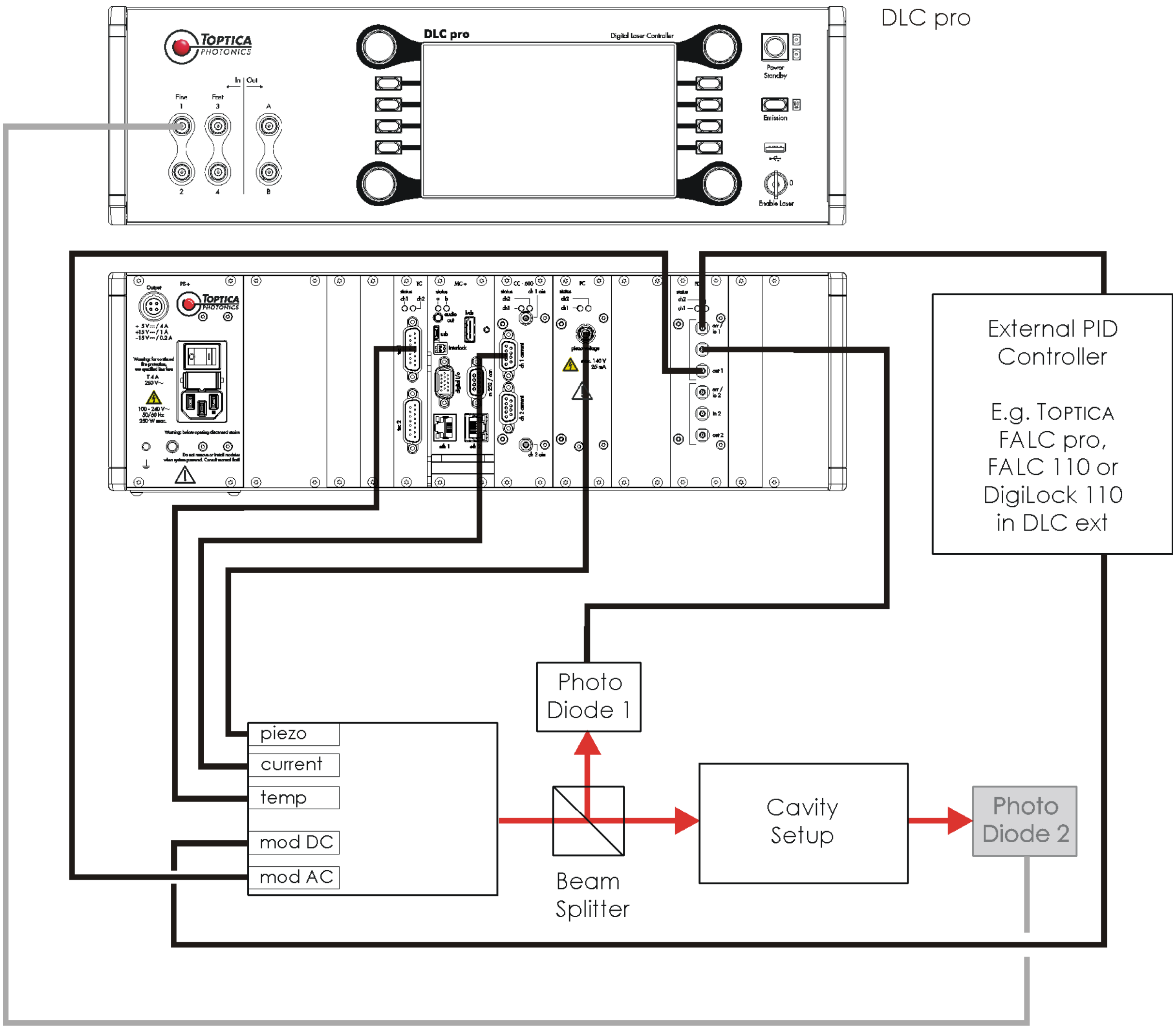


Figure 114 Experimental setup for Top of Fringe Lock with cavity, PDH module in the DLC pro and an external PID controller to increase the bandwidth of the control loop, e.g. when the laser line-width should be narrowed, or to increase the lock stability.

NOTE !	If you want to use the Lock Points Tool for showing and selecting lockpoints, etc. (for details please refer to section 6.15.1), a DC-coupled photo diode 1 must be used, or photo diode 2 must be connected as shown in Figure 114.

To lock the laser frequency to an extremum of the cavity signal, a zero-crossing slope is generated using frequency modulation and demodulation. **PDH** (Pound-Drever-Hall) lock uses a modulation frequency larger than the characteristic resonance width to obtain the derivative of the absorption signal by demodulation.

1. Press the **Scan/Lock Mode** button to switch to Scan/Lock mode.
   Tap the **xy** symbol at the top of the touchscreen to switch to xy display mode. Select **Display Settings** > **Trace Selection** > **Input Trace Signal** > **Lock Input Signal**.

Tap the **Lockpoint** symbol at the bottom of the touchscreen to choose the Lockpoint function mode.

2. Select the input channel for the photo diode signal that is connected to the PDH module of the DLC pro. (Parameter menu, **Lock Settings > Lock Input Signal > PDH In 1** in the example). From the Lock Input Signal, the PDH Error signal is generated, which is used as the input for all selected PID controllers.

3. In the Parameter menu, select **Lock Settings > Lock Type > Top of Fringe PDH**.

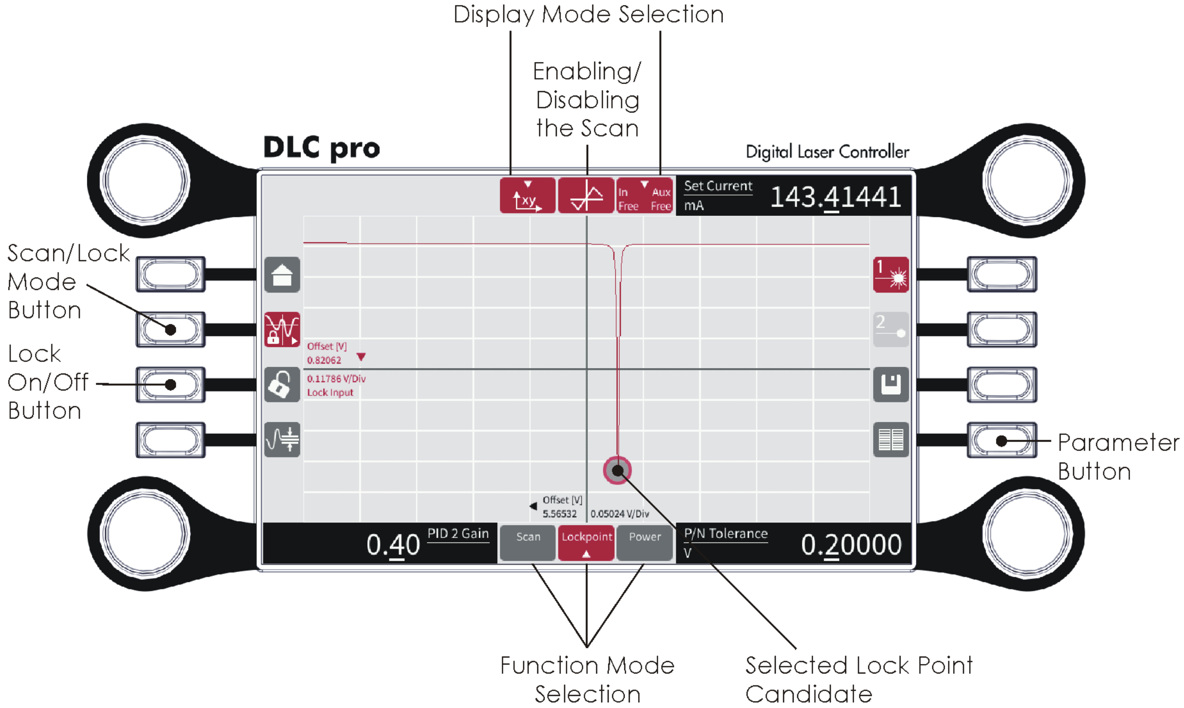


Figure 115 Lockpoint function mode: Lockpoint candidates for Top of Fringe PDH Lock type (example)

4. Select both PID controllers for frequency stabilization (parameter menu, **Lock Settings > PID Selection > PID 1+2**).

5. Zoom and drag the Lock Input signal and adjust the laser current (**Set Current** rotary knob) until the desired lockpoint in the spectrum is clearly visible on the display.

NOTE !	If the lockpoints at the extrema are not properly detected automatically, this behavior can be improved by adjusting the **P/N Tolerance** at the bottom right rotary knob. This parameter is 0 for automatic detection, and automatic detection does not always work perfectly. The parameter should be set to a value that is larger than the peak-to-peak noise and smaller than the peaks that the laser should be locked to.

6. Switch to the PDH Ch 1 Lock function mode by selecting the **PDH Ch 1** symbol.
Select the PDH Error 1 signal to be displayed as the Auxiliary trace in blue
(parameter menu, **Display Settings > Trace Selection > PDH Error 1**).

7. Adjust the blue PDH Error 1 signal until it looks similar to the example shown in Figure 116. Use the rotary knobs and the parameter menu (**PDH**) to configure the PDH lock parameters.

Parameter	Description	Reasonable setting
PDH Modulation Frequency	User-selected modulation/demodulation frequency.	25 [MHz]
PDH Modulation Amplitude	Amplitude of the PDH modulation.	Depending on experimental setup [dBm] (*****)
PDH Demodulation Phase	Phase difference between modulation and demodulation.	0 … 360 [°] (to be adjusted, ******)

***** The PDH modulation amplitude is a tradeoff between the desired PDH Error 1 signal strength and the power in the side bands. The larger the amplitude, the larger the PDH Error 1 signal. However, the side bands will be stronger.

****** The PDH Error 1 signal resembles the derivative of the input signal (i.e., positive Error signal on positive signal slope). The phase between the modulation and the reference signal must be adjusted to obtain a large error signal with steep slopes and zero crossings at the maxima of the spectral signal.

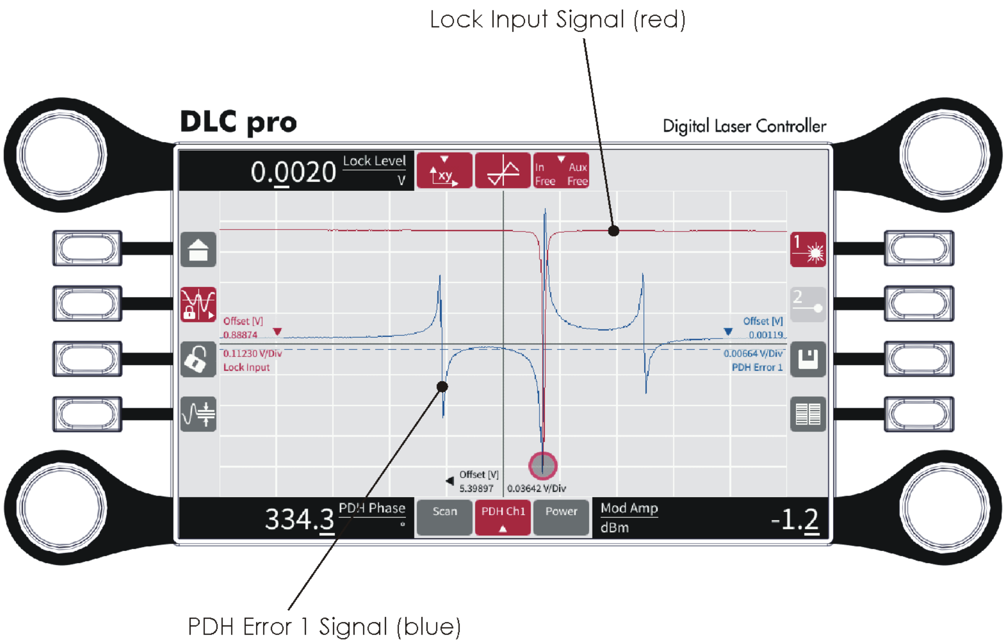


Figure 116 Display of the cavity spectrum (Lock Input Signal, red) with the corresponding PDH Error 1 signal (blue).
Note: The phase of the PDH Error 1 signal is chosen to resemble the derivative of the input signal.

7.1. Choosing the correct sign for the PID 1/2 controllers in the DLC pro: Please refer to section 8.3.

7.2. Choosing the correct sign for the external PID controller: Increase the P-contribution until the slope of the PDH Error 1 signal at the selected lockpoint gets significantly shallower/broader. If the slope gets steeper/narrower, the sign of the external PID controller must be inverted. Set the P-contribution to zero again.

8. Determine the level of the PDH Error 1 signal at the selected lockpoint. Enter this value as **Lock Level** (top-right rotary knob).

9. Switch to **Lockpoint** function mode.
Locking with lockpoint candidates: Select the lockpoint by tapping on the **Lockpoint Candidate** (see Figure 125). For a clearer display, unwanted lockpoint candidates can be deselected in the context parameter menu (**Lock Settings > Peak/Trough Lock Candidates).**

Locking without lockpoint candidates: Enable **Lock Settings > Lock Without Lockpoint** in the context parameter menu. Move the spectrum on the touchscreen in x-direction so that the desired region to trigger the lock is located in the center.

10. Press the **Lock On/Off** button or tap the corresponding symbol (see section 5.6).
Locking with lockpoint candidates: The laser scans to the selected lockpoint. When the scan reaches the lockpoint, the scan stops, and the PID controller(s) switch on.

Locking without lockpoint candidates: The laser scans to the center of the spectrum (**Offset**). When the scan reaches this point, the scan stops, and the PID controller(s) switch on.

11. Select the PID 1 or PID 2 function mode by selecting the **PID** symbols.
Adjust the **PID Gain** settings with the rotary knobs. Please refer to section 8.1 for information on PID controller configuration.

12. To avoid destabilization of the laser by driving it very far from the lockpoint, especially during initial setup and optimization, you can limit the PID output relative to the initial offset (used when activating the lock) of the output channel (parameter menu, **PID 1/PID 2 > Use Limit**).
Set the symmetric limit for the PID output (parameter menu, **PID 1/PID 2 > Limit**). Reasonable choices in the example are:

Configured to feedback on the CC-500 module:
PID 1 > Limit: 1 mA

Configured to feedback on the PC module:
PID 2 > Limit: Depending on the environmental conditions affecting the experimental setup.

Optimization of the external PID controller:
Adjust the PID gain settings to further decrease the peak-to-peak amplitude of the PDH Error 1 signal. Please follow the instructions in section 8.1 correspondingly.

13. We recommend to use the ReLock feature (see section 5.3.11) to improve the convenience of operation during optimization of the various control loops and to increase the long term robustness of the experimental setup.

To turn the lock off, press the **Lock On/Off** button or tap the corresponding symbol (see section 5.6). The PID controllers switch OFF, and the scan starts.

NOTE !	When the lock is switched off, the output value of the PID controller(s) is set to 0.

7.2.2 Optimized for Fast Feedback with FALC pro utilizing the DLC pro Lock Option

As an application example, the wiring for a complete DLC pro laser system being locked to a cavity in a closed loop configuration is shown in Figure 117. Please refer to the FALC pro manual for a detailed description of the locking procedure.

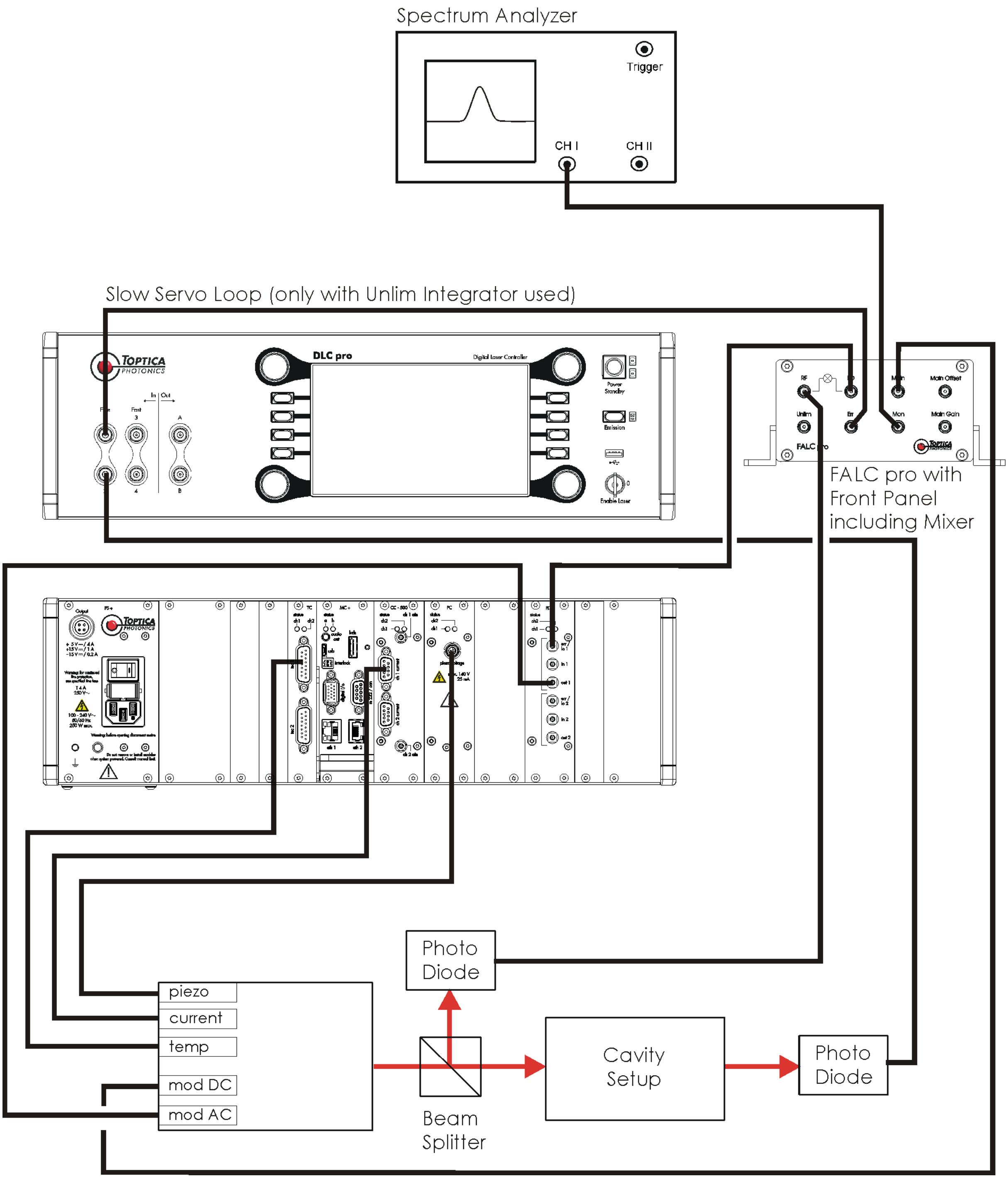


Figure 117 Experimental setup for Top of Fringe Lock with cavity, PDH module in the DLC pro and an external PID controller with integrated mixer (FALC pro with front panel including mixer)

7.2.3 Optimized for Fast Feedback with mFALC 110

Some experiments require an extended control bandwidth in order to achieve high suppression of noise components. The setup in Figure 118 shows a solution that uses the PDH module in the DLC pro as generator for high quality modulation and demodulation signals. The external PID controller with integrated mixer (mFALC 110 in a DLC ext rack) opens up the possibility to design a control loop with short signal paths and highest possible bandwidth.

NOTE !	For using the setup shown in Figure 118, no DLC pro Lock option license is required.

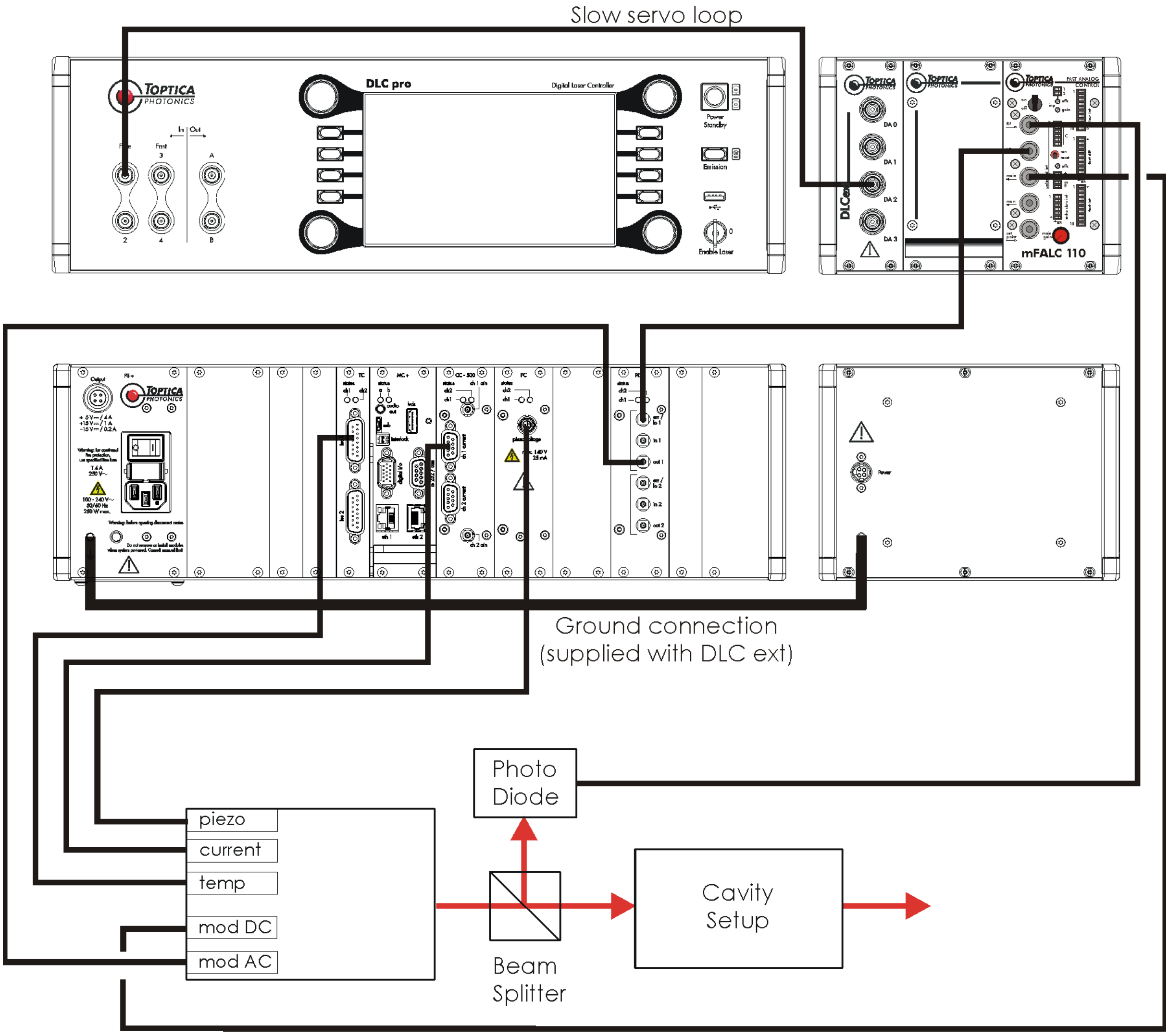


Figure 118 Experimental setup for Top of Fringe Lock with cavity, PDH module in the DLC pro and an external PID controller with integrated mixer (mFALC 110 in a DLC ext rack)

Basic operation principle:

- The PDH module supplies the signal that is used to apply a frequency modulation to the laser.
- The demodulation signal from the PDH module and the photodiode signal are fed to the mixer integrated in the mFALC 110 module in order to generate a PDH error signal.
- A high-speed control signal of the mFALC 110 module (Main output) is used to control the laser current via the Mod DC input at the laser head.
- A low-speed control signal exits the DLC ext via the DA 2 output and is fed into the Fine 1 input of the DLC pro to control the piezo voltage via the Analog Remote Control (ARC) mechanism.

7.3 Doppler-Free Saturation Spectroscopy

This section describes the laser frequency stabilization to an atomic transition by Doppler-free saturation spectroscopy of Rb after realizing the initial setup described in section 7.1. Figure 119 shows the experimental setup.

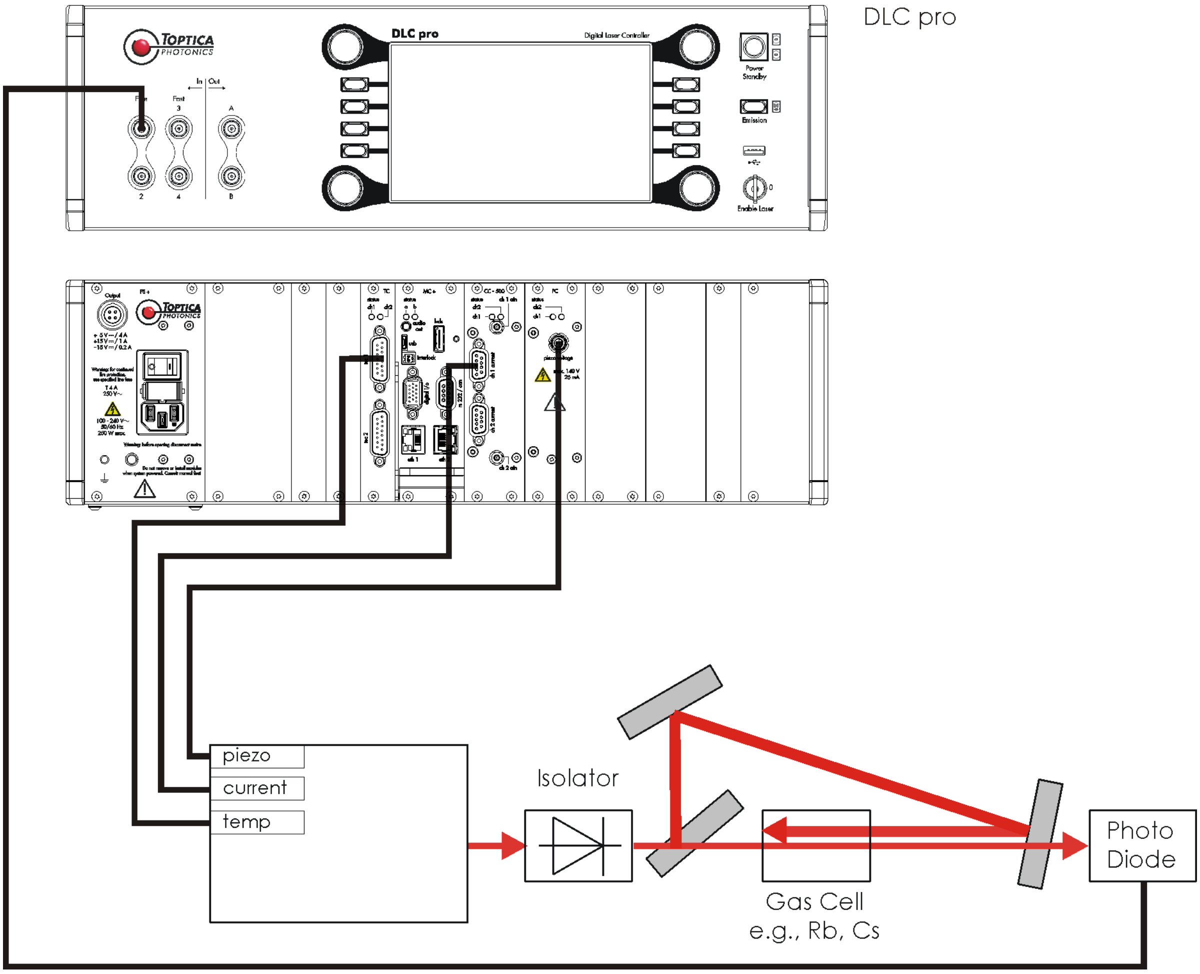


Figure 119 Experimental setup for Doppler-free saturation spectroscopy

Once the Doppler-free saturation spectroscopy setup is adjusted and the laser is tuned to the appropriate transition, the photo detector signal can be optimized by scanning the laser frequency across the desired resonance.

NOTE !	In this application example, application-specific settings are configured via the DLC pro touchscreen. For configuration via TOPAS DLC pro graphical user interface (PC-GUI), please refer to section 6.15.

1. To scan the laser frequency with the piezo, use the touchscreen of the DLC pro in Scan/Lock mode (refer to section 5.3).
Switch to Scan function mode by pressing the **Scan/Lock Mode** button or by tapping the corresponding symbol and further by selecting the **Scan** function mode. Enable the scan by tapping the symbol at the top of the touchscreen (gray: scan disabled, red: scan enabled).
In the parameter menu, select **Scan > Scan Output > PC Voltage**, **Scan > Scan Shape > Triangle** and set **Scan > Scan Frequency** to 10 Hz. Set **Scan Amplitude** in the order of 10 Volts. Depending on the laser diode, this corresponds to several GHz of frequency tuning.

2. Adjust the spectroscopy signal by zooming and dragging the display graph on the touchscreen. The signal expected after the adjustment will look similar to the one shown in Figure 120.

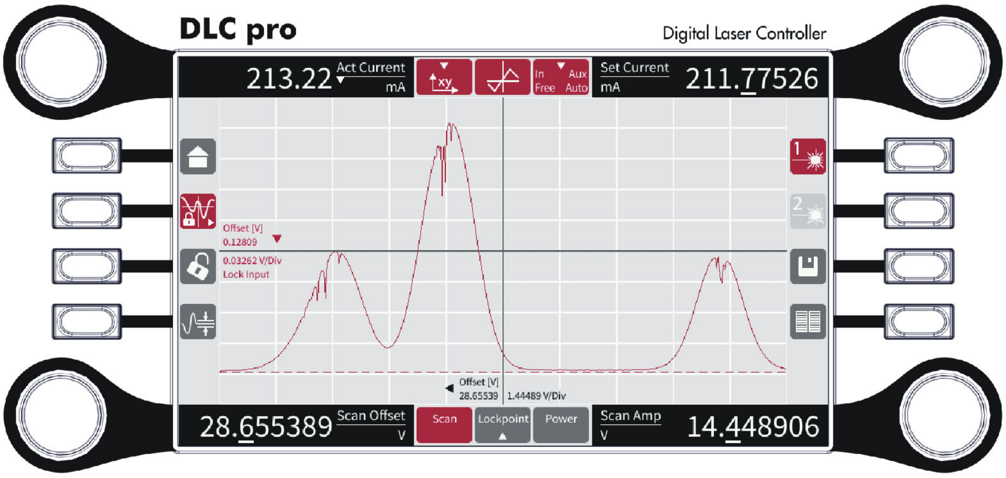


Figure 120 Absorption signal of a Doppler-free Rb spectroscopy

Once the laser scans across the feature of the absorption line to which the laser should be locked, the following locking schemes can be implemented using the Scan/Lock mode of the DLC pro:

- Side of Fringe locking locks the laser to a slope of the absorption line (see section 7.3.1).
- Top of Fringe locking uses frequency modulation/demodulation to lock the laser to a maximum or minimum of the absorption line (see section 7.3.2).

7.3.1 Side of Fringe Locking

To lock the laser to the slope of a Doppler-free absorption line, use the Scan/Lock mode of the DLC pro.

NOTE !	General step-by-step procedures for Side of Fringe locking are provided in sections 5.3.9. and 6.15.2. Section 7.3.1 provides additional application-specific information for parameter configuration.

1. Press the **Scan/Lock Mode** button to switch to Scan/Lock mode.
Select the **xy** symbol at the top of the touchscreen to switch to xy display mode. Select **Display Settings** > **Trace Selection** > **Input Trace Signal** > **Lock Input Signal.**
Select the **Lockpoint** symbol at the bottom of the touchscreen to choose the Lockpoint function mode.

2. Select the input channel for the photo diode signal that is connected to the DLC pro. (Parameter menu, **Lock Settings > Lock Input Signal > Fine In 1** in the example). The selected input channel is used as the input for all selected PID controllers.

3. In the parameter menu, select **Lock Settings > Lock Type > Side of Fringe**.

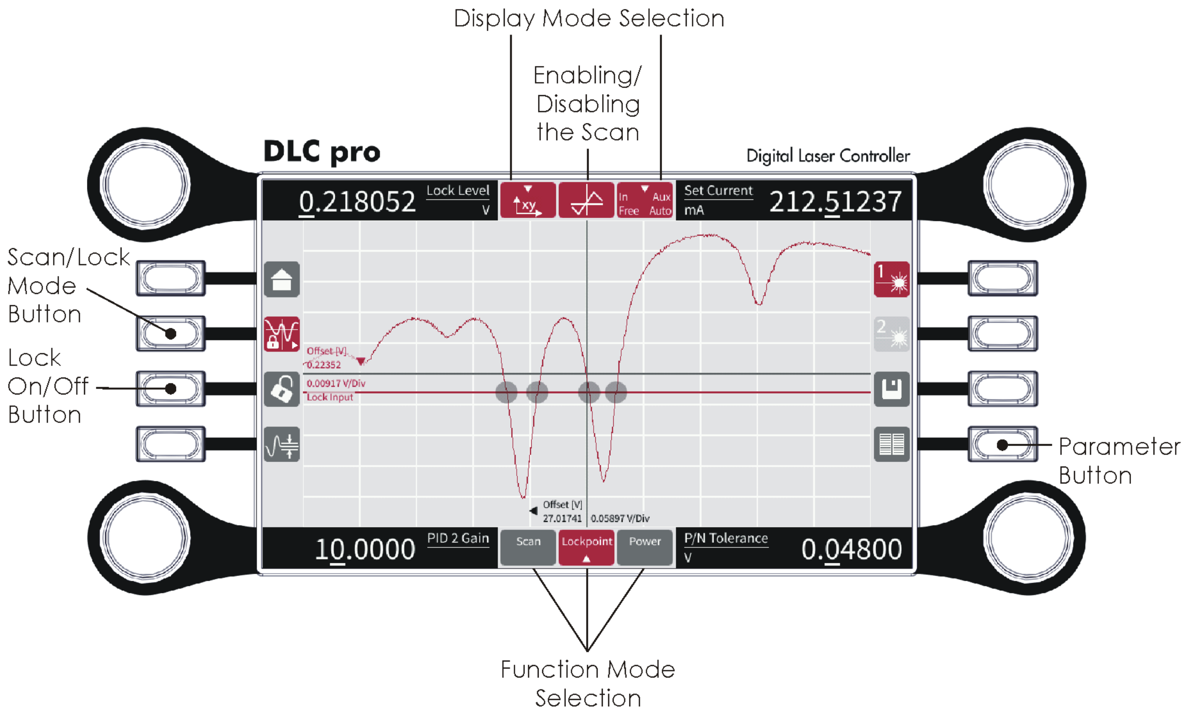


Figure 121 Lockpoint function mode; lock voltage level and lockpoint candidates for Side of Fringe locking (example)

4. Select both PID controller(s) for stabilizing to the lockpoint (Parameter menu, **Lock Settings > PID Selection > PID 1+2**).

5. Zoom and drag the Lock Input signal and adjust the laser current (**Set Current** rotary knob) until the desired lockpoint in the spectrum is clearly visible on the display.

NOTE !	The selected lock voltage level is displayed as a red line. Lockpoint candidates are displayed where the Lock Input signal crosses the lock voltage level line.

In our example, the ^{85}Rb D2 transitions at 780 nm are used (Figure 122), and the desired lockpoint is shown.

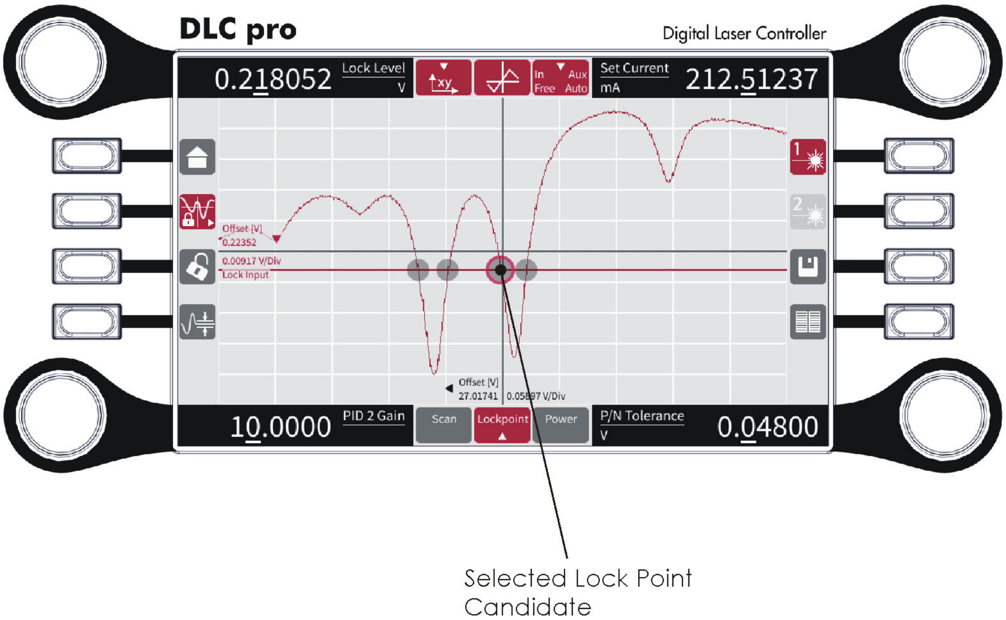


Figure 122 Rb transitions at 780 nm. Lockpoint selected

6. Configure the PID 1 controller to handle the high-frequency feedback by controlling the laser current via the modulation option in the laser head (Parameter menu, **PID 1 > Output Channel > CC**). Configure the PID 2 controller to handle the large range, low-frequency feedback by controlling the piezo voltage (Parameter menu, **PID 2 > Output Channel > PC**).

7. To prevent the PID controllers from mutual interaction by accumulating offsets in opposite directions, an “I cut-off“ frequency can be defined for the PID 1 controller (parameter menu, **PID 1 > Use I cut-off**). The “I cut-off“ frequency defines the corner frequency below which the integral gain of the controller is limited. A reasonable choice is in the order of 100 Hz (Parameter menu, **PID 1 > I cut-off frequency**).

8. To avoid destabilization of the laser by driving it very far from the lockpoint, especially during initial setup and optimization, you can limit the PID output relative to the initial offset (used when activating the lock) of the output channel (parameter menu, **PID 1/PID 2 > Use Limit**).
Set the symmetric limit for the PID output (parameter menu, **PID 1/PID 2 > Limit**). Reasonable choices in the example are:
PID 1 > Limit: 1 mA
PID 2 > Limit: 3 V

9. Set the desired lock level voltage by turning the **Lock Level** rotary knob. Lockpoint candidates are displayed where the Lock Input signal crosses the lock voltage level line.
Before enabling the lock for the first time, please set the Gain, P, I and D parameters of both PIDs to reasonable values. If unsure about reasonable parameters, start with PID 2 by setting PID 1 gain to zero. Optimize PID values for PID 2 as described in section 8.1, then add PID 1 by increasing its gain and PID values.

10. **Locking with lockpoint candidates:** Select the lockpoint by tapping on the **Lockpoint Candidate**. For a clearer display, unwanted lockpoint candidates can be deselected in the context parameter menu (**Lock Settings > Positive-Edge/Negative-Edge Lock Candidates**).

Locking without lockpoint candidates: Enable **Lock Settings > Lock Without Lockpoint** in the context parameter menu. Move the spectrum on the touchscreen in x-direction so that the desired region to trigger the lock is located in the center.

11. Press the **Lock On/Off** button or tap the corresponding symbol (see section 5.6).
Locking with lockpoint candidates: The laser scans to the selected lockpoint. When the scan reaches the lockpoint, the scan stops, and the PID controller(s) switch on.

Locking without lockpoint candidates: The laser scans to the center of the spectrum (**Offset**). When the scan reaches this point, the scan stops, and the PID controller(s) switch on.

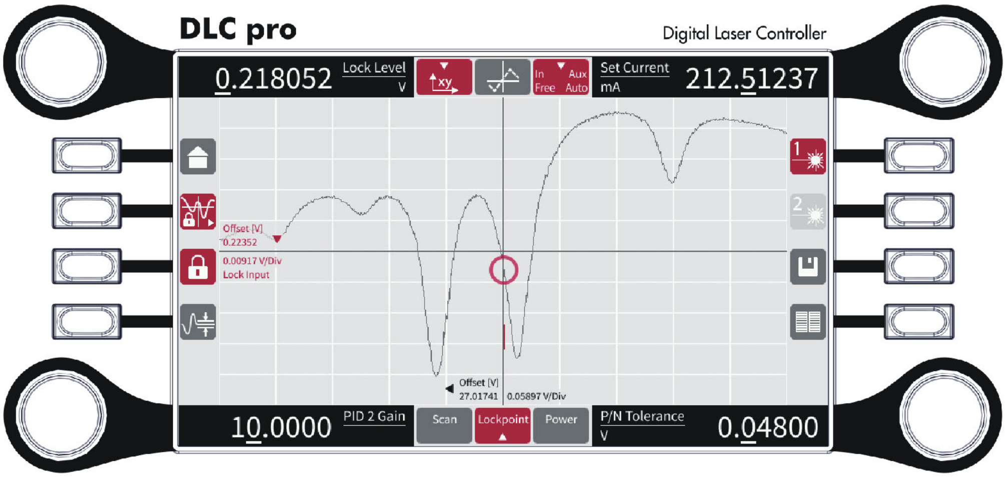


Figure 123 Side of Fringe lock display after the lock is engaged

12. Set the values of the gain parameters for the PID controllers with the rotary knobs (see section 5.3.7.4). Their settings depend on the slope of the Error signal and the actuator response. In most cases, the low-frequency feedback of **PID 2** is sufficient to achieve a first lock. We advise starting with conservative (small) gain settings.
To find the correct settings for the sign of each PID controller, please refer to section 8.3.
Once locking is accomplished, the PID gain parameters can be optimized (see section 8.1).

To turn the lock off, press the **Lock On/Off** button or tap the corresponding symbol (see section 5.6). The PID controllers switch OFF, and the scan starts.

NOTE !	When the lock is switched off, the output value of the PID controller(s) is set to 0.

General Hints on Parameter Optimization:
To obtain a "good" lock, it is necessary to optimize the gain settings of the PID controllers to values which do not lead to oscillations of the error signal (see section 8.1 for details). As **PID 2** is only responsible for the low-frequency components, this controller can be left at moderate gains. The performance of the lock is predominantly determined by the settings of **PID 1** that is connected to the fast actuator.

To improve the lock performance, increase the gain of the I, P, and D parts of the PID in an iterative manner, to values well below the point at which the control loop starts to oscillate. The general strategy for optimizing the P, I and D parameters is described in section 8.1.

A helpful tool for the optimization process is the Frequency display mode (see Figure 124 and section 5.3.2). Figure 124 shows the result of the Fourier transformation of the sampled time signal. In our example, select **Lock Settings > Lock Input signal > Fine In 1**. Chose the frequency scale according to the bandwidths of the experiment. Typical bandwidths of the gratings are in the range of a few kHz while the CC-500 output has a bandwidth of up to 30 kHz.

In most cases, the DC component of the frequency signal is quite dominant. In order to better resolve the peaks in the frequency spectrum, set the display trace scaling to appropriate amplitude values.

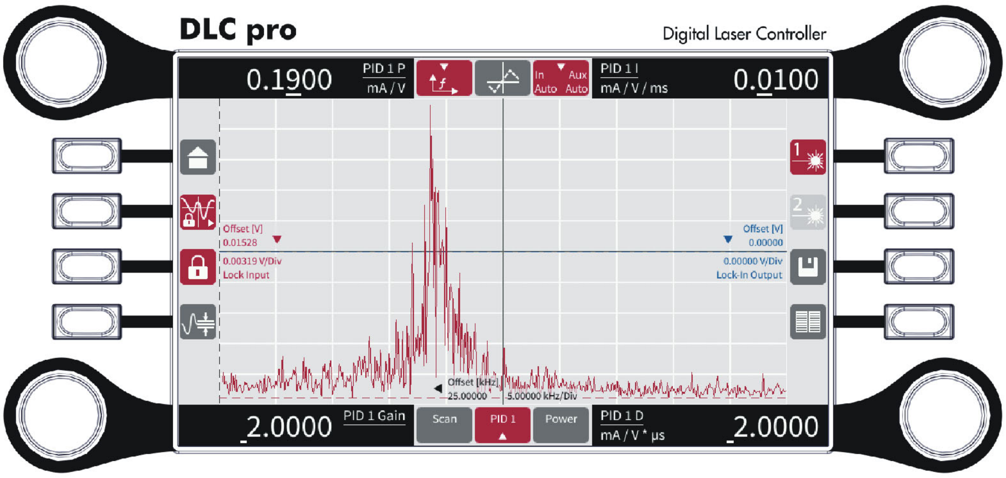


Figure 124 Frequency display of a photo diode signal.
In this example, the frequency analysis clearly shows the onset of an oscillation at about 20 kHz due to high gain settings.

7.3.2 Top of Fringe Locking (Lock-In)

To lock the laser frequency to an extremum of the Doppler-free absorption signal, a zero-crossing slope is generated using frequency modulation and demodulation. **Lock-In** uses a modulation frequency smaller than the characteristic resonance width to obtain the derivative of the absorption signal by demodulation.

NOTE !	The general step-by-step procedures for Top of Fringe locking are provided in sections 5.3.10. and 6.15.3. This section provides additional application-specific information for the parameter configuration. **Only Top of Fringe (Lock-In)**: The Lock Wizard in the TOPAS DLC pro PC-GUI (**Menu > Optimization Tools > Lock Wizard**, see section 6.11) is an interactive tool which helps to set-up a Top of Fringe lock.

NOTE !	It is possible to route the Lock-In Error signal to the Out A/B BNC connectors on the DLC pro front panel. Please refer to section 6.15.3 for details. By routing the Lock-In Error signal to analog outputs, the signal resolution may be reduced. Please use the parameters io:out-a:external-input:factor or io:out-b:external-input:factor, respectively, in order to increase signal-to-noise.

1. Press the **Scan/Lock Mode** button to switch to Scan/Lock mode.
Tap the **xy** symbol at the top of the touchscreen to switch to xy display mode. Select **Display Settings** > **Trace Selection** > **Input Trace Signal** > **Lock Input Signal.**
Tap the **Lockpoint** symbol at the bottom of the touchscreen to choose the Lockpoint function mode.

2. Select the input channel for the photo diode signal that is connected to the DLC pro. (Parameter menu, **Lock Settings > Lock Input Signal > Fine In 1** in the example). From the Lock Input Signal, the Lock-In Output signal (error signal) is generated, which is used as the input for all selected PID controllers.

3. In the Parameter menu, select **Lock Settings** > **Lock Type > Top of Fringe**.

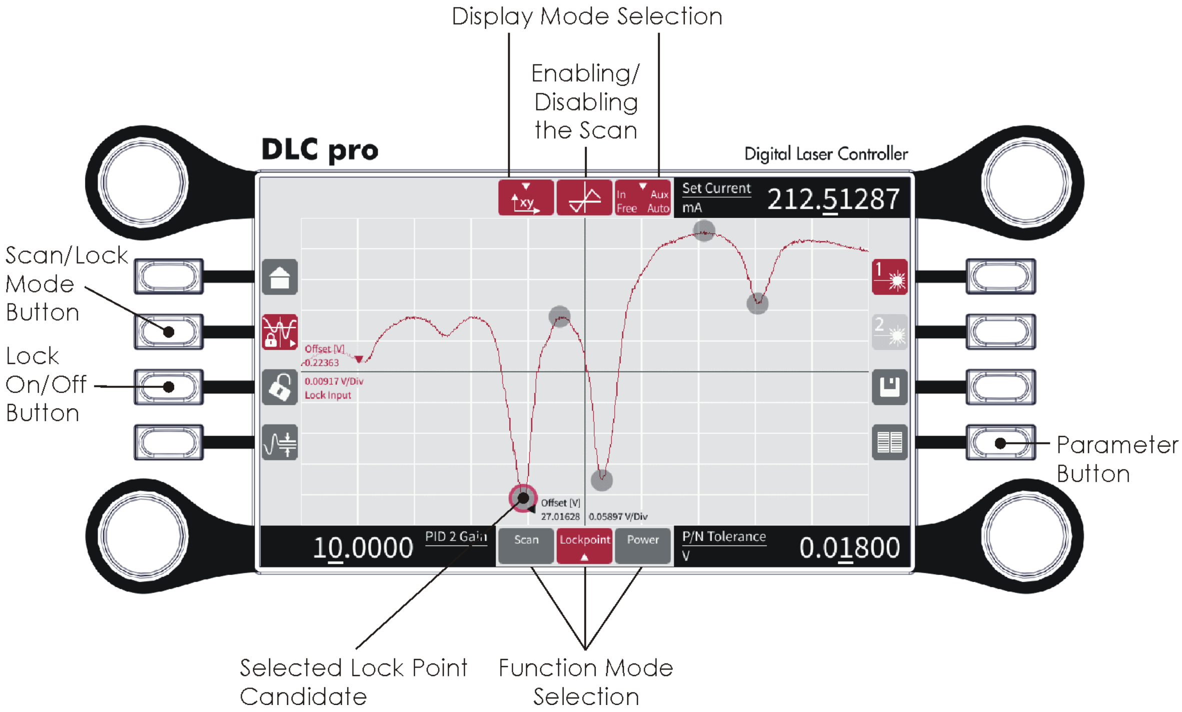


Figure 125 Lockpoint function mode: Lockpoint candidates for Top of Fringe Lock type (example)

Status: 29.3.22

4. Select both PID controllers for frequency stabilization (parameter menu, **Lock Settings > PID Selection > PID 1+2**).

5. Zoom and drag the Lock Input signal and adjust the laser current (**Set Current** rotary knob) until the desired lockpoint in the spectrum is clearly visible on the display.

NOTE !	If the lockpoints at the extrema are not properly detected automatically, this behavior can be improved by adjusting the **P/N Tolerance** at the bottom right rotary knob. This parameter is 0 for automatic detection, and automatic detection does not always work perfectly. The parameter should be set to a value that is larger than the peak-to-peak noise and smaller than the peaks that the laser should be locked to.

6. Switch to the LIR Lock function mode by selecting the **LIR** symbol.
Select the Lock-In Output signal (Error signal) to be displayed as the Auxiliary trace in blue (parameter menu, **Display Settings > Trace Selection > Lock-In Output**).

7. Adjust the blue Lock-In Output signal until the Error signal matches the derivative of the red Lock Input signal. Use the rotary knobs and the parameter menu (**Lock-In**) to configure the Lock-In parameters.

Parameter	Description	Reasonable setting
Lock-In Modulation Frequency	User-selected modulation/demodulation frequency, depending on the output channel.	CC output channel: 20000 [Hz]
Lock-In Modulation Amplitude	Amplitude of the Lock-In modulation.	0.05 [mA_{pp}] (*****)
Lock-In Demodulation Phase	Phase difference between modulation and demodulation.	0 … 360 [°] (to be adjusted, ******)
Output Channel	Output to which the modulation is added.	CC: laser diode current

***** The Lock-In modulation amplitude is a tradeoff between the desired lock-in signal strength and the allowed frequency modulation of the laser. The larger the amplitude, the larger the lock-in signal. However, the linewidth of the laser increases at the same time.

****** The Lock-In Out signal is the derivative of the input signal (i.e., positive Error signal on positive signal slope). The phase between the modulation and the reference signal must be adjusted to obtain a large error signal with steep slopes and zero crossings at the maxima of the spectral signal.

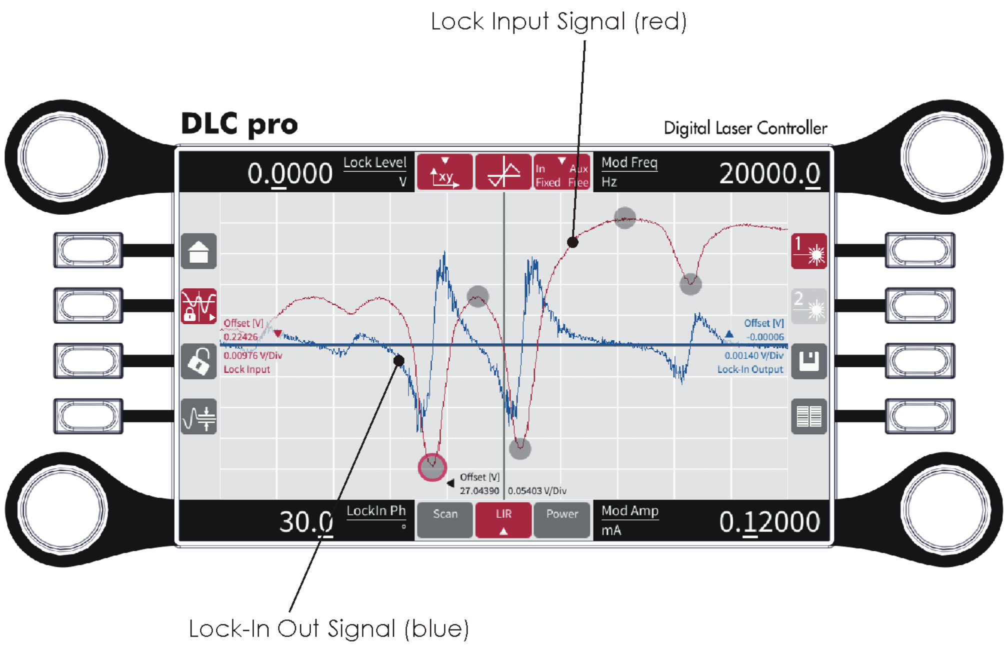


Figure 126 Display of the Doppler-free Rb spectrum (red) with the corresponding Lock-In Output signal (blue).
Note: The phase of the Lock-In Output signal is chosen to be the derivative of the absorption signal.

8. Switch to **Lockpoint** function mode.
Locking with lockpoint candidates: Select the lockpoint by tapping on the **Lockpoint Candidate** (see Figure 125). For a clearer display, unwanted lockpoint candidates can be deselected in the context parameter menu (**Lock Settings > Peak/Trough Lock Candidates**).

Locking without lockpoint candidates: Enable **Lock Settings > Lock Without Lockpoint** in the context parameter menu. Move the spectrum on the touchscreen in x-direction so that the desired region to trigger the lock is located in the center.

9. Press the **Lock On/Off** button or tap the corresponding symbol (see section 5.6).
Locking with lockpoint candidates: The laser scans to the selected lockpoint. When the scan reaches the lockpoint, the scan stops, and the PID controller(s) switch on.

Locking without lockpoint candidates: The laser scans to the center of the spectrum (**Offset**). When the scan reaches this point, the scan stops, and the PID controller(s) switch on.

10. Select the PID 1 or PID 2 function mode by selecting the **PID** symbols.
Adjust the **PID Gain** settings with the rotary knobs. Please refer to section 8.1 for information on PID controller configuration.

NOTE !	The laser is actually locked to the Lock-In Output signal. The Lock-In Output signal is the input signal for the PID controller(s).

11. To avoid destabilization of the laser by driving it very far from the lockpoint, especially during initial setup and optimization, you can limit the PID output relative to the initial offset (used when activating the lock) of the output channel (parameter menu, **PID 1/PID 2 > Use Limit**).
Set the symmetric limit for the PID output (parameter menu, **PID 1/PID 2 > Limit**). Reasonable choices in the example are:

Configured to feedback on the CC-500 module:
PID 1 > Limit: 1 mA

Configured to feedback on the PC module:
PID 2 > Limit: 3 V

To turn the lock off, press the **Lock On/Off** button or tap the corresponding symbol (see section 5.6). The PID controllers switch OFF, and the scan starts.

NOTE !	When the lock is switched off, the output value of the PID controller(s) is set to 0.

7.3.3 Top of Fringe Locking (PDH)

To lock the laser frequency to an extremum of the Doppler-free absorption signal, a zero-crossing slope is generated using frequency modulation and demodulation. A FM spectroscopy lock with the PDH module uses a modulation frequency larger than the characteristic resonance width to obtain the derivative of the absorption signal by demodulation.

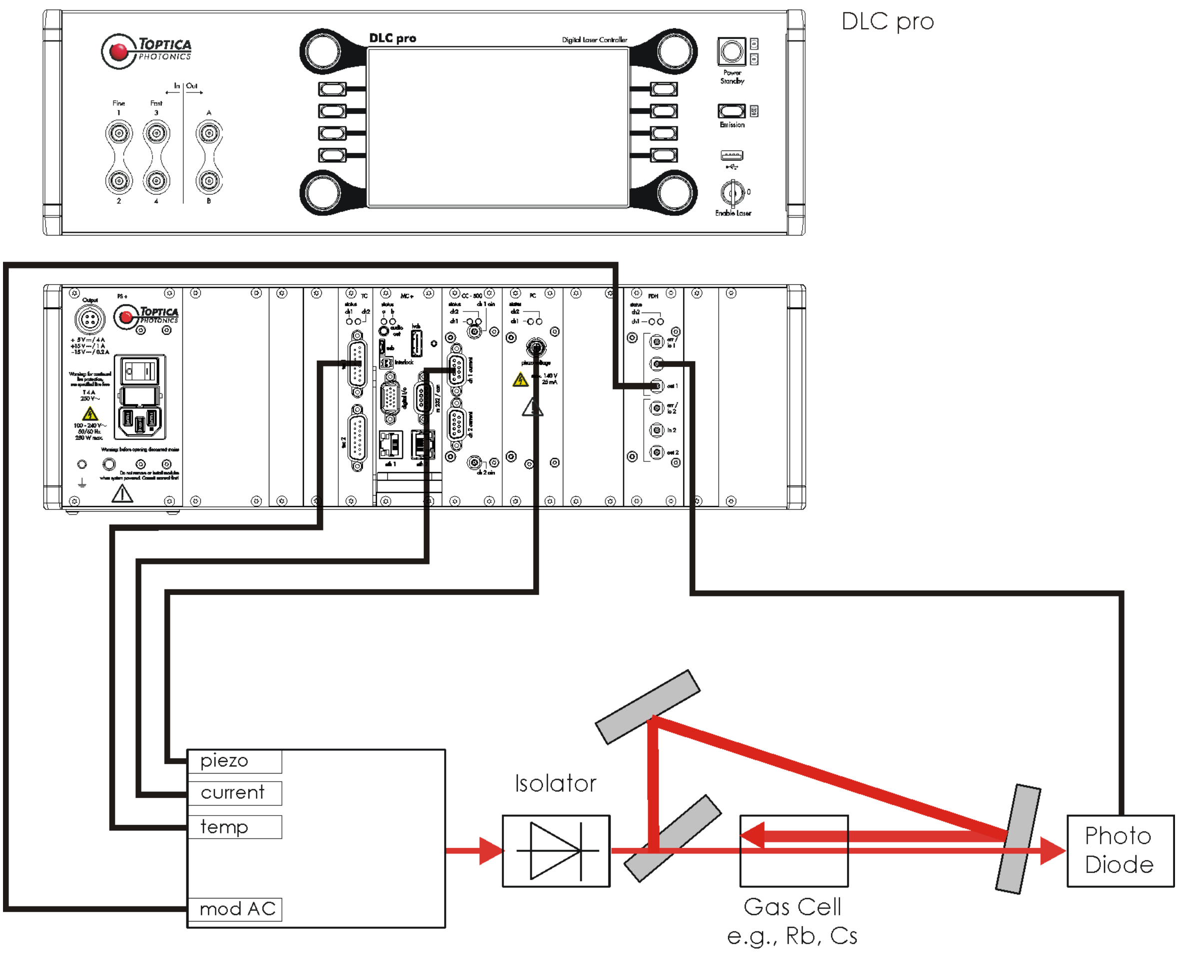


Figure 127 Experimental setup for Doppler-free saturation spectroscopy using the PDH module

If your DLC pro is equipped with a PDH module (see section 9.2.9), you can also use the PDH Ch1/PDH Ch2 function modes for Top of Fringe locking, instead of the LIR function mode described in section 7.3.2. In this case connect your experimental setup as shown in Figure 127 and follow the relevant instructions in section 7.2 accordingly.

8 Notes on Feedback Control Loops with DLC pro

NOTE !	To utilize the DLC pro Lock function modes, a Lock option license is required. When a Lock option license is acquired, TOPTICA provides an option license key via e-mail or USB flash drive. The license is unlimited in time but linked to the individual hardware of the DLC pro and cannot be used for other devices. The license key must be activated via the TOPAS DLC pro PC-GUI (please refer to section 10.19). If purchased along with the DLC pro, the licence is already installed. Otherwise a 30-day trail licence is provided on the USB flash drive in the Options Folder.

8.1 Controller Parameter Adjustment and Optimization

To obtain a good lock, it is necessary to optimize the gain settings of the PID controllers. Once a suitable Lock-In Output signal (Error signal) is at hand, the feedback loop (see Figure 128) can be closed and optimized. The general working principle of the Proportional-Integral-Differential (PID) controller is to minimize the deviation of a physical measure (Process Variable) from a selected Set Value by modifying the actuator drive (Manipulated Variable) accordingly. The output of the controller is a weighted sum of the integral (I), proportional (P), and differential (D) paths scaled by the overall gain. The digital PIDs in the DLC pro allow for a precise and reproducible control of the gain settings.

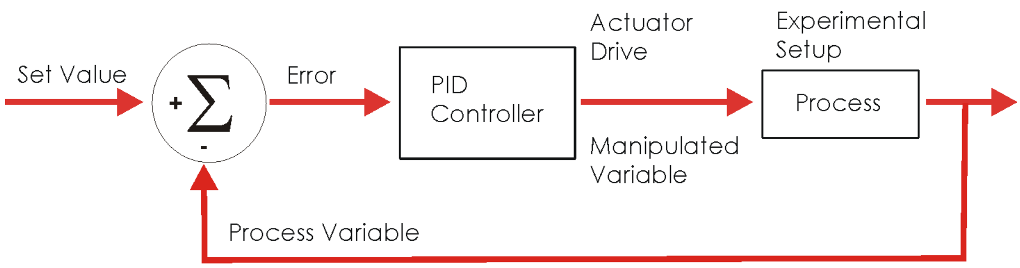


Figure 128 PID controller feedback loop

The three contributions differ in their frequency dependence:

1. The integral (I) part is given by the time integral of the Error signal. Therefore, its gain increases to lower frequencies, and it is responsible for the compensation of (dc) offset changes. The residual deviation of the error signal from zero, or respectively the difference between the physical measure and the set value (see (P) part) is also eliminated. The integral (I) part is also one of the parameters used to optimize the lock dynamics, i.e. the response to perturbances at different frequencies.

2. The proportional (P) part has a flat frequency response and is limited by the bandwidth of the control loop. A larger proportional gain (P) reduces the deviation from the set value and is limited by the onset of oscillations. The residual error which would remain with (P) operation only, can be compensated by setting the integral (I) part of the PID controller.

3. The differential (D) part reacts to sudden changes in order to reduce deviations (e.g., an over shoot in the transient response). Its frequency response increases with frequency and is limited to higher frequencies by the bandwidth of the control loop. Since it provides a phase lead, the differential (D) part can help to improve the phase response at higher frequencies, which in turn allows to increase the gain on the I and P parts before inducing oscillations. Note, that due to the high-bandwidth transient response, the differential part is also particularly prone to amplification of noise.

Before adjusting the parameters of the PID controllers, select the correct phase and polarity of the PID controller with respect to the scan output. Positive polarity means that an increased PID controller output results in an increase of the Lock Input signal (bottom-left rotary knob with Scan/Lock screen and PID1/PID2 function mode selected, Scan/Lock mode parameter menu, **PID 1/PID 2 > Sign Positive,** or PC-GUI Scan & Lock tab, **PID 1/PID 2** groups).

To start, select a low input gain and set all contributions (P, I, D) to zero. Now, increase the integral part until the system locks[1]. Generally speaking, the quality of the lock will now improve with increasing gain of the controller until the feedback loop starts to oscillate. This is the case when the feedback loop reaches a gain of 1 at a 180° phase shift. Therefore, the usable bandwidth of many actuators (e.g., piezos) is limited by their characteristic frequencies.

In any case, phase shifts due to finite bandwidths and signal propagation times in the control loop lead to phase lags which increase with frequency. The appearance of oscillations can be observed in the display of the Error signal. The frequency analysis (Frequency display mode) may be better suited because it is often more sensitive and directly shows the resonance peak. It is usually helpful to drive the system into oscillation and note the characteristic frequencies for reference. A simple parameter adjustment is obtained by an iterative process:

1. Set the integral (I) gain to a non-zero value (all others to zero) and increase the overall gain until the system locks.

2. Alternate between increasing the proportional (P) gain and the integral (I) gain each until the feedback loop starts to oscillate, then reduce the gains until the oscillation definitely stops. Standard optimization procedures set the proportional (P) gain to about 0.6 of the value where oscillations start.

3. Increase the integral (I) gain until the feedback loop starts to oscillate, then increase the differential (D) gain until the oscillation stops. Proceed iteratively Increasing both gains until the oscillation cannot be stopped by further increase of the differential (D) gain. At that point, reduce both gains until the oscillation definitely stops.[2]

NOTE !	The optimized parameters depend on the slope of the error signal at the current lockpoint and the actuator response. Therefore, there is usually a trade-off between a good locking result and a reasonable robustness against external disturbance. Higher gains will lead to the smallest error signal and narrow linewidth. However, the system can react too strongly when larger disturbances occur, and, due to the reaction, fall out of the lock. Lower gain settings relax the feedback control loop and can ensure longer locking times.

1. If the system does not lock, check the polarity by trying the opposite **Sign Positive** polarity setting.
2. Alternatively, there are several methods for estimating PID controller parameters which mostly originate from slow (temperature type) controller applications. The Ziegler–Nichols method gives rule of thumb values derived from the proportional gain $P_{,\,osc}$ where an oscillation of frequency ν_{osc} starts: $P = 0.6 \times P_{,osc}$; $I = 2\ P_{,osc} / \nu_{osc}$; $D = (P_{,osc} \times \nu_{osc}) / 8$

8.2 Signal Limitations in Analyzing the Locking Performance

NOTE !	To analyze the performance of a lock based on a frequency modulation technique, we recommend using the demodulated signal (Lock-In Out) to observe residual excursions in the display as well as using the frequency analysis tools (Frequency display mode).

As common to any digital signal sampling, the DLC pro shows effects of aliasing. When the sampled signals have frequency components faster than half the sampling rate, they will be folded into the frequency band from zero to this Nyquist frequency. The sampling rate of the DLC pro is automatically set to make full use of the number of acquired points. Therefore, in the Scan/Lock mode display, the sampling rate is given by the number of points per trace (1024) divided by the time range chosen. According to the Nyquist theorem, the sampling rate in the frequency analysis (FFT) is set to twice the selected maximum frequency.

Because of aliasing effects, the X/Y, time, and frequency display of DLC pro can show signals that are actually at other frequencies. This effect is well known from digital oscilloscopes. In general, signals appear at the difference frequency between their original frequency and the sampling frequency (or its harmonics). In the X/Y and Time display mode, this can appear as fast oscillations or noise, but also as slow variations or "breathing" of signal amplitudes if the frequency difference is small.

In case of the DLC pro, there is an additional effect to be observed for sampling rates well below the Nyquist frequency. Due to the complete synchrony of the sampling with the applied modulation, the undersampled signal can show up as a (noisy) line at a finite offset that varies from shot to shot. Note that this is not an indication of the performance of the lock, but merely an artifact of the input signal sampling including the applied modulation. This explains why we recommend using the demodulated signal for analysis.

8.3 Identification of Signal Polarity and Slope

To support the lock features, the DLC pro takes a consistent approach to the definition of the signal polarity of each PID controller.

The *polarity* of a PID controller is used to match the action of the corresponding output to the direction of the scan. Select the polarity in such a way that an increased controller output acts in the same direction as an increase of the SC scan output. If the output of the PID controller is identical to the SC scan output, the polarity is positive. Otherwise, the polarity has to be determined for the particular actuator used. For example, if the laser is scanned via the PC module and PC is selected as the output channel of PID 2, the PID 2 polarity is trivially positive.

In general, the polarity of the controller output for any actuator can be determined by comparing the signals of the regular SC scan output with the signal observed while scanning the PID controller output. To determine the directionality of the resulting effect, look at a characteristic part of the error signal (e.g., close to the lockpoint), or use a wavelength meter reading, if available.

A general method to verify the correct polarity is to compare the signals during the scan with the PID controller switched on and off while using just the proportional part. To do so:

- Select the appropriate PID controller (PID 1 **or** PID 2; not PID 1+2) in the Scan/Lock mode parameter menu (**Lock Settings > PID Selection**)
- Select the **xy** display mode.
- Select the Lock function mode/Side of Fringe and enable the Lockpoint display (Scan/Lock mode parameter menu, **Lock Settings > Lock Type**).
- Set the lockpoint candidate to a rising signal slope. If **Lock Without Lockpoint** is enabled, a rising signal slope is chosen as default.
- Select the **xy** display mode and adjust the Time Base according to the Scan Frequency (Time Base [s] = 1/ 2 * Scan Frequency [Hz]) (**Display Settings > Time**).
- Set the integrator and differentiator parts of the PID controller to zero.
- Set the proportional part and the overall gain of the PID controller to some non-zero value such as 10. (PID 1 or PID 2 Lock Function mode, rotary knobs).
- Enable the PID controller (Scan/Lock mode parameter menu, **Enable PID** in the respective PID controller settings) while scanning across the region of interest in the spectrum.
- Increase the proportional part and/or overall gain of the PID controller until you see a significant distortion of the signal.
- Disable the PID controller.

To check the observed effect, you can compare with the cases of the other polarity as well as with the PID controller being switched off. The cases of Side of Fringe locking and locking to a Lamb dip of a saturated absorption signal are illustrated in Figure 129 and Figure 130.

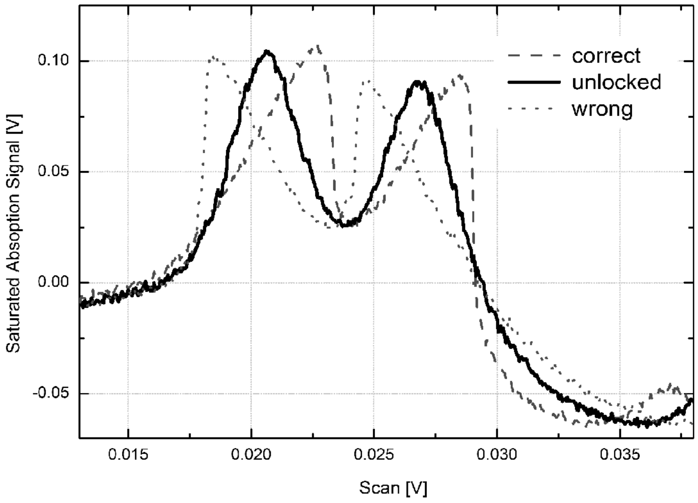


Figure 129 Polarity of the PID controller for Side of Fringe lock.
The graph shows the characteristic distortions of the error signal of a Side of Fringe lock for different polarities. The displayed example is a zoom into the saturated absorption spectrum of Rb. The undistorted signal (solid black) is given for reference. When the correct polarity is selected, the rising slopes are shallower/broader than the unlocked slope. Rising slopes that are steeper/narrower than the unlocked slope indicate an incorrect polarity.

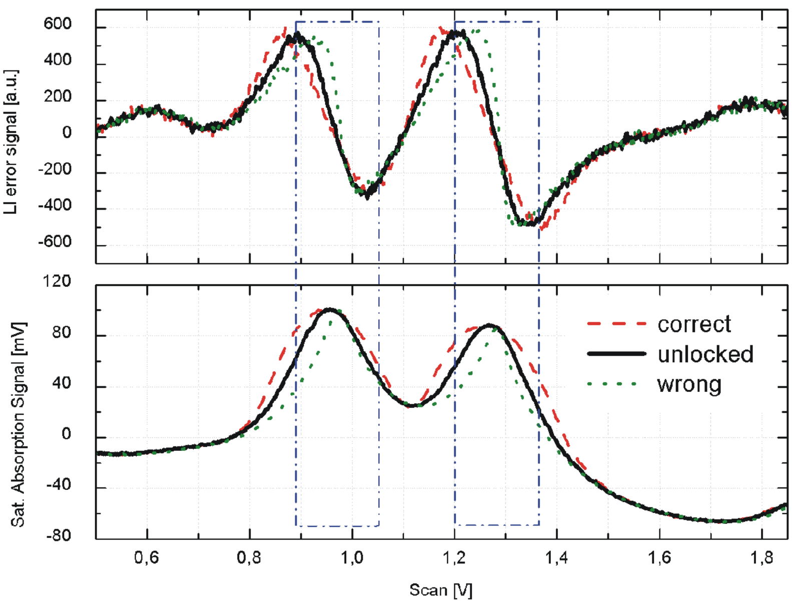


Figure 130 Polarity of the PID controller using frequency modulation
The graph shows the characteristic distortions of the error signal as well as the saturated absorption signal of a Top of Fringe lock for different polarities. The undistorted signal (solid black) is given for reference. For the correct polarity (dashed red), the slope of the error signal at the peak is shallower while the peak itself is broader (see boxed part of the graph). In contrast, the slope is steeper and the peak narrower for the incorrect polarity (dotted green).

If the polarity is correct (incorrect), a resonance should become wider (narrower) as compared to the case of the controller being inactive. The slope of the error signal, e.g. in frequency modulation, should become flatter (steeper) when the polarity is correct (incorrect).

9 DLC pro Hardware Description

9.1 DLC pro Front Panel

The DLC pro front panel allows direct and quick control by the user and provides access to most of the available functionality.

The main control element is the projected capacitive touchscreen (PCT) with 17.8 cm (7") diagonal size and 800 x 480 pixels. Eight push buttons are located left and right of the touchscreen. Some operator controls are designed to be context-sensitive, so their function is determined by the firmware and accordingly displayed on the touchscreen. The push buttons are mainly used for navigation and to select frequently-used functions or functions that need to be performed "blindly" (e.g., while looking at the experiment).

Rotary knobs are located at each corner of the touchscreen. They are used (context-sensitive) for adjusting operating parameters, such as laser diode current, operating temperature, piezo voltage for wavelength tuning and many more. For a detailed description of the front panel operator controls, please refer to section 4.

9.1.1 I/O Board

The I/O board is part of the front panel and provides four analog inputs and two analog outputs that are accessible as BNC-connectors at the DLC pro front panel. The board comprises analog input/output amplifiers and A/D D/A converters for each input and output as well as an FPGA unit and a reference power supply unit.

Input signals applied to the fine BNC-connectors are directed to a precise 24-bit A/D converter whereas input signals which are applied to the fast BNC-connectors are directed to a 16-bit A/D converters for fast signal processing. Output signals are generated by a dual 16-bit D/A converter.

All control commands for the A/D D/A converters and the communication with the MC board in the MC+ module are implemented in the FPGA unit.

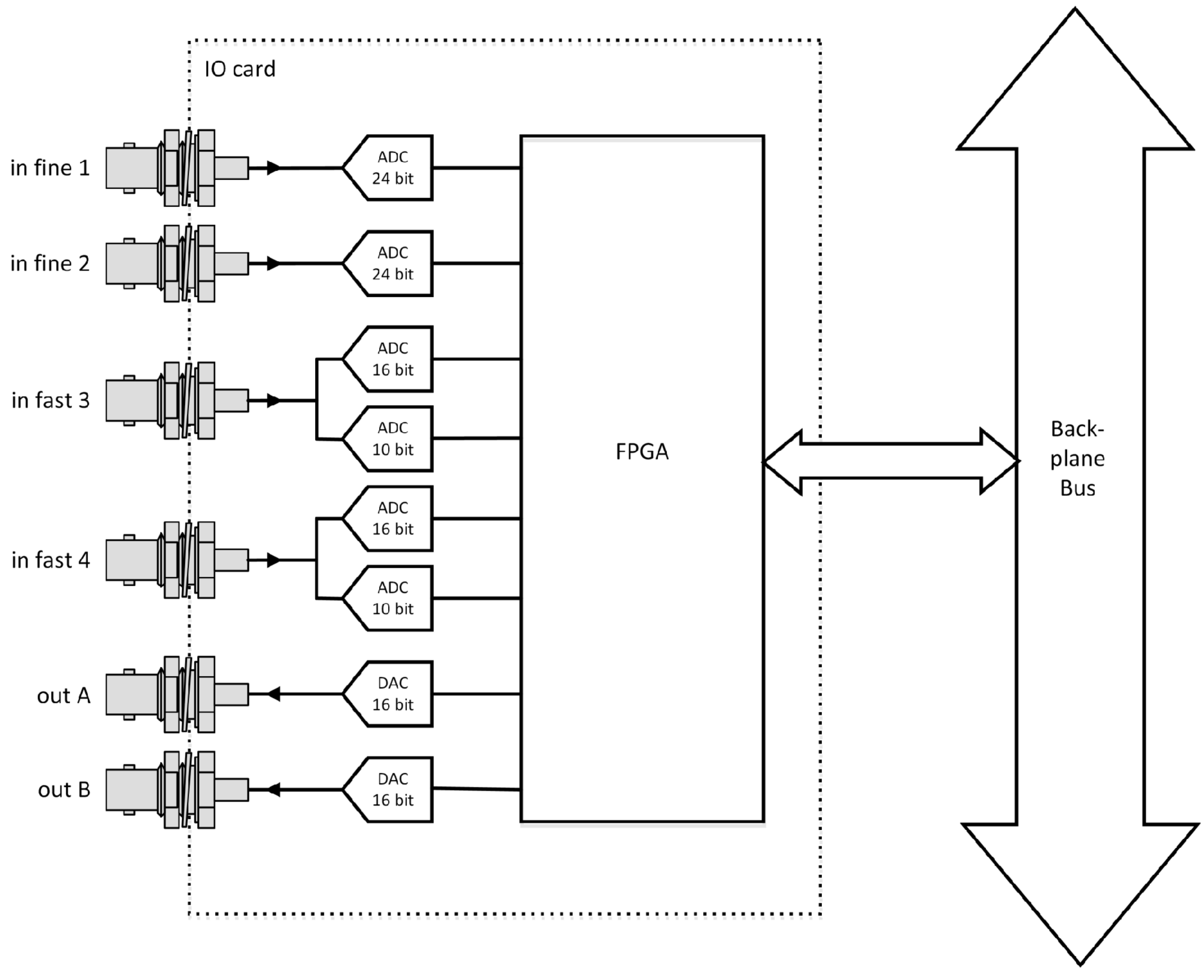


Figure 131 I/O Board schematic overview

9.2 Modules on the DLC pro Rear Panel

NOTE !	Please note that for every type of module the mounting position must be chosen correctly. Please refer to section 10.5 for information.

9.2.1 PS+ Module

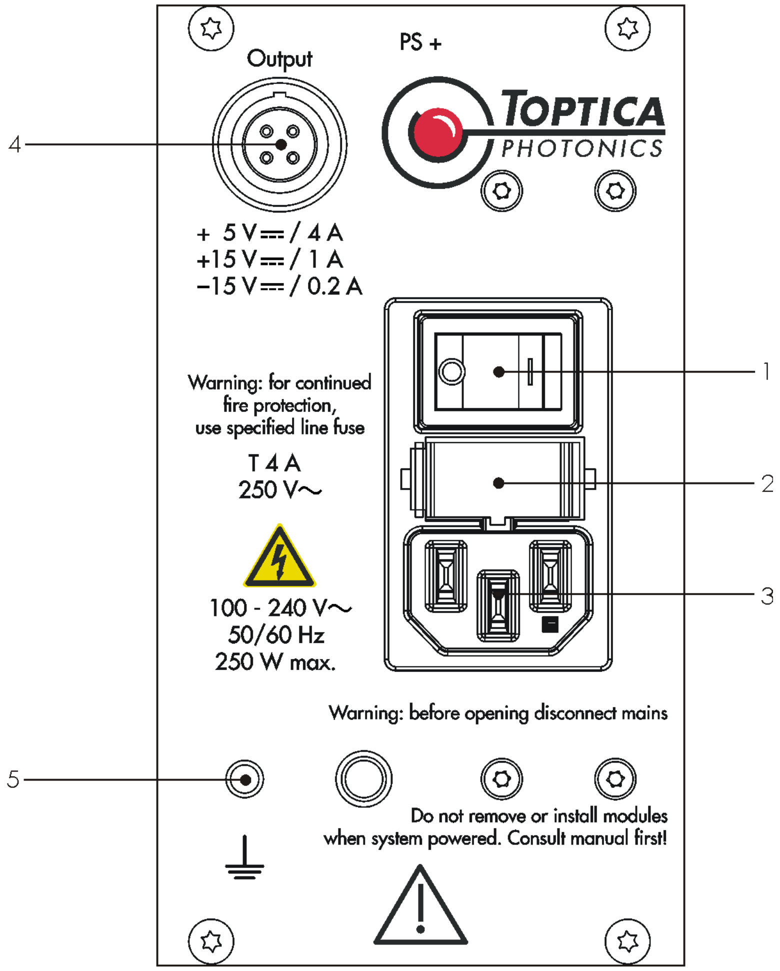


Figure 132 Panel of the PS+ module

1	ON/OFF Switch	**3**	Mains Connector	**5**	Ground Pin
2	Fuse Cartridge	**4**	Output Connector		

NOTE !	Item 4 is not present at PS modules.

1 ON/OFF Switch	Switch for mains supply ON/OFF. **NOTE !** After switching off, please wait for at least 10 seconds before switching the DLC pro on again.
2 Fuse Cartridge	**DANGER !** Before exchanging a fuse, make sure to switch off and disconnect the device from the mains supply ! The mains supply is protected by a 250 V~, 4 A T (slow blow) fuse 5 x 20 mm, which are accessible after removing the fuse cartridge. For exchanging the fuse please refer to section 10.7.1.
3 Mains Connector	Connector for the supplied mains cable.
4 Output Connector • LEMO 2B.304 connector	Power output connector for supply of TOPTICA laser heads. Not intended for general use. For pin assignment and power values, please refer to section 10.9.6. **NOTE !** The Output Connector is not present at PS modules.
5 Ground Pin	Pin for installation of a ground connection to external devices.

9.2.2 PS HP Module

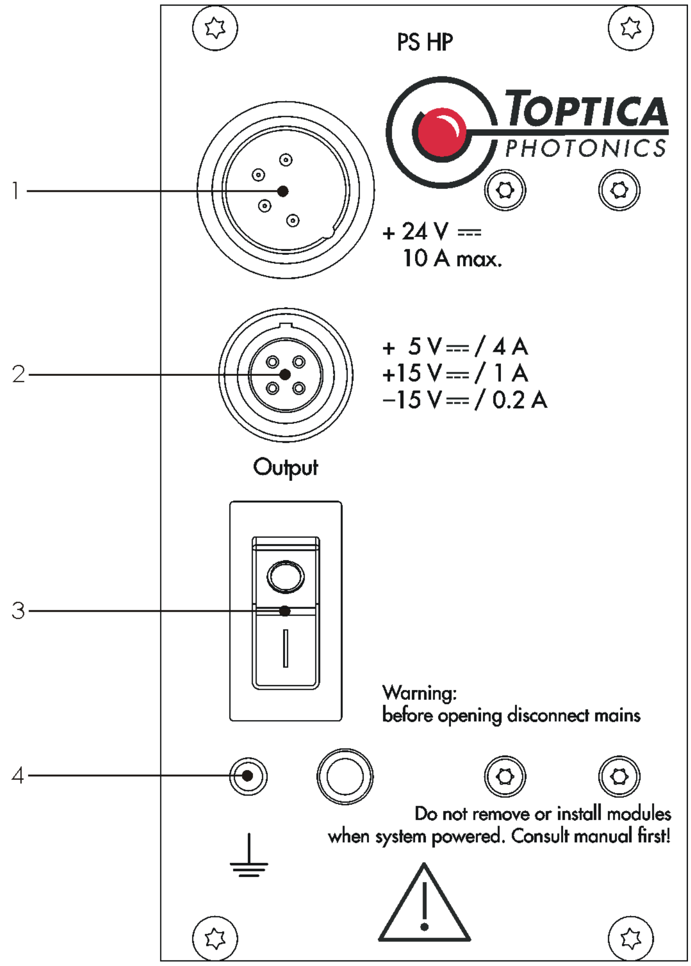


Figure 133 Panel of the PS HP module

1	External Power Adaptor Connector	**3**	ON/OFF Switch
2	Output Connector	**4**	Ground Pin

1 External Power Adaptor Connector	Input connector for power supply by the delivered external power adaptor.
2 Output Connector • LEMO 2B.304 connector	Power output connector for supply of TOPTICA laser heads. Not intended for general use. For pin assignment and power values, please refer to section 10.9.6. **NOTE !** The Output Connector is not present at PS modules.
3 ON/OFF Switch	Switching off the PS HP at the ON/OFF switch, only sets the power supply to standby. Disconnect the mains cable to the external power adaptor to completely shut down the DLC pro. **NOTE !** After switching off, please wait for at least 10 seconds before switching the DLC pro on again.
5 Ground Pin	Pin for installation of a ground connection to external devices.

Please refer to Figure 134 for connecting a DLC pro with PS HP module to mains via the supplied external power adaptor and mains cable.

DANGER ! **CAUTION !**	Before **connecting/disconnecting the mains cable or the power adaptor connector**, always switch off the DLC pro at the ON/OFF switch of the PS HP module.

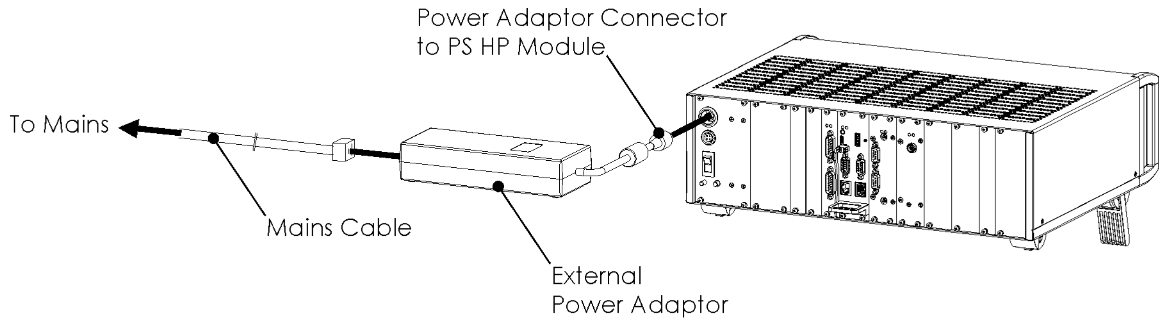


Figure 134 Mains connection of DLC pro with PS HP module. The external power adaptor is delivered by TOPTICA

9.2.3 MC+ Module

The MC+ module is the control center of the DLC pro. It comprises a module with an ARM microcontroller and an FPGA unit for various control purposes and communication with other plug-in modules. Several peripheral connectors as well as digital inputs and outputs are also available.

All other plug-in modules and the touchscreen on the DLC pro front panel are connected to the MC+ module via the backplane.

The MC+ module offers various interfaces (USB, two Ethernet connectors, an RS232 interface, and an LVDS socket).

The LVDS connector is used for digital high-speed communication, e.g., with a CTL laser head. All other plug-in modules and the touchscreen on the DLC pro front panel are connected to the MC+ module via the backplane.

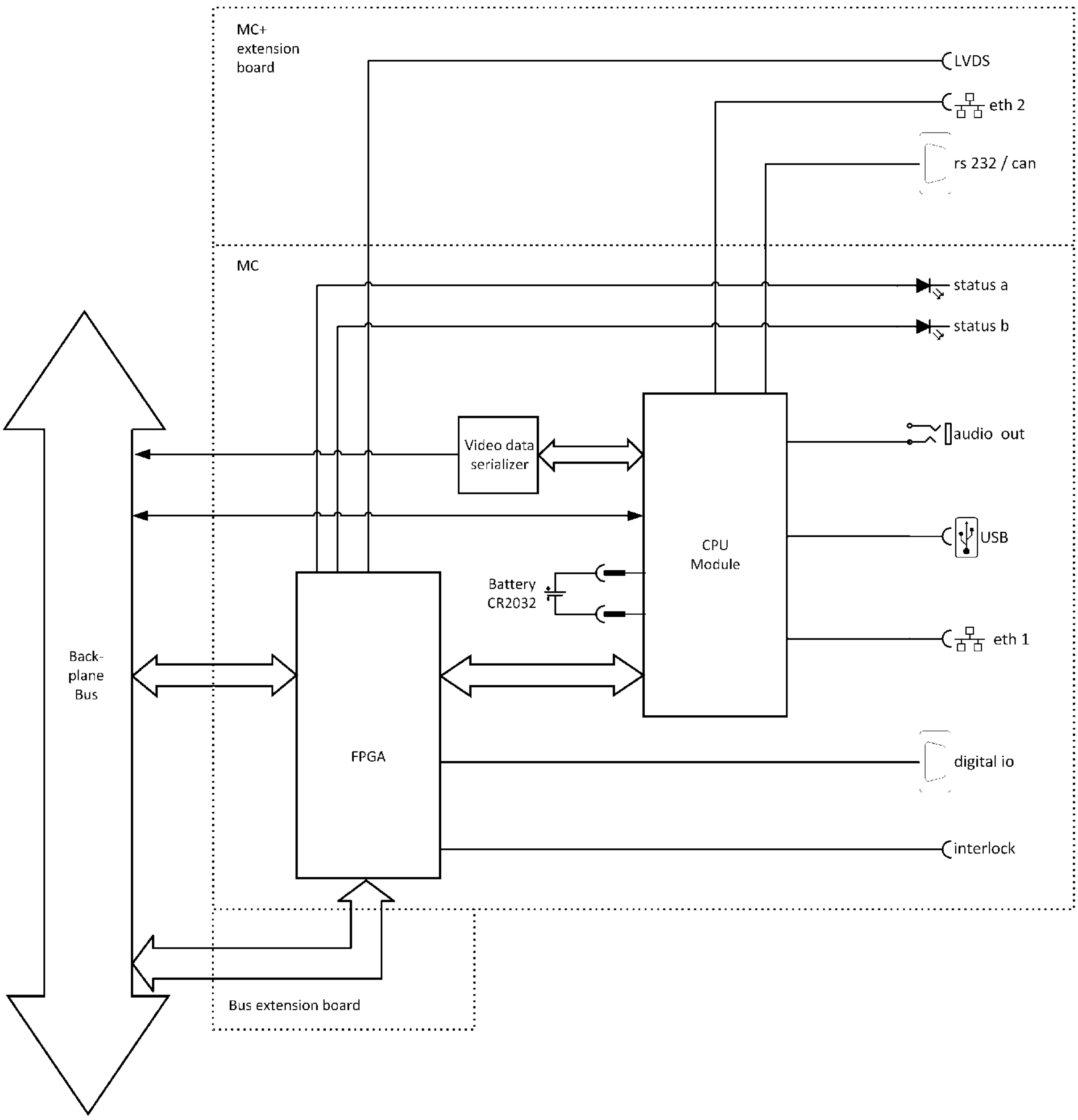


Figure 135 Block diagram of the MC+ module

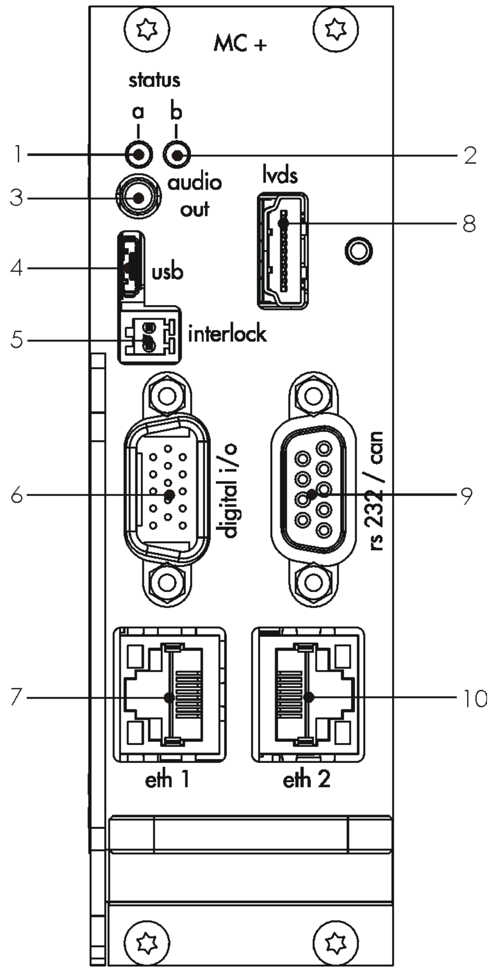


Figure 136 Panel of the MC+ module

1	Status LED a	**5**	External Interlock Connector	**8**	LVDS Connector
2	Status LED b	**6**	Digital I/O Connector	**9**	RS 232/Can Connector
3	Audio Out	**7**	Ethernet 1 Connector	**10**	Ethernet 2 Connector
4	USB Connector				

NOTE !	Items 8, 9, and 10 are not present at MC modules.

1 Status LED a	**Dark Orange:** Not initialized. **Off:** Ready
2 Status LED b	Please see description of Status LED a for information.
3 Audio Out • 3.5 mm Audio Stereo Jack	not yet implemented.
4 USB Connector	Micro USB 2.0 connector (host/slave, USB on-the-go) can be used for remote control of the DLC pro by a computer. When connected to a computer, the DLC pro appears as a USB-connected serial interface. For details on setting up the USB connection, please refer to section 10.20. **NOTE !** A micro USB 2.0 cable with **connector type B** must be used. We recommend operating the DLC pro via Ethernet over using a USB connection due to the higher communication bandwidth. Using a USB to Ethernet adapter on the PC side allows fast communication while having a point-to-point connection between PC and DLC pro – without connecting the DLC pro to the local network or disconnecting the PC from it.
5 External Interlock Connector • Phoenix MC 0.5/2-G-2.5 connector	Connector for installation of an external interlock circuit to switch off the laser (e.g., using a door switch). Use the supplied interlock plug if no external interlock circuit is installed. For details on the external interlock circuit, please refer to section 2.3.1.

6 Digital I/O Connector • D-Sub 15 HD male connector	Connector for multi-purpose digital inputs and outputs. A breakout cable (article number K DLC/Digital I/O) is available from TOPTICA for convenient access to all 8 digital lines.	
	Digital Input 0	1 (high) Lock function for laser 1 is on hold (pause). 0 (low) Lock function for laser 1 is continued.
	Only Dual-Laser-Operation: **Digital Input 1**	1 (high) Lock function for laser 2 is on hold (pause). 0 (low) Lock function for laser 2 is continued.
	Digital Input 2 or 3	Input trigger for initiating a wide scan.
	Specifications Digital Inputs:	Input resistance 10 kΩ TTL level high > 2.0 V TTL level low < 0.8 V
	Each of the four Digital Outputs can be operated in different modes. The modes can be selected in the parameter menu or the Params tab by the parameter io > digital-out0 > mode, io > digital-out1 > mode, io-digital-out2 > mode or io > digital-out3 > mode, respectively. Depending on the mode, the voltage level at the Digital Output pin is driven by different features of the DLC pro. Some modes are reserved for future developments and some modes only work if the corresponding license is installed	
	Digital Output 0	
	mode 0	**(Default)** A square form (duty cycle 1:1) trigger signal synchronous with the scan ramp generating the laser frequency scan for laser 1 is available as a digital signal.
	mode 1	Reserved
	mode 2	Reserved
	mode 3	Software control. Use parameter io > digital-out0 > value-set to control the voltage of this pin.
	Digital Output 1	
	mode 0	Reserved
	mode 1	**(Default)** Only with Lock option license installed. TTL output signal indicating whether laser 1 is locked AND whether the measured signal is within the defined window. This signal may be used for fast lock/unlock detection to stop data acquisition when laser 1 falls out-of-lock.
	mode 2	Trigger signal at the trigger threshold of a wide scan (please refer to sections 5.3.12 and 6.14.1).
	mode 3	Software control. Use parameter io > digital-out1 > value-set to control the voltage of this pin.

<table>
<tr><td>6 Digital I/O Connector
• D-Sub 15 HD male connector

(continued)</td><td>Digital Output 2
mode 0 Reserved
mode 1 (Default) Only with Dual-Laser-Operation and Lock option licenses installed.
TTL output signal indicating whether laser 2 is locked AND whether the measured signal is within the defined window. This signal may be used for fast lock/unlock detection to stop data acquisition when laser 2 falls out-of-lock.
mode 2 Reserved
mode 3 Software control. Use parameter io > digital-out2 > value-set to control the voltage of this pin.

Digital Output 3
mode 0 (Default) Only with Dual-Laser-Operation.
A square form (duty cycle 1:1) trigger signal synchronous with the scan ramp generating the laser frequency scan for laser 2 is available as a digital signal.
mode 1 Reserved
mode 2 Trigger signal at the trigger threshold of a wide scan (please refer to sections 5.3.12 and 6.14.1).
mode 3 Software control. Use parameter io > digital-out3 > value-set to control the voltage of this pin.

Specifications Digital Outputs:
high: min. 4 V at 10 kΩ load
low: max. 0.4 V at 10 kΩ load

For pin assignment of the D-Sub 15 HD connector, please refer to section 10.9.4.</td></tr>
<tr><td>7 Ethernet 1 Connector</td><td>Ethernet connector for remote control of the DLC pro via TCP/IP.</td></tr>
<tr><td>8 LVDS Connector</td><td>Connector for high-speed digital communication with supported TOPTICA laser heads.

CAUTION ! Connection to other devices may damage the DLC pro laser driver electronics.

NOTE ! The LVDS Connector is not present at MC modules.</td></tr>
<tr><td>9 RS 232/Can Connector
• D-Sub 9 connector</td><td>Digital communication connection.

NOTE ! The RS232/Can Connector is not present at MC modules.</td></tr>
<tr><td>10 Ethernet 2 Connector</td><td>Ethernet connector RJ45.
DLC DL-/TA-SHG/FHG pro: Connection between DLC pro and DL-/TA-SHG/FHG pro laser head.

NOTE ! The Ethernet 2 Connector is not present at MC modules.</td></tr>
</table>

9.2.4 CC-500 Module

The CC-500 module is a digitally controllable, low-noise current source for diode lasers. Its most important features are:

- Two available channels (245 mA each) that can be combined to one channel (490 mA).
- Support for laser diodes with either positive or negative polarity.
- Monitoring of the voltage applied to the laser diode.
- High current/voltage or loose connection detection to prevent damage to the laser diode.
- Two available differential analog SMB inputs on each CC-500.
- Power supply for the laser head modulation circuit.
- Built-in temperature sensors for overheat detection.

The CC-500 shows superior short-term and temperature stability of the laser diode current and fits into an M-Slot of the DLC pro.

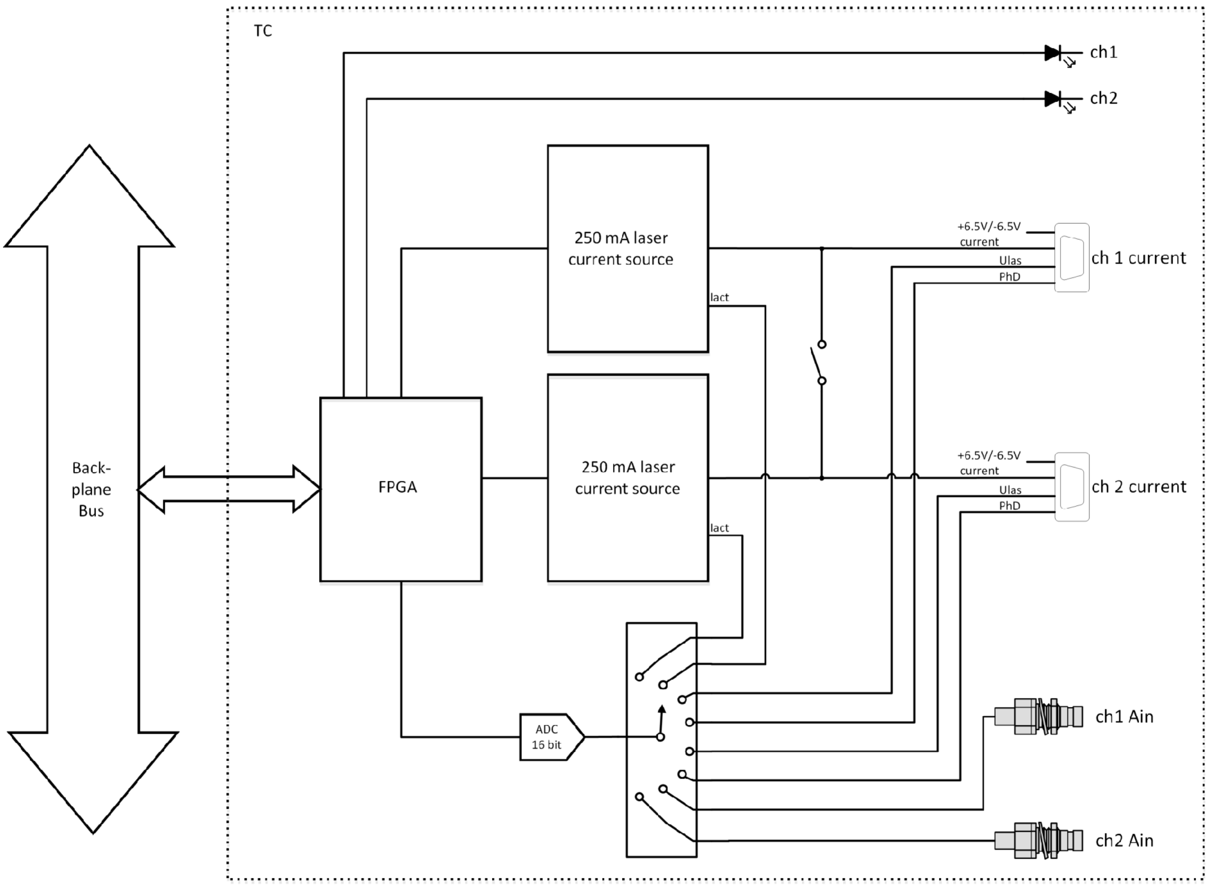


Figure 137 Block diagram of the CC-500 module

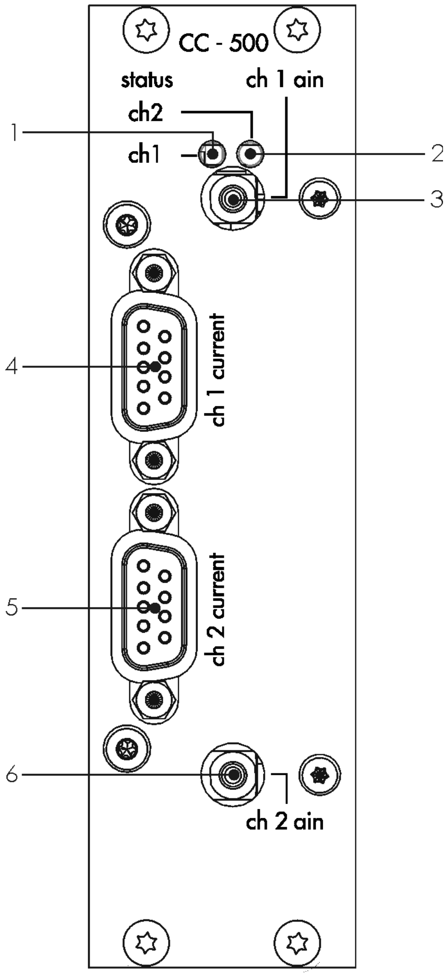


Figure 138 Panel of the CC-500 module

1	Status LED Channel 1	**4**	Channel 1 Current Connector
2	Status LED Channel 2	**5**	Channel 2 Current Connector
3	Channel 1 ain (Analog Input)	**6**	Channel 2 ain (Analog Input)

1 Status LED Channel 1	**Red:** Error: LD overcurrent, LD overvoltage, Power not OK. **Green:** Output active. **Green flashing:** Disabled, waiting.
2 Status LED Channel 2	Please see description of Status LED 1 for information.
3 Channel 1 ain • SMB connector	Multi-purpose measurement input, - 4 V .. + 4 V, input resistance 1 MΩ.
4 Channel 1 Current Connector • D-Sub 9 connector	Connector for channel 1 current. For pin assignment of the D-Sub 9 connector, please refer to section 10.9.1. **NOTE !** When the CC-500 is set to a current output of 1 x 490 mA (see section 9.2.4.1), only Channel 1 is active.
5 Channel 2 Current Connector • D-Sub 9 connector	Connector for channel 2 current. For pin assignment of the D-Sub 9 connector, please refer to section 10.9.1. **NOTE !** Channel 2 is deactivated when the CC-500 is set to a current output of 1 x 490 mA (see section 9.2.4.1).
6 Channel 2 ain • SMB connector	Multi-purpose measurement input, - 4 V .. + 4 V, input resistance 1 MΩ. **DLC TA pro/-AL:** Used for monitoring the seed power (please refer to the TA pro or TA pro AL laser head manual).

9.2.4.1 Changing the CC-500 Current Output (Service Operation)

DANGER ! The CC-500 module must be removed from the DLC pro for changing between the current output options. Switch off the DLC pro, disconnect it from the mains supply, and follow the instructions noted in section 10.4 to remove and install the plug-in module.

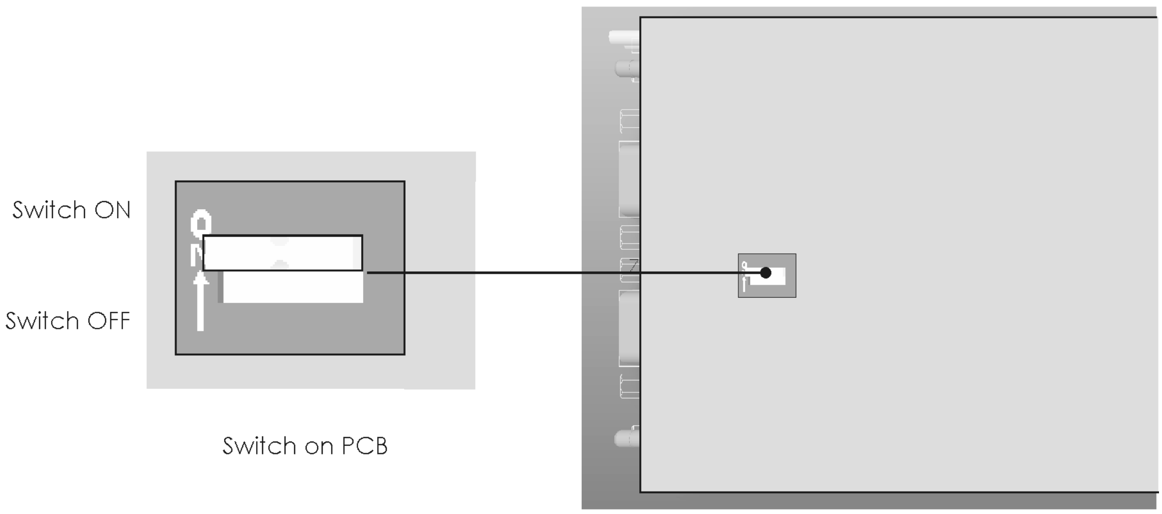


Figure 139 Switch on the CC-500 pcb to change the current output

The current output of the CC-500 module is set by a switch on the pcb.

Switch ON Max. Current Output 1 x 490 mA on Channel 1 (Factory Setting)
Switch OFF Max. Current Output 2 x 245 mA on Channel 1 and 2 (Factory Setting for some DLC MDL pro)

9.2.5 CC-5000 Module

The CC-5000 module is a digitally controllable, low-noise current source for high-power diode lasers and amplifiers. Its most important features are:

- Support for negative laser diodes (anode grounded).
- Monitoring of the voltage applied to the laser diode.
- High current/voltage or loose connection detection to prevent damage to the laser diode.
- Differential analog SMB input.
- Power supply for the laser head modulation circuit.
- Built-in temperature sensors for overheat detection.

Modulation and stabilization sources within DLC pro can be directed to the CC-5000 module - with little limitations:
- Above a Set Current of 500 mA, current modulation can be applied with slew rates up to 500 Ampere per second. Limitations are a -3 dB bandwidth of 70 Hz and a constant delay of 2 ms.
- Below a Set Current of 500 mA, current slew rates of more than 50 Ampere per second will cause a distorted waveform.

The CC-5000 shows low noise properties and allows high stability of the laser diode or amplifier current. It fits into an S-Slot of the DLC pro.

CAUTION !	**Do not interchange the CC-5000 and the TC Module** as this leads to malfunction. Observe the mounting instructions noted in section 10.5.

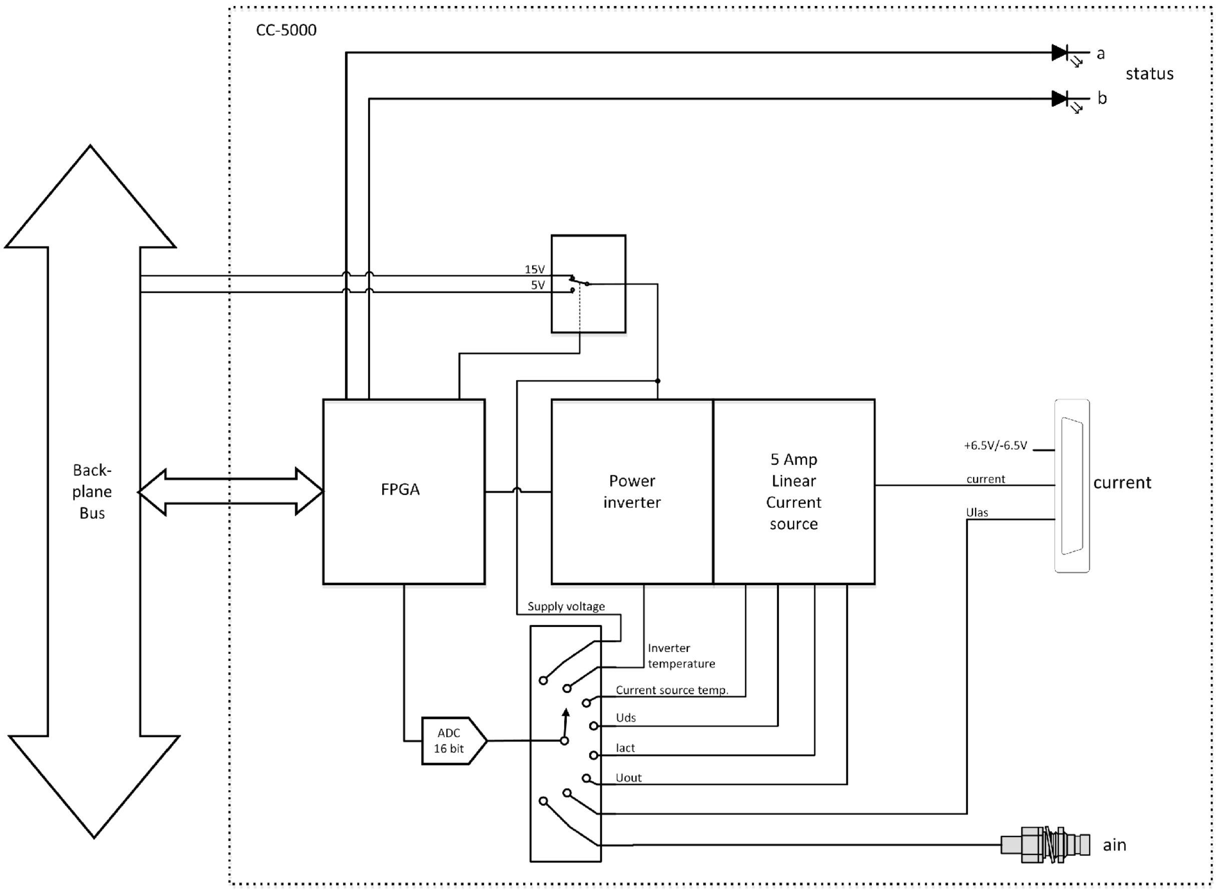


Figure 140 Block diagram of the CC-5000 module

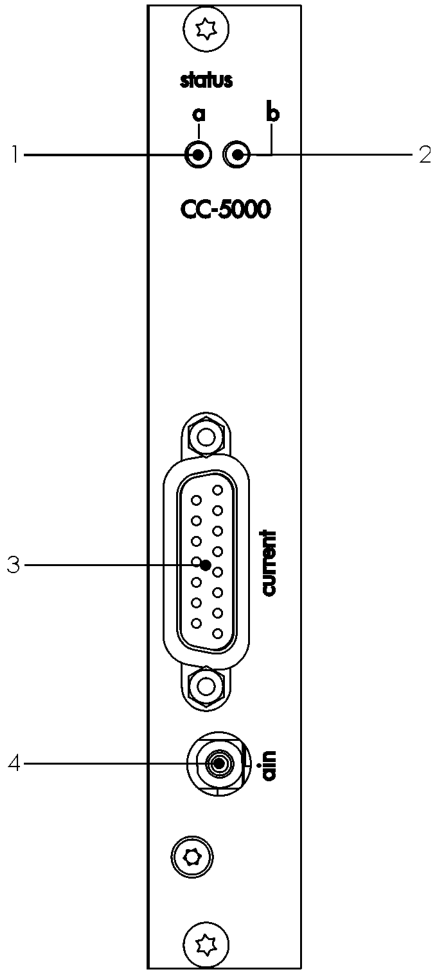


Figure 141 Panel of the CC-5000 module

1	Status LED a	**3**	Current Connector
2	Status LED b	**4**	Ain (Analog Input)

1 Status LED a	**Red:** Error: LD overcurrent, LD overvoltage, Power not OK. **Green:** Output active. **Green flashing:** Disabled, waiting.
2 Status LED b	Not active.
3 Current Connector • D-Sub 15 connector	Connector for output current. For pin assignment of the D-Sub 15 connector, please refer to section 10.9.2.
4 Ain • SMB connector	Multi-purpose measurement input, - 4 V .. + 4 V, input resistance 1 MΩ. **DLC TA pro/-AL:** Used for monitoring the amplified output power (please refer to the TA pro or TA pro AL laser head manual).

9.2.5.1 Combination of two CC-5000 Modules for up to 10 A

Two CC-5000 modules can be combined to deliver currents up to 10 A. In this case, the two modules are connected internally, one of the current connectors is sealed and the accessible current connector of is used to supply the combined current.

NOTE !	If the DLC pro is using the PS or PS+ module, the maximum current is limited to 7 A by the power supply module as well as the heat generated within the DLC pro. If the DLC pro is powered with a PS HP module up to 10 A are possible. Please refer to the laser head manuals for the required cooling.

NOTE !	For installation of a combination of two CC-5000 modules, please refer to section 10.4.2.

The most important features are:

- Support for negative laser diodes (anode grounded).
- Monitoring of the voltage applied to the laser diode.
- High current/voltage or loose connection detection to prevent damage to the laser diode.
- Differential analog SMB input.
- Power supply for the laser head modulation circuit.
- Built-in temperature sensors for overheat detection.

The combination of two CC-5000 modules shows low noise properties and allows high stability of the laser diode current and is available factory installed together with Article SUR TA / HP. If you wish your DLC pro laser driver electronics to be upgraded (Article UPGR TA / HP), please contact TOPTICA Photonics AG.

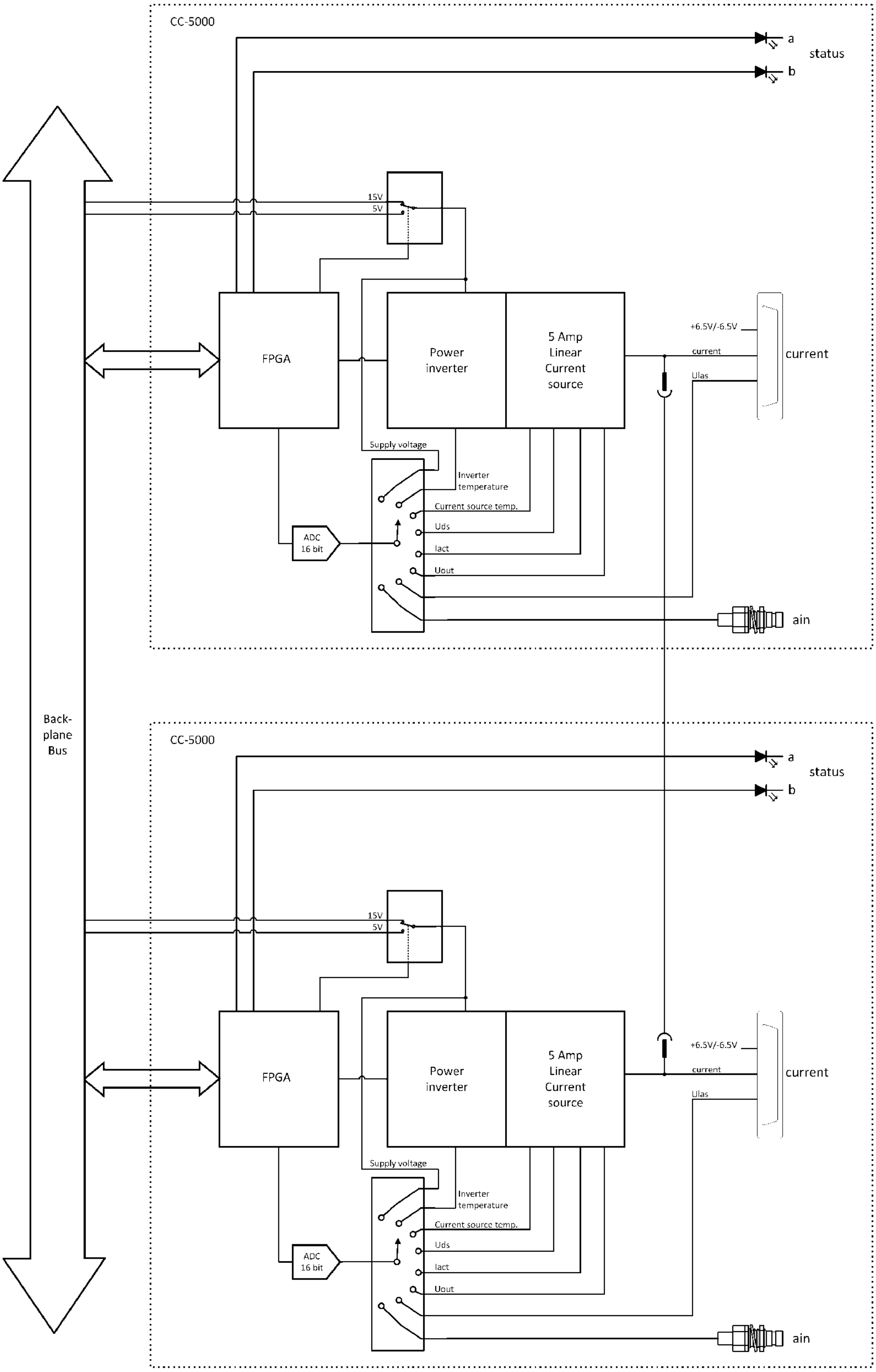


Figure 142 Block diagram of the combination of two CC-5000 modules

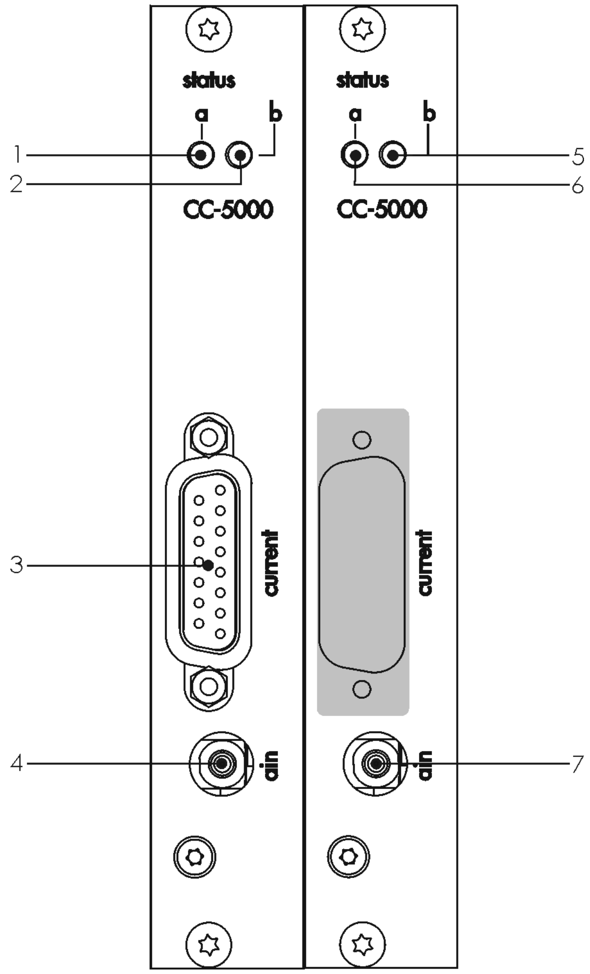


Figure 143 Panel of the combination of two CC-5000 modules

1	Status LED a (left CC-5000)	**4**	Ain (Analog Input left CC-5000)	**7**	Ain (Analog Input right CC-5000)
2	Status LED b (left CC-5000)	**5**	Status LED b (right CC-5000)		
3	Current Connector	**6**	Status LED a (right CC-5000)		

CAUTION !	The DLC pro software is designed to support the Current Connector (3). **Do not use the covered connector and the ain SMB connector of the right CC-5000 !**

1 Status LED a (left CC-5000)	**Red:** Error: LD overcurrent, LD overvoltage, Power not OK. **Green:** Output active. **Green flashing:** Disabled, waiting.
2 Status LED b (left CC-5000)	Not active.
3 Current Connector • D-Sub 15 connector	Connector for current connection. For pin assignment of the D-Sub 15 connector, please refer to section 10.9.2.
4 Ain (left CC-5000) • SMB connector	Multi-purpose measurement input, - 4 V .. + 4 V, input resistance 1 MΩ. **DLC TA pro/-AL:** Used for monitoring the amplified output power (please refer to the TA pro or TA pro AL laser head manual).
5 Status LED b (right CC-5000)	Not active.
6 Status LED a (right CC-5000)	**Red:** Error: LD overcurrent, LD overvoltage, Power not OK. **Green:** Output active. **Green flashing:** Disabled, waiting.
7 Ain (right CC-5000) • SMB connector	Do not use.

9.2.6 TC Module

The TC module is designed for driving peltier elements (TEC) that are regulated depending on the signal of a negative temperature coefficient resistor (NTC). The NTC measures the temperature inside the connected laser head and, depending on the configured operating parameters, the TEC controls the temperature.

The TC module comprises power stages, measurement functions, and digital regulators to perform this task. In the basic set up, two absolutely independent regulators are available.

The block diagram below shows the setup and the most important elements. Communication between the TC module and the MC+ module is carried out via the internal digital bus which comprises fast serial interfaces (LVDS) and hardware control lines. The core of the TC module is an FPGA with a microcontroller. Together, they contain the interface for communication with the MC+ module and the digital software regulators. The relevant TC parameters (PID settings, limits etc.) can be set via touchscreen, PC-GUI or software commands.

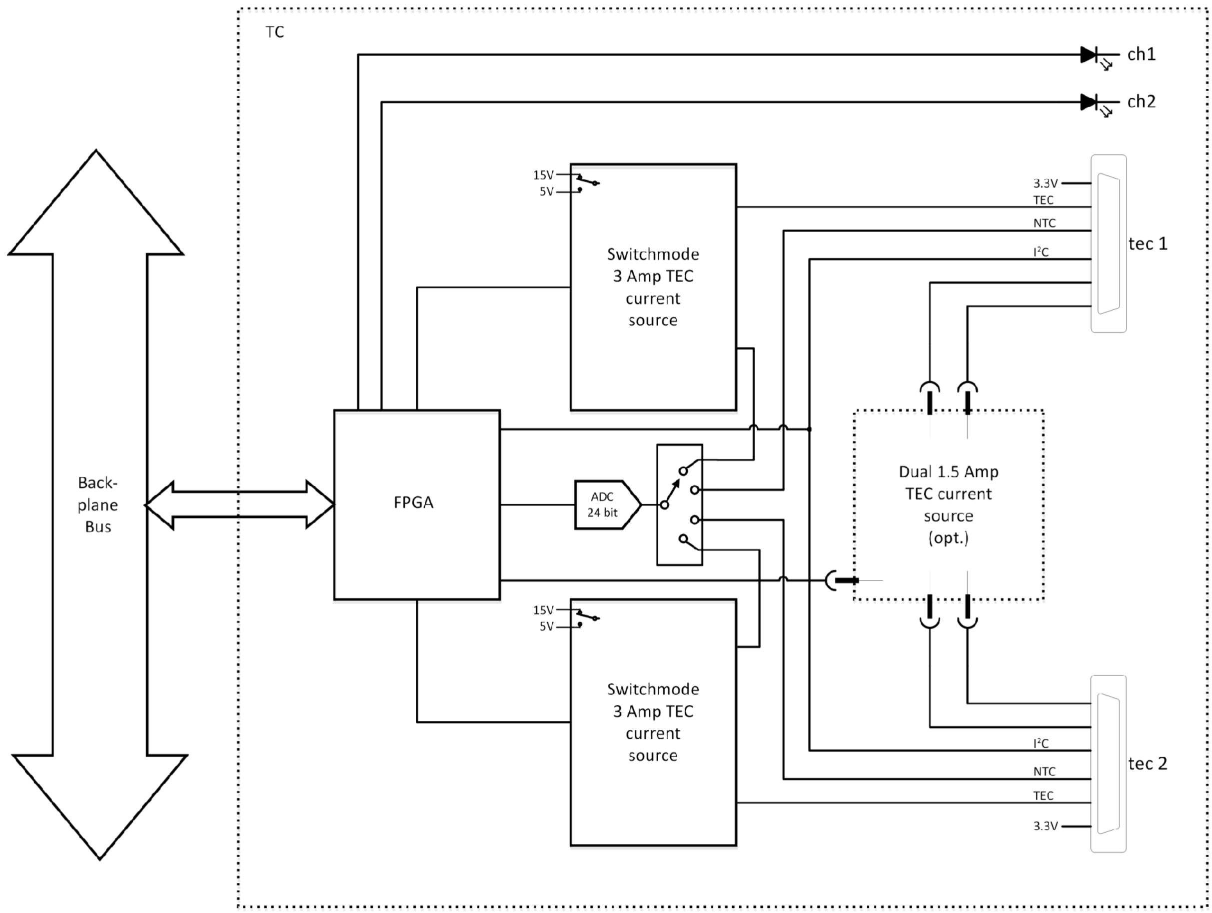


Figure 144 Block diagram of the TC module

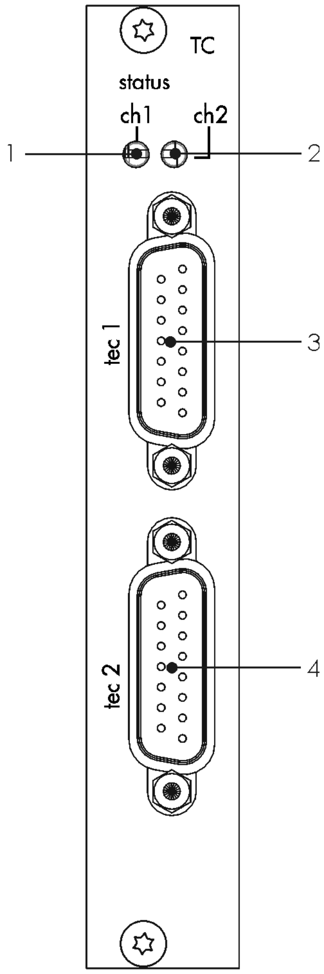


Figure 145 Panel of TC module

1	Status LED Channel 1	**3**	TEC 1 Connector
2	Status LED Channel 2	**4**	TEC 2 Connector

1 Status LED Channel 1	**Red:** Error: Power Driver Problem, NTC missing or TEC not OK. **Off:** No head connection (TEC and NTC missing). **Green:** Output active, settled. **Green flashing:** Disabled, waiting. **Orange:** Output active, regulating. **Orange flashing:** Output active, regulating, saturated;
2 Status LED Channel 2	Please see description of Status LED 1 for information.
3 TEC 1 Connector • D-Sub 15 connector	Connector for TEC 1 temperature control connection. For pin assignment of the D-Sub 15 connector, please refer to section 10.9.3.
4 TEC 2 Connector • D-Sub 15 connector	Connector for TEC 2 temperature control connection. For pin assignment of the D-Sub 15 connector, please refer to section 10.9.3.

9.2.7 PC Module

The PC module applies an analog voltage to a piezo element inside the laser head, which allows to tune the wavelength. The digital circuit area comprises D/A and A/D converters and an FPGA. The analog circuit area features its own reference voltage source and various high-quality operational amplifiers. The digital input signal that is applied internally via the backplane is converted to an analog voltage. The following discrete and fully analog high-voltage amplifier provides the piezo control voltage.

This unipolar voltage signal, typically -1 V .. +140 V with max. 25 mA, allows to generate frequencies up to 1000 Hz at a piezo capacity of typically 1µF. For typical TOPTICA laser heads, the scan amplitude corresponds to a wavelength tuning of several 10 GHz.

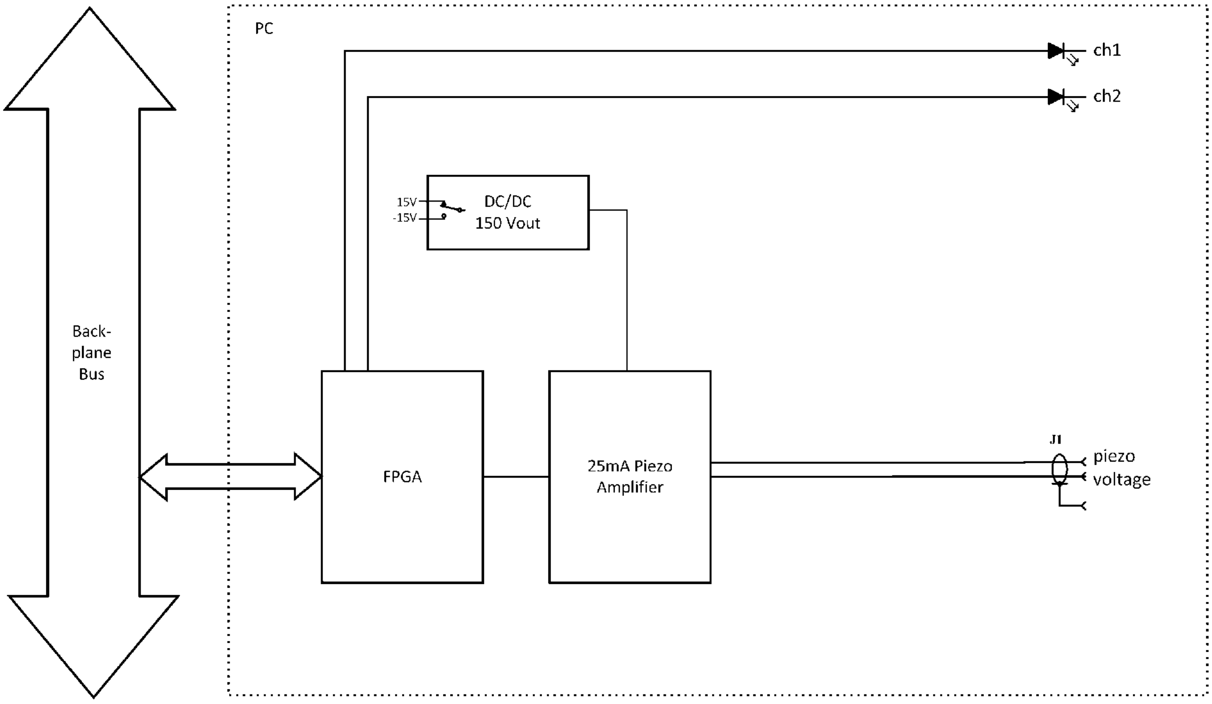


Figure 146 Block Diagram of the PC module

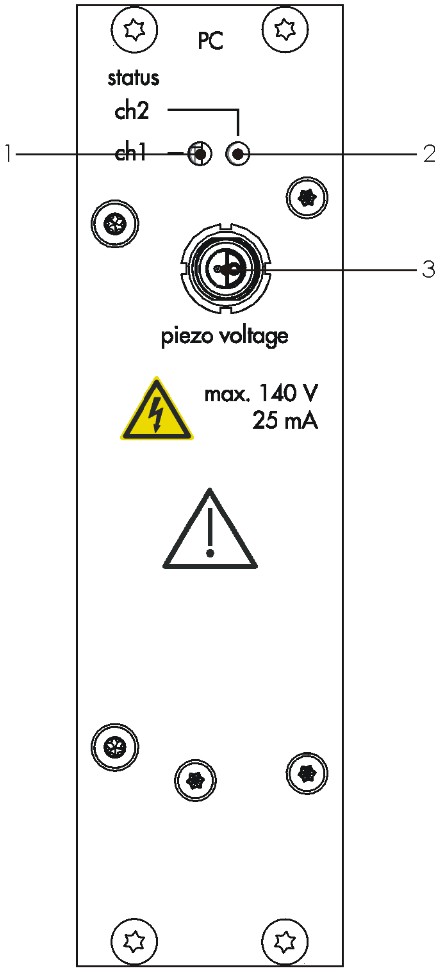


Figure 147 Panel of the PC module

1 Status LED Channel 1 **2** Status LED Channel 2 **3** Piezo Connector

1 Status LED Channel 1	**Red:** HV not OK. **Green:** Output active. **Green flashing:** Disabled, waiting.
2 Status LED Channel 2	Not active.
3 Piezo Connector • LEMO 0S.302 -connector	Analog voltage output for piezo control. Voltage range: - 1 V .. + 140 V. For pin assignment, please refer to section 10.9.5. **NOTE !** The piezo voltage output is short-circuit proof. When the power of the piezo driver channel is not sufficient to realize proper modulation of the piezo together with its connected mechanics, this is detected and a warning message (xxx: piezo driver current fault) is displayed. This message disappears 2 s after normal piezo modulation is resumed.

9.2.8 PC2 Module

The two channel PC2 module applies analog voltages to piezo elements inside the laser head, which allow to tune the wavelength. The digital circuit area comprises D/A and A/D converters and an FPGA. The analog circuit area features its own reference voltage source and various high-quality operational amplifiers. The digital input signals that are applied internally via the backplane are converted to analog voltages. The following discrete and fully analog high-voltage amplifiers provide the piezo control voltages.

These unipolar voltage signals, typically -1 V .. +140 V with max. 25 mA, allow to generate frequencies up to 1000 Hz at a piezo capacity of typically 1µF. For typical TOPTICA laser heads, the scan amplitude corresponds to a wavelength tuning of several 10 GHz.

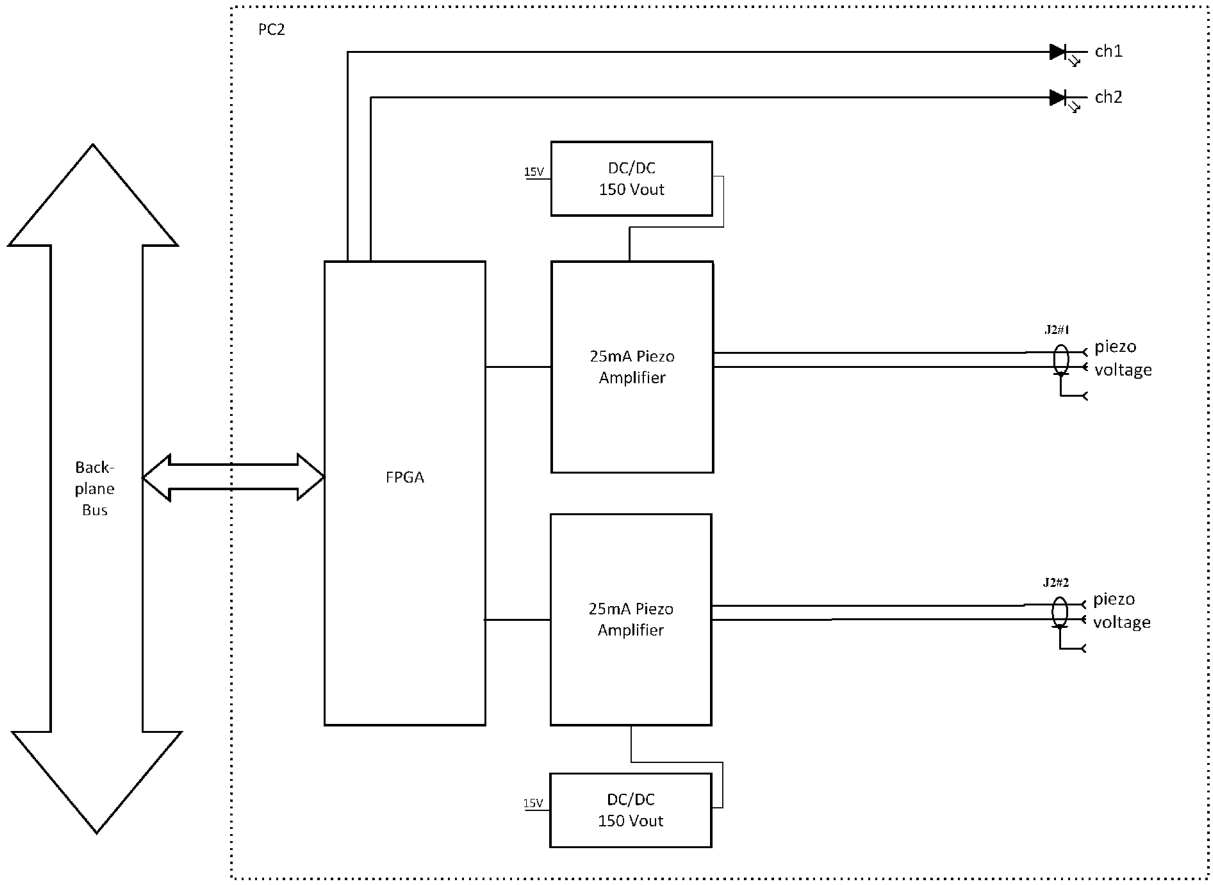


Figure 148 Block Diagram of the PC2 module

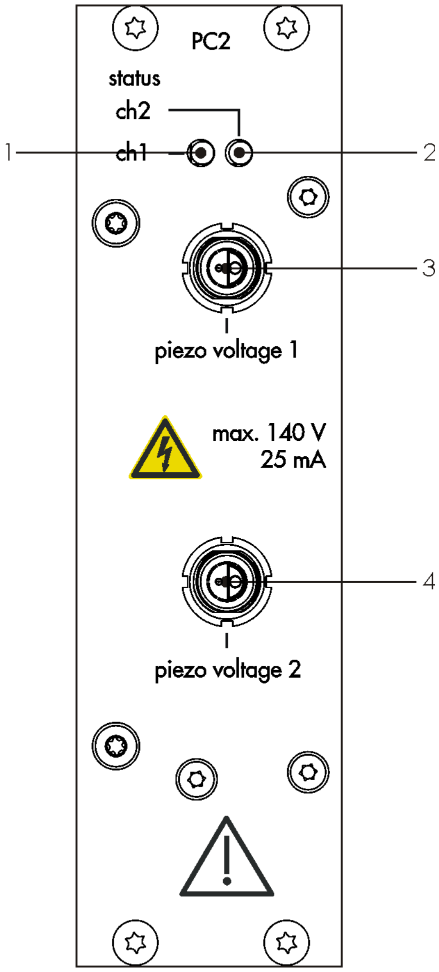


Figure 149 Panel of the PC2 module

1	Status LED Channel 1	**3**	Piezo Connector 1
2	Status LED Channel 2	**4**	Piezo Connector 2

1 Status LED Channel 1	**Red:** HV not OK. **Green:** Output active. **Green flashing:** Disabled, waiting.
2 Status LED Channel 2	Please see description of Status LED 1 for information.
3 Piezo Connector 1 • LEMO 0S.302 -connector	Analog voltage output for piezo control. Voltage range: - 1 V .. + 140 V. For pin assignment, please refer to section 10.9.5. **NOTE !** The piezo voltage output is short-circuit proof. When the power of the piezo driver channel is not sufficient to realize proper modulation of the piezo together with its connected mechanics, this is detected and a warning message (xxx: piezo driver current fault) is displayed. This message disappears 2 s after normal piezo modulation is resumed.
4 Piezo Connector 2 • LEMO 0S.302 -connector	Analog voltage output for piezo control. Voltage range: - 1 V .. + 140 V. For pin assignment, please refer to section 10.9.5. **NOTE !** The piezo voltage output is short-circuit proof. When the power of the piezo driver channel is not sufficient to realize proper modulation of the piezo together with its connected mechanics, this is detected and a warning message (xxx: piezo driver current fault) is displayed. This message disappears 2 s after normal piezo modulation is resumed.

9.2.9 PDH Module

NOTE !	When the PDH module is acquired, TOPTICA also provides relevant software to update your DLC pro. Please refer to section 10.3 for a step-by-step description on how to install the PDH module. If purchased along with the DLC pro, the PDH module and the software is already installed.

NOTE !	To use the PDH module for Top of Fringe PDH locking (see sections 5.3.10 and 6.15.3), a Lock option license is required. The PDH module itself can be used without Lock option license. The Error signals are applied to the SMB-connectors of the PDH module and can be used together with an external controller.

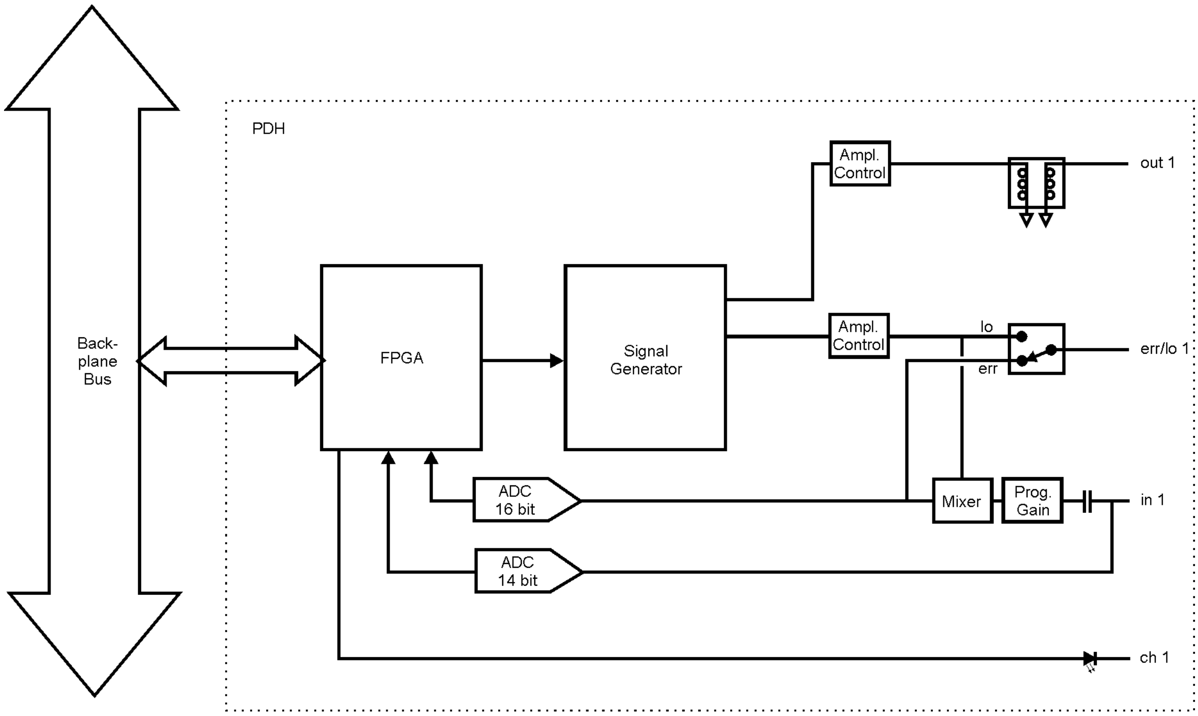


Figure 150 Block diagram of the PDH module (only channel 1 shown)

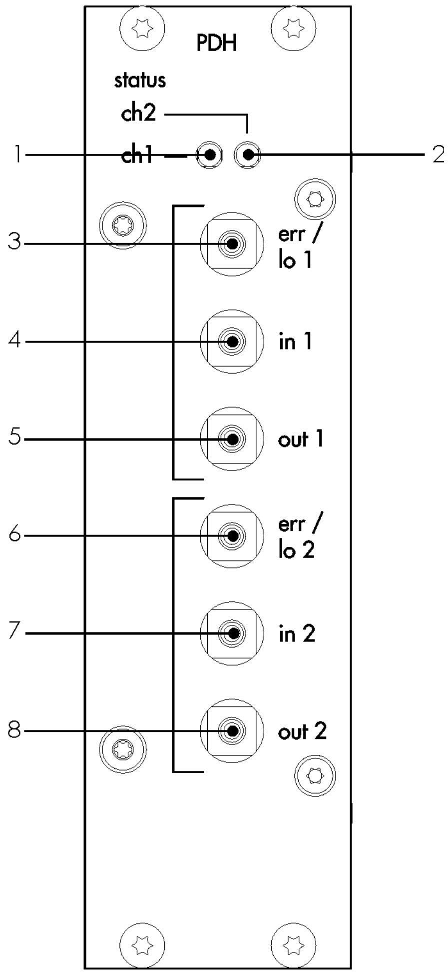


Figure 151 Panel of the PDH module

1	Status LED Channel 1	**4**	Input 1	**7**	Input 2
2	Status LED Channel 2	**5**	Output 1	**8**	Output 2
3	Error/Local Oscillator 1	**6**	Error/Local Oscillator 2		

1 Status LED Channel 1	**Red:** PDH module error. **Green:** Modulation enabled. **Green flashing:** Modulation disabled.
2 Status LED Channel 2	Please see description of Status LED 1 for information.
3 Error/Local Oscillator 1 • SMB-connector	**Err 1**: Pound-Drever-Hall error signal output for channel 1. The analog error signal of the PDH module is superimposed by the sum frequency of the modulation and demodulation signal. For viewing the error output on an oscilloscope, an external lowpass filter is recommended. **Lo 1**: Demodulation signal output for channel 1. **LO Output** can be enabled in the PDH tab (see section 6.21) or via touchscreen (context parameter menu with Scan/Lock screen selected, see section 5.3.8) **NOTE !** When **LO Output** is enabled, the **LO Amplitude** can be set as desired. This may affect the error signal generated by the PDH module. If you wish to output the demodulation signal and ensure optimum error signal quality at the same time, set **LO Amplitude** to 8.8 dBm.
4 Input 1 • SMB-connector	Channel 1 input for connection of a photo diode monitoring the spectrum of the respective cavity or atomic transition. The **Maximum Input Level** can be adapted in the PDH tab (see section 6.21) or via touchscreen (context parameter menu with Scan/Lock screen selected, see section 5.3.8).
5 Output 1 • SMB-connector	Channel 1 output for the modulation signal applied to the laser diode current or EOM for generating the Pound-Drever-Hall error signal. The signal **Amplitude** can be set in the PDH tab (see section 6.21) or via touchscreen (context parameter menu with Scan/Lock screen selected, see section 5.3.8).
6 Error/Local Oscillator 2 • SMB-connector	**Err 2**: Pound-Drever-Hall error signal output for channel 2. **Lo 2**: Demodulation signal output for channel 2. Please see description of Error/Local Oscillator 1 for information.
7 Input 2 • SMB-connector	Channel 2 input for connection of a photo diode. Please see description of Input 1 for information.
8 Output 2 • SMB-connector	Channel 2 output for the modulation signal. Please see description of Output 1 for information.

10 Appendix

10.1 Specifications of the DLC pro

10.1.1 General and Environmental Conditions

General and Environmental Specifications	
Voltage Requirements	100 .. 240 V~, 50/60 Hz (Wide Range Input)
Power Requirements	max. 250 W
Weight	8.0 kg (Mainframe with MC+, CC, PC, TC module)
Size (H x W x D)	154 mm x 450 mm x 348 mm
Overvoltage Category	II
Applicable Pollution Degree	2, indoor use only
Operating Temperature	5 °C .. 40 °C, non-condensing
Transport Temperature	0 .. 40° C, non-condensing
Storage Temperature	0 .. 40° C, non-condensing
Operating Altitude	up to 2000 m
Relative Humidity	non-condensing

10.1.2 System Components and Performance

Mainframe Specifications	
Operator Controls	1 touchscreen, 10 push-buttons, 4 rotary knobs, 1 key switch
Display size and resolution	7 inch diagonal, 800 x 480 pixels, 262k colors
LCD type	TFT, transmissive, anti-glare
Touchscreen	projected capacitive (PCT) with multi-touch capability
I/O port connectors	6 BNC, 1 USB type A
I/O port types	4 Analog Inputs, 2 Analog Outputs, 1 USB 2.0 host
Input Range (all Inputs)	-4 V .. +4 V
Input Impedance (all Inputs)	10 kΩ
Max. Input GND Voltage above PE	-4 V .. +4 V
ADC Resolution (Inputs 1, 2) and Bandwidth	24 bits, 200 kHz analog bandwidth
ADC Resolution (Inputs 3, 4) and Bandwidth	16 bits, 200 kHz analog bandwidth
DAC Resolution (Outputs A, B) and Bandwidth	16 bits, 200 kHz analog bandwidth
Output Range (Outputs A, B)	-4 V .. +4 V (no load), during startup temporarily -4 V
Output Impedance (Outputs A, B)	50 Ω, min. load 200 Ω to prevent overload
# of M-Slots (PC, CC-500, ...)	4
# of S-Slots (TC, CC-5000, ...)	2 - 4

Current Controller CC-500	
Laser Current Connectors	D-Sub, 9-pin female (1 Connector for each Channel)
ADC Input Connectors	SMB (1 Connector for each Channel)
Max. Laser Current	2 x 245 mA or 1 x 490 mA (selectable via switch on CC pcb)
Min. Laser Current	0.5 mA
Laser Current Polarity	selectable via software
Max. Output Voltages	7 V @ 360 mA, 5 V @ 490 mA
Current Noise Density	280 pA/sqrt (Hz) @ 1 kHz
Low Freq. Current Noise (0.1 Hz .. 10 Hz)	< 50 nA p-p
Smallest Current Step	16 nA (enhanced resolution ON)
Absolute Accuracy	+/1 mA (without offset calibration)
Modulation Bandwidth	DC to 15 kHz .. 30 kHz (depending on laser diode)
Achievable Power Stabilization Bandwidth	DLC DL pro, DLC DFB pro: 10 kHz, DLC CTL: 4 kHz
Temperature Coefficient of Laser Current	< 3 ppm/K typ.*
Long Term Stability of Laser Current	< 100 ppm/sqrt (khrs)*
ADC Input Range	-4 V .. + 4 V
Input Impedance	10 kΩ
ADC Resolution	16 bits
Max. Input GND Voltage above PE	-8 V .. + 8 V
	* after >1 hr warm-up period

Current Controller CC-5000	
Laser Current Connectors	D-Sub, 15-pin female
ADC Input Connectors	SMB
Max. Laser Current	5000 mA
Min. Laser Current	5 mA
Laser Current Polarity	negative (anode grounded)
Output Voltage	0.85 V .. 4 V
Maximum Laser Voltage @ Max. Current + 2 m Cable	0.85 V .. 3.5 V
Current Noise Density	120 nA/sqrt (Hz)
Low Freq. Current Noise (0.1 Hz .. 10 Hz)	10 µA p-p
Smallest Current Step	5 µA
Absolute Accuracy	max. 0.1 % dev. from setpoint
Modulation Bandwidth	100 Hz
Achievable Power Stabilization Bandwidth	DLC TA pro/-AL: 4 kHz, DLC SHG pro, DLC FHG pro: 1 kHz
Temperature Coefficient of Laser Current	10 ppm/K typ.*
ADC Input Range	-4 V .. + 4 V
Input Impedance	10 kΩ
ADC Resolution	16 bits
Max. Input GND Voltage above PE	-8 V .. + 8 V
	* after >1 hr constant current

Current Controller combination of two CC-5000	
Laser Current Connectors	D-Sub, 15-pin female
ADC Input Connectors	2 x SMB
Max. Laser Current	10000 mA with PS HP module 7000 mA with PS or PS+ module
Min. Laser Current	10 mA
Laser Current Polarity	negative (anode grounded)
Output Voltage	0.85 V .. 4 V
Maximum Laser Voltage @ Max. Current + 2 m Cable	0.85 V .. 3.2 V
Current Noise Density	200 nA/sqrt (Hz)
Low Freq. Current Noise (0.1 Hz .. 10 Hz)	20 µA p-p
Smallest Current Step	10 µA
Absolute Accuracy	max. 0.1 % dev. from setpoint
Modulation Bandwidth	100 Hz
Achievable Power Stabilization Bandwidth	DLC TA pro/-AL: 4 kHz, DLC SHG pro, DLC FHG pro: 1 kHz
Temperature Coefficient of Laser Current	10 ppm/K typ.*
ADC Input Range	-4 V .. + 4 V
Input Impedance	10 kΩ
ADC Resolution	16 bits
Max. Input GND Voltage above PE	-8 V .. + 8
	* after >1 hr constant current

Temperature Controller TC	
TEC Current Connectors	2 D-Sub, 15-pin male (1 Connector for each Ch)
Max. TEC Current	2 x 3 Amps
Act. Temperature Noise (100 µHz .. 1 Hz)	< 300 µK p-p
Smallest Set Temperature Step	50 µK
Absolute Accuracy of Actual Temperature	+/1 °C (typ., dep. on NTC)
Repeatability of Actual Temperature	< 0.001 K*
NTC Value @ Room Temperature	10 kΩ
Temperature Coeff. of Actual Temperature	< 140 ppm K/K* (TEC temperature change divided by ambient temperature change)
Temp. Control Loop Bandwidth	30 Hz
	* after > 1 hr warm-up period

Piezo Controller PC	
Piezo Voltage Connector	Lemo Series 0S.302
Piezo Voltage Range	-1 V .. +140 V
Max. Piezo Current (Charge/Decharge)	25 mA
Amplifier Output Impedance	50 Ω
Voltage Noise Density	140 nV/sqrt (Hz) @ 1 kHz
Smallest Piezo Voltage Step	9.5 µV
Load Capacitance Range	0 .. ∞ µF
Small Signal Bandwidth	3 kHz at C_{load} = 0
Temperature Coefficient of Piezo Voltage	< 5 mV/K

Piezo Controller PC2 (specifications per channel)	
Piezo Voltage Connector	Lemo Series 0S.302
Piezo Voltage Range	-1 V .. +140 V
Max. Piezo Current (Charge/Decharge)	25 mA
Amplifier Output Impedance	50 Ω
Voltage Noise Density	140 nV/sqrt (Hz) @ 1 kHz
Smallest Piezo Voltage Step	9.5 µV
Load Capacitance Range	0 .. ∞ µF
Small Signal Bandwidth	3 kHz at C_{load} = 0
Temperature Coefficient of Piezo Voltage	< 5 mV/K

Main Controller MC+	
I/O Connectors	2 x ETH, Digital I/O, LVDS, RS 232/Can (currently not supported), Interlock, USB, Audio Out
CPU	ARM Cortex-A8 CPU with graphics acceleration
Operating System	Linux
ETH Connector	RJ-45 for 10BASE-T/100BASE-TX
Digital I/O Connector	HD-Sub, 15-pin male, a breakout cable (article number K DLC/ Digital I/O) is available from TOPTICA for convenient access to all 8 digital lines.
Digital I/O Configuration	4 Inputs, 4 Outputs, TTL-compatible
Input Impedance of Digital Input	10 kΩ
High Level Input Voltage	> 2.0 V (maximum voltage 5.5 V)
Low Level Input Voltage	ca. 4.9 V @ no load, ca. 2.3 V @ I = -32mA; I_{max} = -32 mA
Output Impedance of Digital Output	50 Ω
High Level Output Voltage	ca. 4.9 V @ no load, ca. 2.3 V @ I = -32mA; I_{max} = -32 mA
Low Level Output Voltage	ca. 0.1 V @ no load, ca. 2.05 V @ I = 32mA; I_{max} = 32 mA
USB Connector	Micro-USB type B for USB 2.0 on-the-go
Audio Out Connector	3.5 mm Audio Stereo Jack
Audio Output Level (Full Scale)	1.0 V rms
Audio Output Power	40 mW max. @ 16 Ω, 30 mW max. @ 32 Ω
Stereo Codec	Texas Instruments TLV320AIC23B

NOTE ! See section 10.4.1 for exchange of a MC+ module.

Pound-Drever-Hall PDH module (specifications per channel)	
Input/Output Connectors	3 x SMB per channel
Modulation Output 1/2	
Waveform	Sine
Level	- 49.2 dBm .. 13.8 dBm (2.2 mV .. 3.1 V peak-to-peak voltage)
Step Size	0.5 dB
Frequency	5 MHz or 25 MHz, switchable
Output Impedance	50 Ω
Input Range	- 10 dBm, 0 dBm, + 10 dBm (max. input level)
Mod./Demod. Relative Phase Step	1.3° (5 MHz), 6.5° (25 MHz)
Adjustable Phase Range	0 .. 360°
<PDH in> ADC resolution	14 bit
<PDH error> ADC resolution	16 bit
Error Signal Bandwidth (digital)	1.5 MHz (- 3 dB)
Input Impedance	50 Ω
Error Output 1/2	
Range	±1.5 V
Output Impedance	50 Ω
Bandwidth	50 MHz (-3 dB)
Group delay	20 ns
LO Output 1/2	
Level	- 20.7 dBm .. 10.8 dBm (58 mV .. 2.2 V peak-to-peak voltage)
Step Size	0.5 dBm
Output Impedance	50 Ω
Common Mode Input/Output Range of Connectors	Err/LO: +/-1 V Out: +/- 10 V In: +/- 10 V
All Outputs Short-Circuit Proof	Yes

Power Supply Module PS+	
Mains Input	100 .. 240 V~, 50/60 Hz (Wide Range Input)
Fuse	250 V, 4 A T (slow blow) fuse 5 x 20 mm
Max. Power Consumption	250 W
Typ. Power Consumption (examples)	approx. 40 W (DLC pro is switched on, CTL laser emission is off), 45 W (CTL laser emission is on)

Power Supply Module PS HP	
Mains Input to External Power Adaptor	100 .. 240 V~, 50/60 Hz (Wide Range Input)
Fuse	2 x 10 A T (slow blow) fuse, 5 x 20 mm on PS HP pcb
Max. Power Consumption	280 W
Typ. Power Consumption (examples)	approx. 42 W (DLC pro is switched on, CTL laser emission is off), 47 W (CTL laser emission is on) approx. 55 W (DLC pro is switched on, TA-SHG pro laser emission is off), 95 W (TA-SHG pro laser emission is on)

10.2 Upgrade for Control of a 2nd Laser (Service Operation)

NOTE !	To use the DLC pro for control of two lasers (Dual-Laser-Operation), an upgrade is required. When the Dual-Laser-Operation upgrade is acquired, TOPTICA provides a license key via e-mail or USB flash drive and additional hardware, such as modules and cables. The license is unlimited in time but linked to the individual hardware of the DLC pro and cannot be used for other devices. If purchased along with the DLC pro, the licence and the hardware will already be installed.

The Digital Laser Controller DLC pro is capable of controlling two laser systems of the type DL pro, DFB pro, TA pro, BoosTA pro or two modules in the TA pro AL (MTA pro) laser head. If an Upgrade for Control of a 2nd laser is purchased to upgrade an existing DLC pro, plug-in modules must be installed, software must be updated and a software license needs to be activated. Please follow the instructions below to upgrade your DLC pro.

1. Switch off the ON/OFF switch on the DLC pro rear panel and disconnect the DLC pro from the mains supply.

2. Install the required plug-in modules (see Figure 159 as an example). Please follow the instructions noted in section 10.4 accordingly and observe the mounting positions which are noted in section 10.5.

3. Perform a DLC pro system software update (see section 10.18) to ensure that all modules have the same system software version.

NOTE !	**For Dual-Laser-Operation, System Software 5.5.0 or higher and Firmware 1.7.0 or higher are required.**

4. Install TOPAS DLC pro (PC-GUI) as described in section 6.2.

NOTE !	**For Dual-Laser-Operation, TOPAS DLC pro 1.7.0 or higher is required.**

5. Activate the license key for Upgrade for Control of a 2nd laser as described in section 10.19.

10.2.1 Rules for TC, CC, and PC Module Connection for Dual-Laser-Operation

The Digital Laser Controller DLC pro is capable of controlling two laser systems of the type DL pro, DFB pro, TA pro, BoosTA pro or two modules in the TA pro AL (MTA pro) laser head.

When connecting the cables between the laser heads and the TC, CC, and PC modules of the DLC pro, please follow the general rules in the order noted below:

- **1. TC modules connections:**
  The DLC pro identifies laser 1/laser 2 by the order of TC module tec channels to which a diode laser or Master Oscillator (for amplified laser systems) is connected, counting from the left to the right, up to down (view see example in Figure 152).

- **2. CC-500 modules connections:**
  Start with connecting a diode laser or Master Oscillator which consumes > 250 mA to the ch 1 current connector of the CC-500 module inserted in M-Slot 1. In this case (> 250 mA) the ch 2 current connector of this CC-500 module cannot be used, connect the next diode laser or Master Oscillator to the ch 1 current connector of the CC-500 module inserted, e.g. in M-Slot 2. If the first diode laser or Master Oscillator consumes < 250 mA, you can use the ch 2 current connector of the CC-500 module inserted in M-Slot 1 for the second one, if this consumes also < 250 mA. For changing the CC-500 current output from one-channel operation to two-channel operation, please refer to section 9.2.4.1.

- **3. PC modules connections:**
  PC module connections are also counted from the left to the right, up to down (for PC 2 modules). Start with the first piezo voltage connector and connect according to the temperature control connections in step 1.

- **CC 5000/10000 modules connections:**
  Connect the tapered amplifiers of the connected laser heads as required from the left to the right to the CC 5000/10000 modules installed in S-Slots 1 and 2.

10.2.1.1 Connection Example DLC pro with two MTA TA pro Modules in TA pro AL (MTA pro)

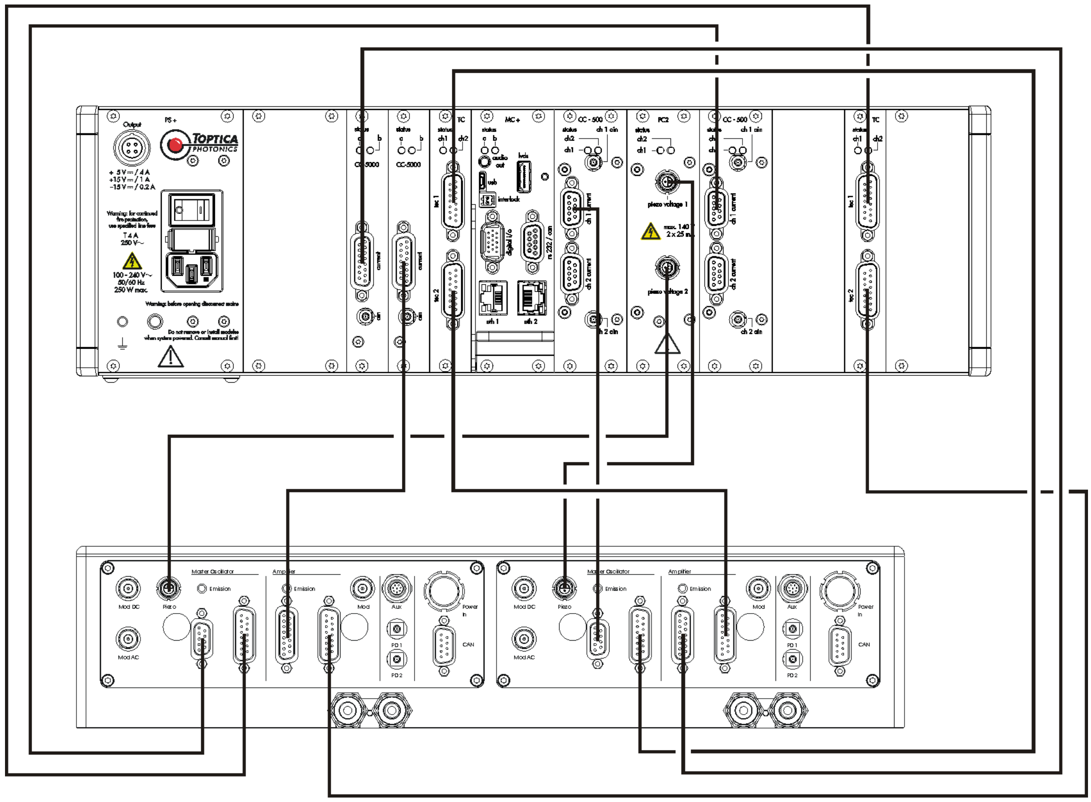
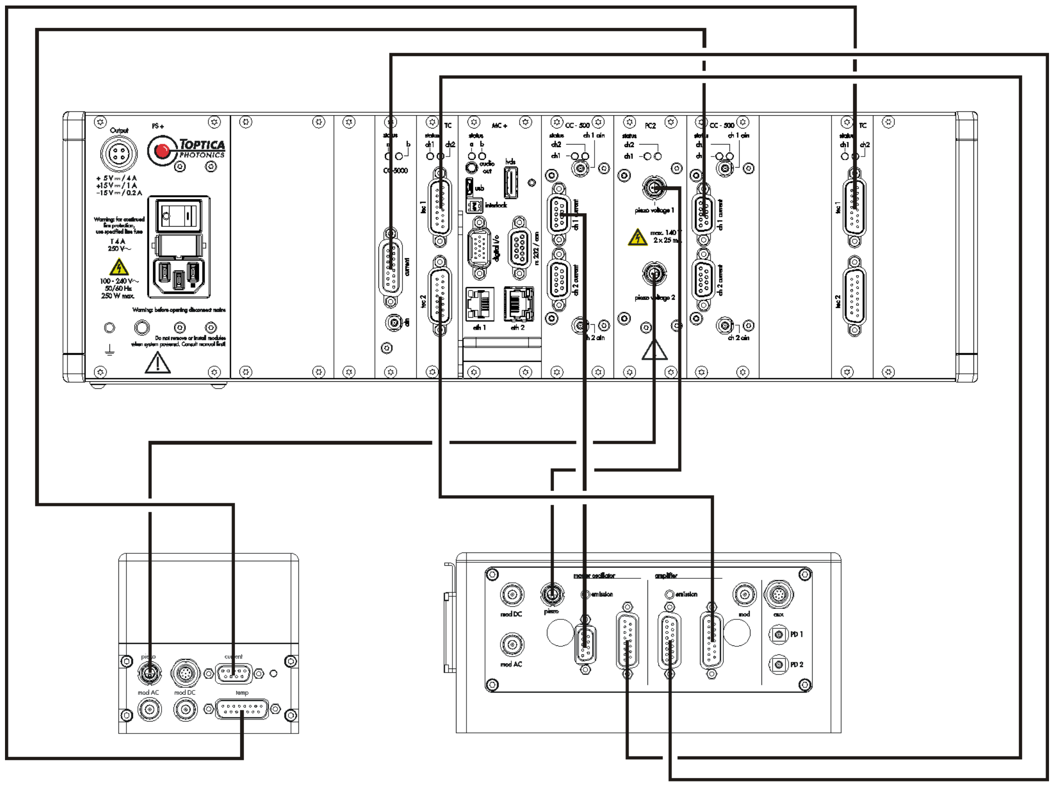


Figure 152 Connection example: DLC pro with two MTA TA pro modules in a TA pro AL (MTA pro), connected as laser 1 and laser 2.
In this example both MTA TA pro Master Oscillator consume > 250 mA, so the ch 2 current connector of both CC-500 module cannot be used.

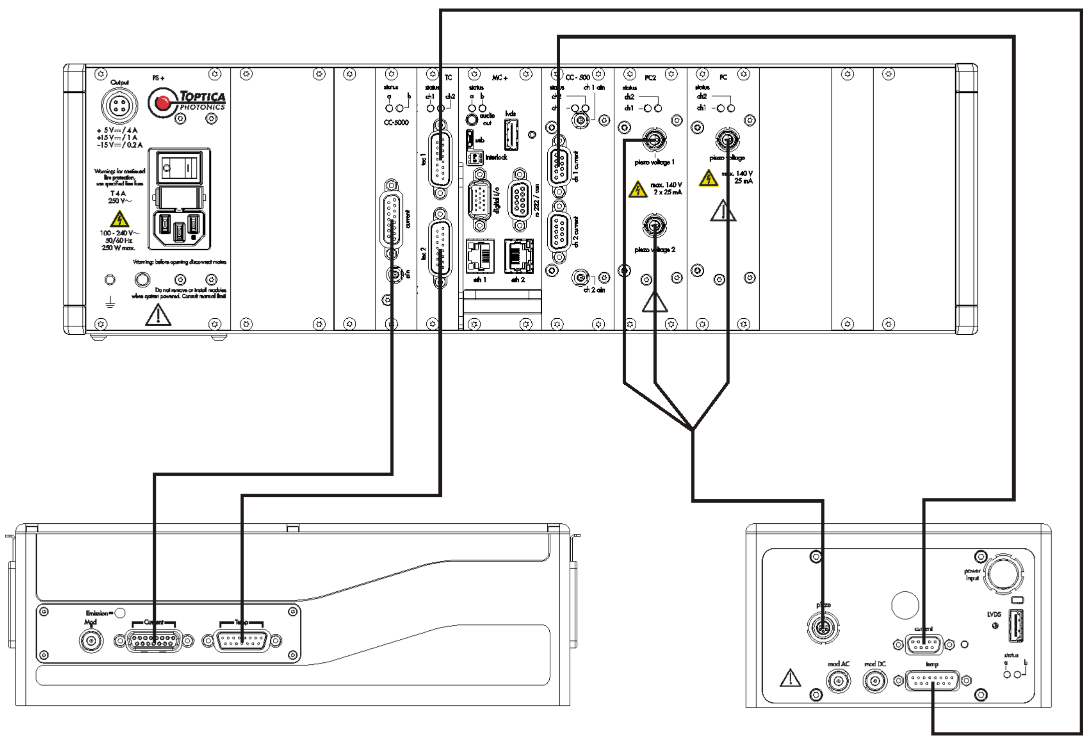
10.2.1.2 Connection Example DLC pro with TA pro and DL pro



Laser 2 **Laser 1**

Figure 153 Connection example: DLC pro with TA pro laser head connected as laser 1 and DL pro laser head connected as laser 2.
In this example both, the TA pro Master Oscillator and the DL pro consume > 250 mA, so the ch 2 current connector of both CC-500 module cannot be used.

10.2.1.3 Connection Example DLC pro with CTL and BoosTA pro



CTL and BoosTA pro connected as a Combined System (Laser 1)

Figure 154 Connection example: DLC pro with a combination of CTL laser head and BoosTA pro laser head connected as laser 1

NOTE !	**In case you want to operate CTL and BoosTA pro as separate lasers**, then connect the BoosTA pro temperature control to the tec 1 connector of the TC module, and the CTL temperature control to the tec 2 connector. The DLC pro then detects separate lasers, and the BoosTA pro is operated as laser 1, the CTL as laser 2.

10.3 Installation of a PDH Module (Service Operation)

NOTE !	When the PDH module is acquired, TOPTICA also provides relevant software to update your DLC pro. If purchased along with the DLC pro, the PDH module and the software is already installed.

If PDH module is purchased to upgrade an existing DLC pro, the PDH module must be installed and software must be updated. Please follow the instructions below to upgrade your DLC pro.

1. Switch off the ON/OFF switch on the DLC pro rear panel and disconnect the DLC pro from the mains supply.

2. Install the PDH module. Please follow the instructions noted in section 10.4 accordingly and observe the mounting position which is noted in section 10.5.

3. Perform a DLC pro system software update (see section 10.18) to ensure that all modules have the same system software version.

NOTE !	**For PDH module operation, System Software 5.6.0 or higher and Firmware 1.8.0 or higher are required.**

4. Install TOPAS DLC pro (PC-GUI) as described in section 6.2.

10.4 Changing Plug-In Modules (Service Operation)

DANGER ! **CAUTION !**	Before removing a plug-in module, the DLC pro must be switched off and disconnected from the mains supply. **Do not remove plug-in modules unless absolutely necessary as the procedure is strenuous to the hardware.**

For changing a plug-in module (except MC+), follow the steps below:

1. Switch off the ON/OFF switch on the DLC pro rear panel and disconnect the DLC pro from the mains supply.

2. Unscrew the two/four fixing screws at the top and the bottom of the respective module.

3. Carefully remove the module, either by pulling at two (if possible diagonal) fixing screws or better by pulling at a properly fixed D-Sub plug.

CAUTION !	**When changing a PS module (all versions)**, disconnect the ground cable from the old module before pulling out the module completely. Reconnect the ground cable to the new module.

4. Insert the new plug-in module and fix it with the two/four screws.

5. Perform a DLC pro system software update (see section 10.18) to ensure that all modules have the same system software version.

10.4.1 Exchange of a MC+ Module

For exchanging a MC+ module, follow the steps below:

1. Switch off the ON/OFF switch on the DLC pro rear panel and disconnect the DLC pro from the mains supply.

2. Unscrew the four fixing screws at the top and the bottom of the MC+ module.

3. Carefully remove the original MC+ module, by pulling at the lever at the panel.

4. Insert the new MC+ module and fix it with the four screws.

5. Perform a DLC pro system software update (see section 10.18) to ensure that all modules have the same system software version.

6. Perform a TOPAS DLC pro software update (see section 10.16).

7. Load the factory settings of the laser system (see section 4.12) so that the actual settings are used after a restart of the DLC pro.

8. In case you had a Lock option please install the original Lock option on the DLC pro again (see section 10.19).

10.4.2 Mounting a Combination of two CC-5000 Modules

NOTE !	Operating the combination of two CC-5000 modules (see section 9.2.5.1) is only possible in a DLC pro which is equipped with a MC+ module. If necessary, the MC+ module is supplied together with the set of two CC-5000 modules. Please refer to section 10.4.1 for installation.

For installation of the combination of two CC-5000 modules, please follow the steps below:

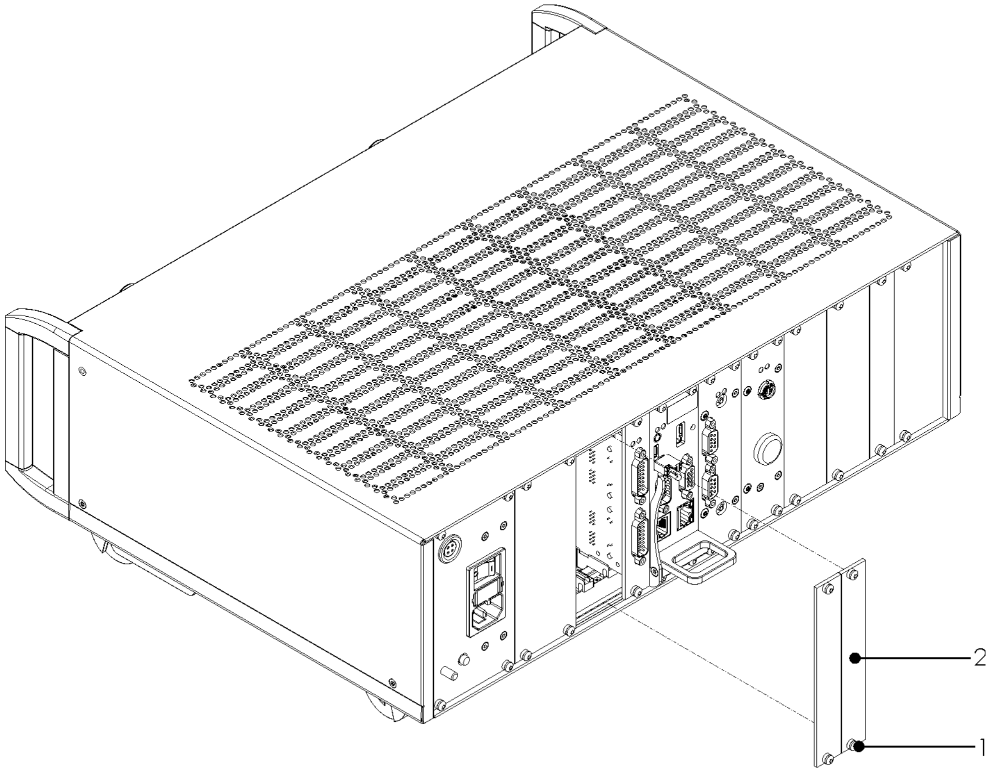


Figure 155 Removing DLC pro cover panels

1. Loosen 4 x screws (1) and remove 2 x cover panels (2).

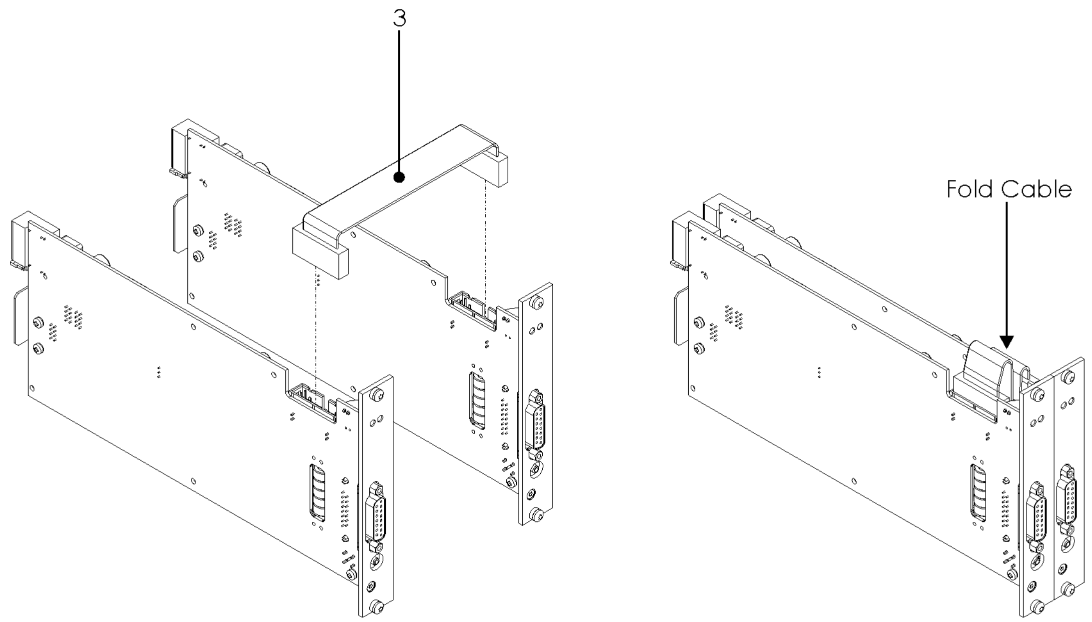


Figure 156 Connecting the two CC-5000 modules

2. Connect the two CC-5000 modules via the supplied cable (3). Fold cable (3) as shown in Figure 156, right.

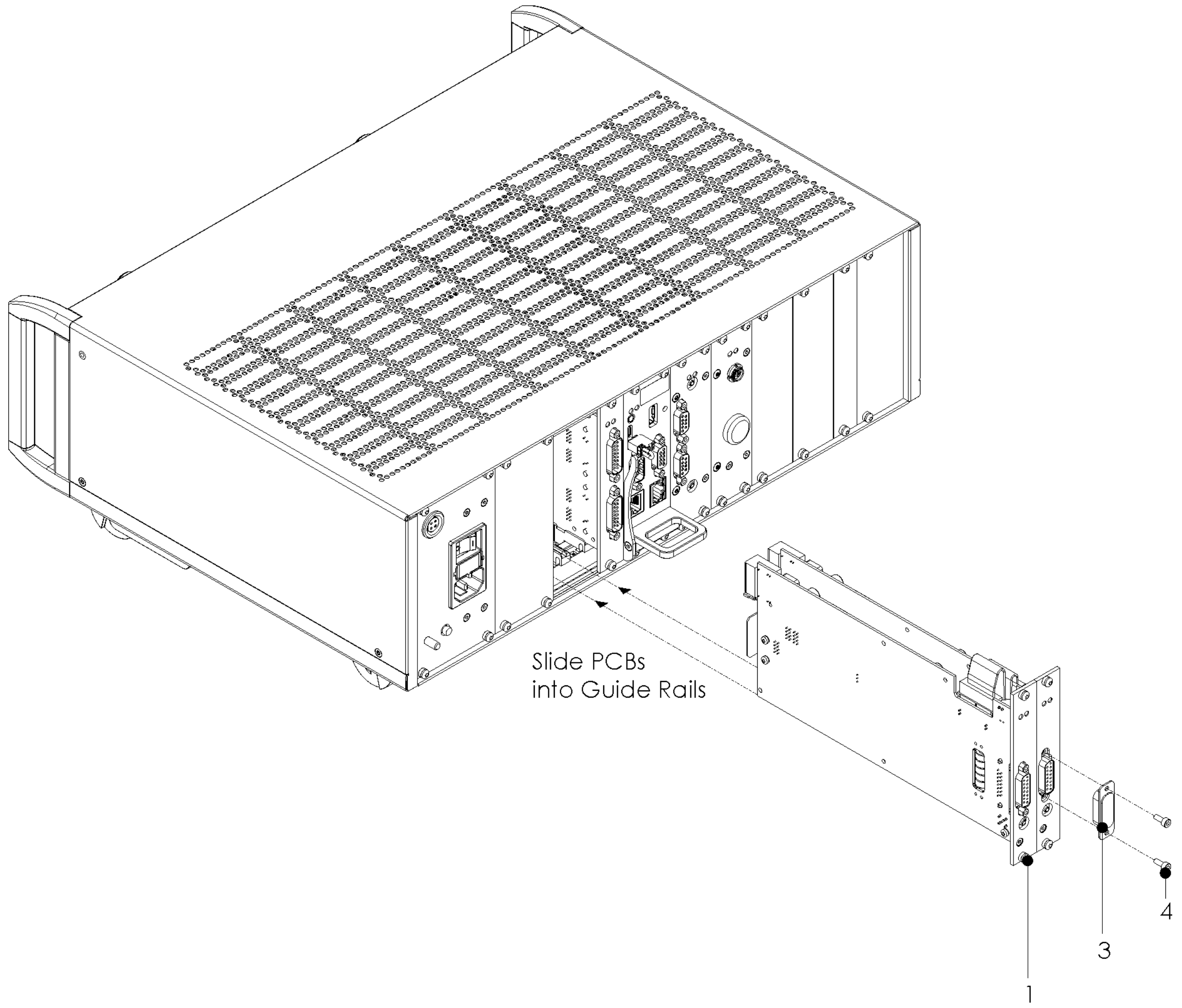


Figure 157 Mounting the CC-5000 modules at the DLC pro and covering the D-Sub-15 connector

3. Place the PCBs of both CC-5000 modules in the guide rails of the DLC pro and slide-in completely. Fix the CC-5000 modules each with 2 x screws (1).

4. Cover the D-Sub-15 connector of the right CC-5000 module with the cover (3) and fix it with 2 x screws (4).

10.5 Arrangement of Plug-In Modules

DANGER !	Before changing a plug-in module, the DLC pro must be switched off and disconnected from the mains supply.

When installing plug-in modules in the DLC pro, observe the following notes:
You can insert different plug-in modules on the rear panel of the DLC pro in certain slots. Please note that the slots and the plug-in modules have different widths (see Figure 158 and Figure 159). Please also refer to Table 2.

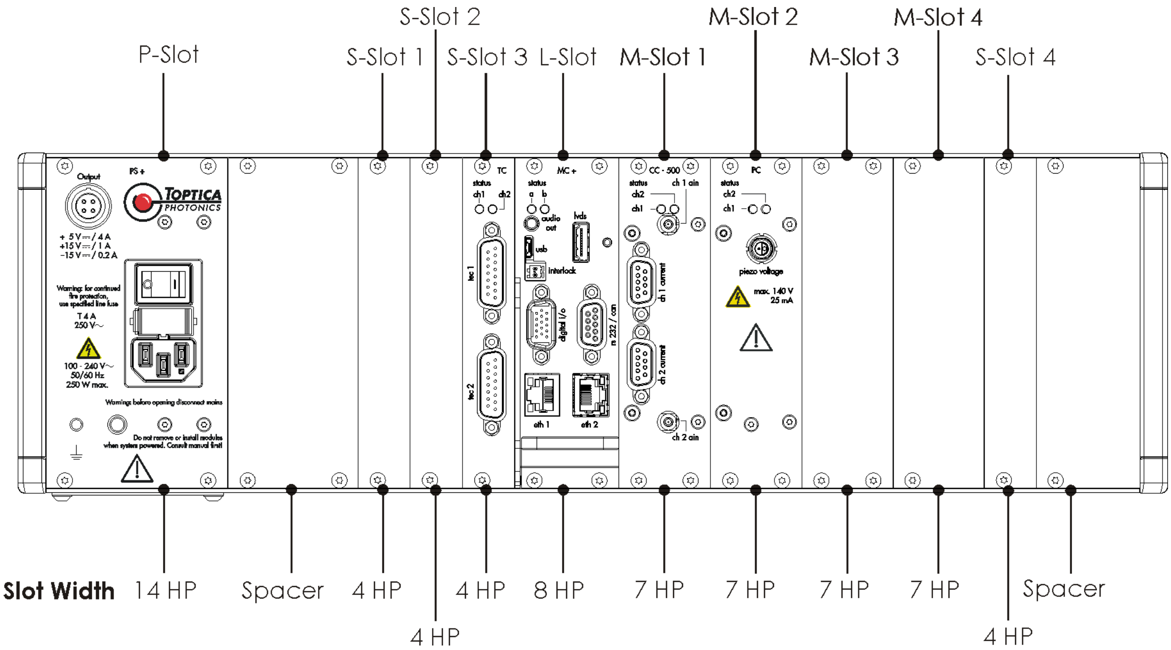


Figure 158 Different slot widths at the rear of the DLC pro Laser Control Electronics (example DLC DL pro)

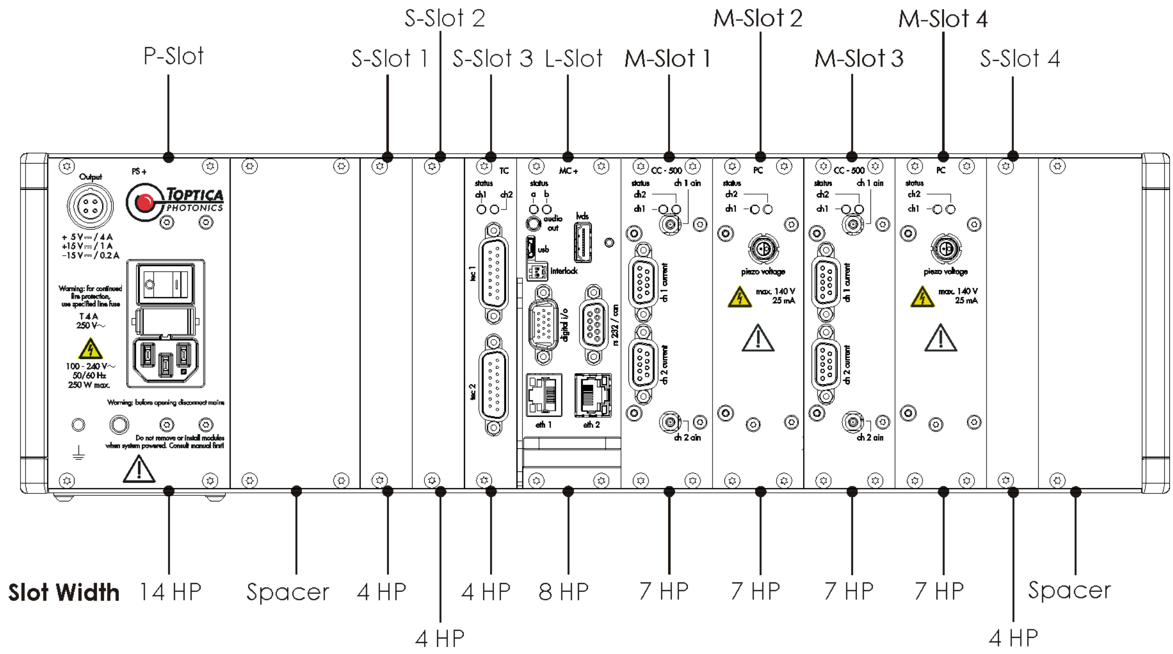


Figure 159 Different slot widths at the rear of the DLC pro Laser Control Electronics (example DLC DL pro upgraded for Dual-Laser-Operation with CC-500 module in M-Slot 3 and PC module in M-Slot 4).

Plug-In Module	**Width** (**H**orizontal **P**itch)	**Mounting Position**
PS+/PS HP Module	14 HP	P-Slot
TC Module	4 HP	S-Slot 3
TC Module for Tapered Amplifier with DLC TA-SHG/FHG pro and FHG crystal with DLC DL-/TA-FHG pro	4 HP	S-Slot 4
TC Module (upgraded for Dual-Laser-Operation)	4 HP	S-Slot 4
TC Module for TOPO crystal and cavity with DLC TOPO	4 HP	S-Slot 2
MC+ Module	8 HP	L-Slot
CC-500 Module	7 HP	M-Slot 1
CC-500 Module (upgraded for Dual-Laser-Operation with diode current > 249 mA per channel)	7 HP	M-Slot 3
CC-5000 Module	4 HP	S-Slot 2
CC-5000 Module (upgraded for Dual-Laser-Operation)	4 HP	S-Slot 1
Combination of two CC-5000 Modules	2 x 4 HP	S-Slot 1 + 2 For mounting instructions, please see section 10.4.2.

Plug-In Module	Width (Horizontal Pitch)	Mounting Position
PC Module PC2 Module (upgraded for Dual-Laser-Operation, if PDH Module is used)	7 HP	M-Slot 2
PC Module (upgraded for Dual-Laser-Operation, if no PDH Module is used)	7 HP	M-Slot 4
PC/PC2 Modules DLC CTL	7 HP	PC2 in M-Slot 2
		PC in M-Slot 3
PC/PC2 Modules DL-/TA-SHG/FHG pro	7 HP	PC2 Master Osc. and SHG Cav. in M-Slot 2
		PC FHG Cav. in M-Slot 3
PDH Module	7 HP	M-Slot 4

Table 2 Arrangement of plug-in modules

CAUTION !	When your DLC pro is equipped with a CC-5000 Module, **do not interchange the CC-5000 and the TC Module** as this will lead to malfunction. Observe the mounting positions in the table above.

10.6 DLC pro for Rack Integration

The DLC pro can be installed in the TOPTICA T-RACK or a third-party 19“ rack. Please refer to section 10.6.1 in this manual for preparation, and the T-RACK manual for installation and operation of the DLC pro in a T-RACK or in a third-party rack. Specifications are only guaranteed when the DLC pro is installed in the TOPTICA T-RACK.

NOTE !	Optical performance specification of TOPTICA Laser Rack Systems is only guaranteed, if the T-RACK exclusively integrates TOPTICA building blocks.

10.6.1 Exchanging the DLC pro Front Handles for Rack Installation (Service Operation)

DANGER !	Before opening the housing, the DLC pro must be switched off and disconnected from the mains supply.

For installation in the Toptica T-RACK or a third-party 19“ rack the DLC pro must be equipped with the appropriate front handles. Please follow the instructions below:

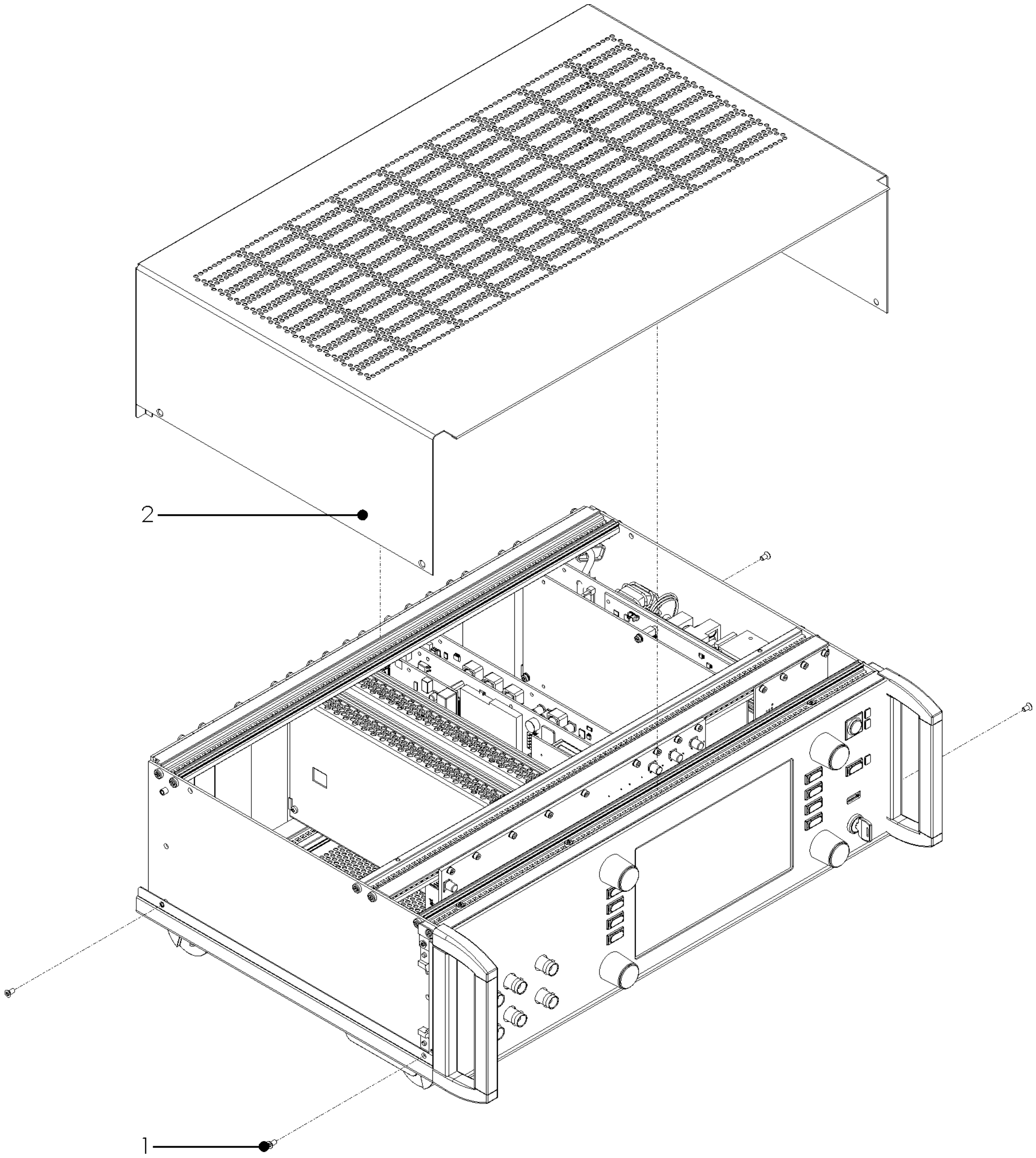


Figure 160 Removing the DLC pro top cover

1. Remove 4 x screws (1) and lift DLC pro top cover (2) upwards. Please note that the top cover (2) is clipped into rails at 6 points (The clips are similar to the ones of the base plate illustrated in Figure 161). These connections must be unclipped when lifting the top cover (2) upwards.

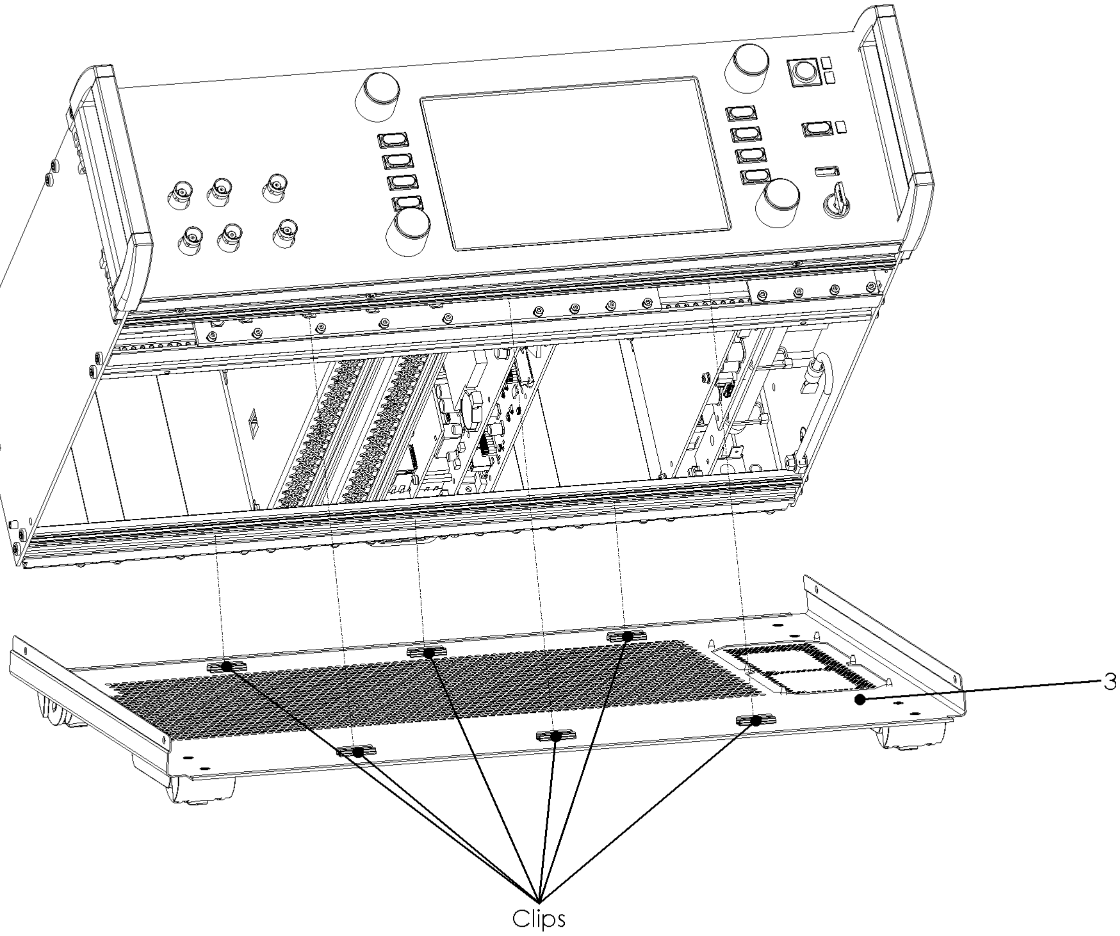


Figure 161 Lifting the DLC pro from the base plate

2. Release the clips between DLC pro and base plate (3) at both sides and lift the DLC pro from the base plate (3) as shown in Figure 161. Please note that the base plate (3) is also clipped into rails at 6 points. These connections must also be unclipped when lifting the DLC pro from the base plate (3).

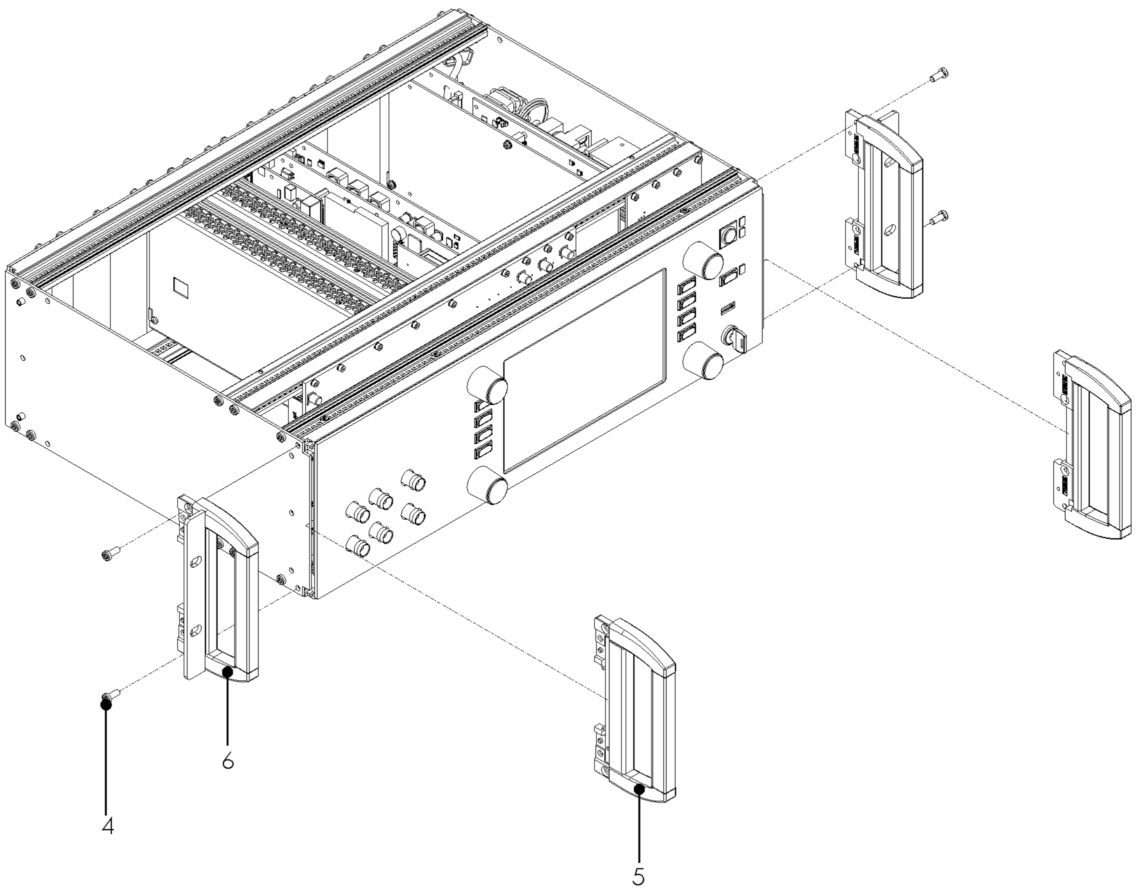


Figure 162 Exchanging the DLC pro front handles

3. Remove 4 x screws (4) and both front handles (5). Mount 2 x T-RACK front handles (6) with 4 x screws (4).

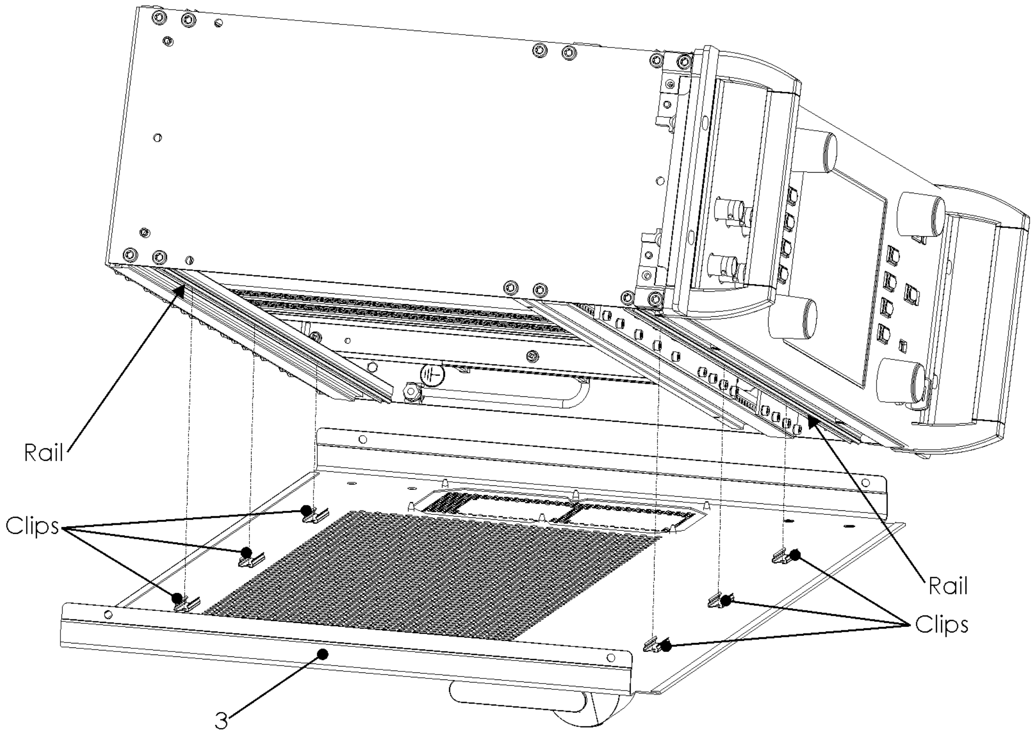


Figure 163 Placing the DLC pro on the base plate

4. Place the DLC pro in correct orientation (see Figure 163) on the base plate (3) so that the six clips of the base plate (3) are aligned with the rails of the DLC pro (see Figure 163). Carefully press together DLC pro and base plate (3). A clicking indicates that a clip is properly engaged.

CAUTION !	The clips can easily be damaged. Check whether the base plate (3) is properly aligned to the DLC pro front- and rear panel after mounting.

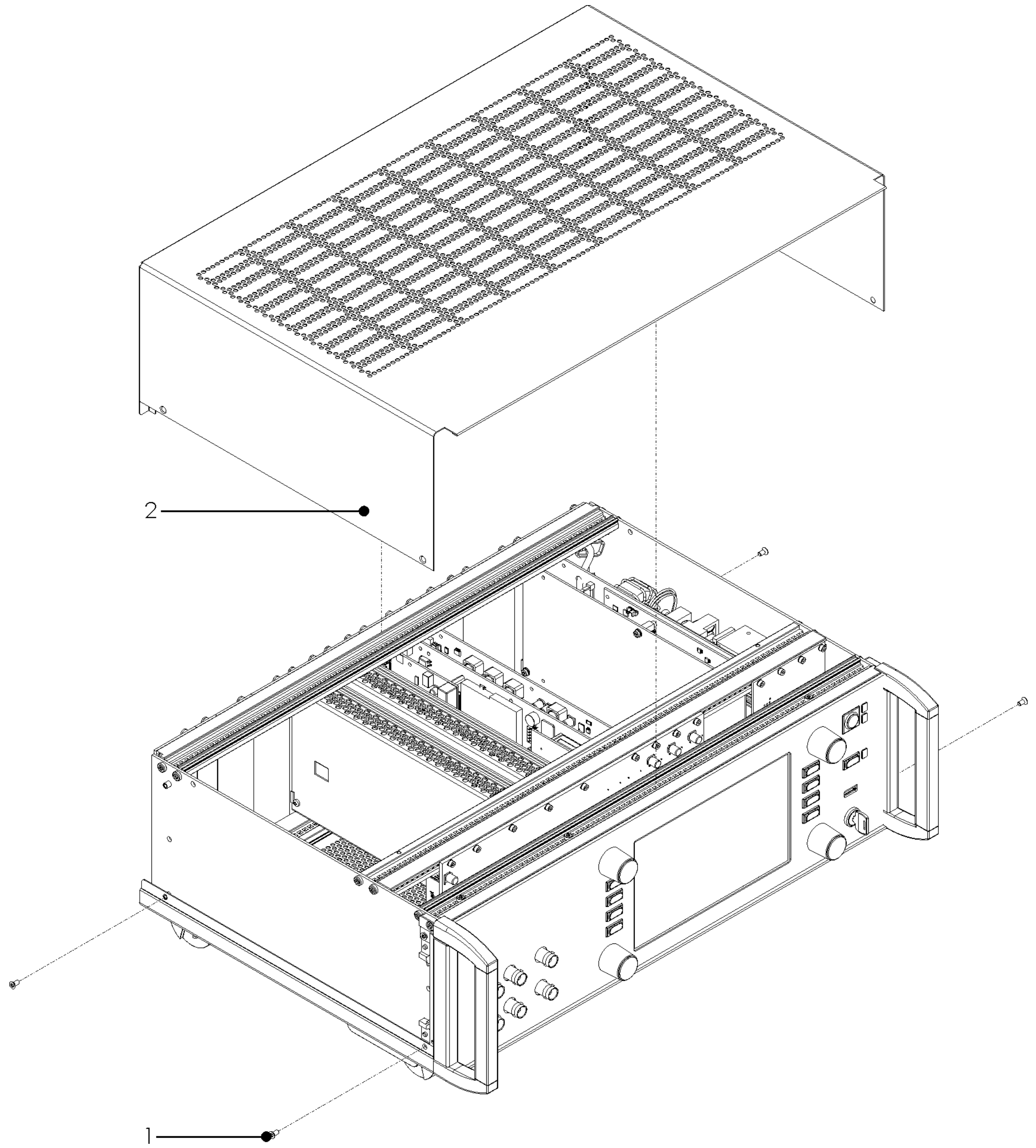


Figure 164 Placing the top cover on the DLC pro

5. Place the top cover (2) on the DLC pro so that the six clips of the top cover (2) are aligned with the rails of the DLC pro (The clips and rails are similar to the ones of the base plate illustrated in Figure 163). Carefully press together top cover (2) and DLC pro. A clicking indicates that a clip is properly engaged.

CAUTION !	The clips can easily be damaged. Check whether the top cover (2) is properly aligned to the DLC pro front- and rear panel after mounting. **Before mounting the top cover, please make sure that there is no material or tools left inside the DLC pro housing.**

Fix top cover with 4 x screws (1).

10.7 Maintenance

10.7.1 Fuse Replacement

DANGER !	Before exchanging the fuse, make sure to switch off and disconnect the device from the mains supply !

The connector block contains a cartridge with a fuse and is located on the rear panel of the DLC pro (see Figure 6).

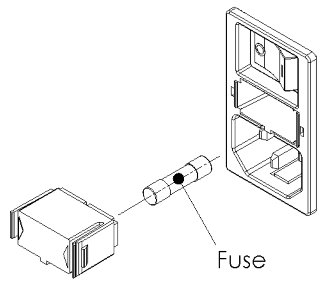


Figure 165 Fuse at the DLC pro connector block

To replace the fuse, open the connector block cover and pull out the fuse cartridge as shown in Figure 165. Use only a 250 V~, 4 A T (slow blow) fuse 5 x 20 mm.

10.7.2 Cleaning

DANGER !	Before cleaning, the DLC pro must be switched off and disconnected from the mains supply.

Clean the outside of the DLC pro Laser Control Electronics, the front panel, and the panels of the plug-in modules with a cloth slightly moistened with a mild detergent solvent. Then dry with a clean cloth. **Do not clean the inside of the DLC pro**.

CAUTION !	If any materials or liquids get into the DLC pro during cleaning, contact TOPTICA. Never use strong solvents such as thinners, benzine, acidic- or alkaline solvents, spray-type cleaners or abrasive cleaners as they may destroy the surface.

10.8 Battery Recycling

NOTE !	**Batteries inside !** The return and disposal of batteries must be complied with and practised in accordance with the current applicable legal requirements and local regulations.

10.9 Pin Assignment of the DLC pro Connectors

10.9.1 CC-500 Module Current Connectors

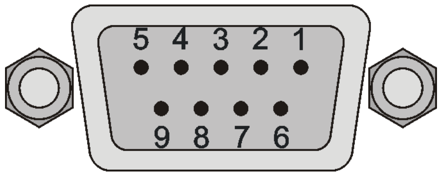


Figure 166 Pin assignment of the current connector (D-Sub-9 female)

Pin 1 Supply voltage + 6.5 V for modulation circuit/short circuit relay
Pin 2 Cathode of internal LD photodiode
Pin 3 Laser diode ground
Pin 4 Anode of internal LD photodiode
Pin 5 Supply voltage - 6.5 V for modulation circuit/short circuit relay
Pin 6 Measurement of laser diode voltage (GND)
Pin 7 Laser diode cathode for anode grounded laser diodes
Pin 8 Laser diode anode for cathode grounded laser diodes
Pin 9 Measurement of laser diode voltage
Shield Earth ground

10.9.2 CC-5000 Module Current Connector

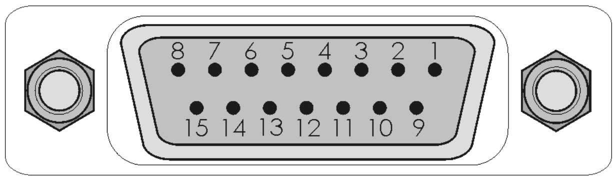


Figure 167 Pin assignment of the current connector (D-Sub-15 female)

Pin 1 Supply voltage + 6.5 V for modulation circuit/short circuit relay
Pin 2 Laser diode ground
Pin 3 Laser diode ground
Pin 4 Laser diode ground
Pin 5 Laser diode cathode for anode grounded laser diodes
Pin 6 Laser diode cathode for anode grounded laser diodes
Pin 7 Measurement of laser diode voltage (GND)
Pin 8 Supply voltage - 6 V for modulation circuit/short circuit relay
Pin 9 Laser diode ground
Pin 10 Laser diode ground
Pin 11 Laser diode ground
Pin 12 Laser diode cathode for anode grounded laser diodes
Pin 13 Laser diode cathode for anode grounded laser diodes
Pin 14 Laser diode cathode for anode grounded laser diodes
Pin 15 Measurement of laser diode voltage
Shield Earth ground

10.9.3 TC Module TEC Connectors

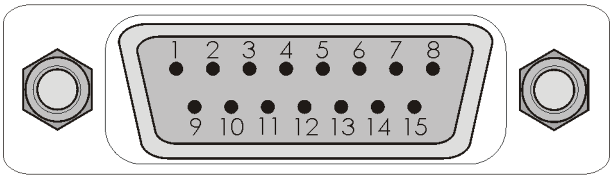


Figure 168 Pin assignment of the temperature control connectors (D-Sub15 male)

Pin 1 Supply for digital electronics + 3.3 V
Pin 2 Serial clock signal I^2C
Pin 3 Thermo-electric element A -
Pin 4 Thermo-electric element B -
Pin 5 Thermo-electric element A +
Pin 6 Thermistor A -
Pin 7 Thermistor B -
Pin 8 Ground for analog electronics
Pin 9 Ground for digital electronics
Pin 10 Serial data signal I^2C
Pin 11 Thermo-electric element A -
Pin 12 Thermo-electric element B +
Pin 13 Thermo-electric element A +
Pin 14 Thermistor A +
Pin 15 Thermistor B +
Shield Earth ground

10.9.4 MC+ Module Digital I/O Connector

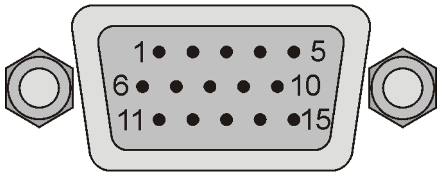


Figure 169 Pin assignment of the Digital I/O connector (D-Sub15 HD male)

NOTE !	A breakout cable (article number K DLC/Digital I/O) is available from TOPTICA for convenient access to all 8 digital lines.

Pin 1 Digital output 3
Pin 2 Digital output 2
Pin 3 Digital output 1
Pin 4 Digital output 0
Pin 5 Ground
Pin 6 Ground
Pin 7 Ground
Pin 8 Ground
Pin 9 not connected
Pin 10 Ground
Pin 11 Ground
Pin 12 Digital input 3
Pin 13 Digital input 2
Pin 14 Digital input 1
Pin 15 Digital input 0
Shield Earth ground

10.9.5 PC Module LEMO Connector

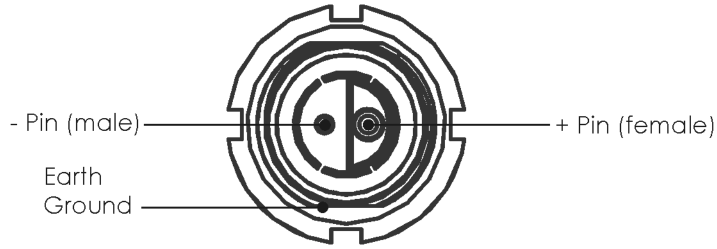


Figure 170 LEMO 0S.302 connector on the PC module

10.9.6 PS+ and PS HP LEMO Connector

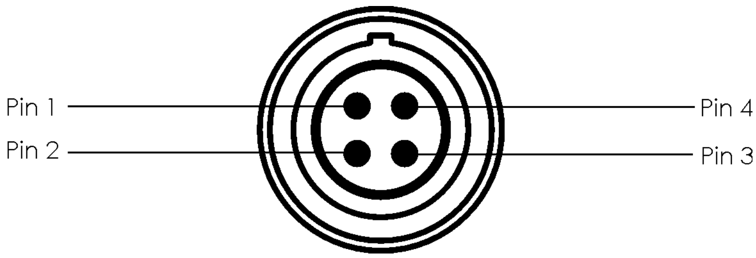


Figure 171 LEMO 2B.304 connector on the PS+ module

Pin 1	5 V/4 A
Pin 2	GND
Pin 3	+15 V/1 A
Pin 4	- 15 V/ 0.2 A

10.10 Analog Remote Control of the Laser Frequency

To support customers who lock or control the laser by proprietary signals or locking schemes, the DLC pro can control the laser frequency via an external voltage connected to a BNC-connector on the DLC pro front panel. Using Analog Remote Control, configurable offsets are applied to the CC, PC or TC output of the DLC pro. With CTL laser heads, an additional voltage can be used to control the motor position for coarse wavelength tuning.

The DLC pro converts the external voltage into an offset for the CC, PC or TC output. In this way the output values set in the DLC pro are modified by these output offsets. Thus, the CC, PC or TC output of the DLC pro can be controlled by the Analog Remote Control.

Prerequisites:

- Experimental setup connected to the DLC pro (for details, see section 7.1).
- External voltage connected to the Fine In or Fast In BNC-connectors on the DLC pro front panel (for details on the connectors, please refer to section 4.3).
- Laser head connected to the DLC pro as described in section 4.5.3.
- For configuration via PC-GUI: TOPAS DLC pro installed as described in section 6.2.

10.10.1 Analog Remote Control Configuration for CC/PC/TC/EOM

Configuration via touchscreen:

1. On the DLC pro front panel, press the **Scan/Lock Mode** button or tap the corresponding symbol to access the Scan/Lock mode or the Wide Scan mode.

2. Press the **Parameter** button or tap the corresponding symbol to access the context parameter Menu.

3 a. Select **Analog Remote Control > CC** in the context parameter menu to configure a CC output offset.

Enable
Enable or disable control via external voltage.
[1: enabled], [0: disabled]

Signal Input
Specify the BNC connector for the external voltage.
["Fine In 1", 0], ["Fine In 2", 1], ["Fast In 3", 2], ["Fast In 4", 4]

Factor
Specify the conversion factor for converting the external voltage [V] into a CC output offset [mA].

Example:

External voltage:	3 V
Factor:	2
CC output offset:	6 mA

Status: 29.3.22

3 b. Select **Analog Remote Control > PC** in the context parameter menu to configure a PC output offset.

Enable
Enable or disable control via external voltage.
[1: enabled], [0: disabled]

Signal Input
Specify the BNC connector for the external voltage.
["Fine In 1", 0], ["Fine In 2", 1], ["Fast In 3", 2], ["Fast In 4", 4]

Factor
Specify the conversion factor for converting the external voltage [V] into a
PC output offset [V].

Example:

External voltage:	2 V
Factor:	-3.5
PC output offset:	-7 V

3 c. Select **Analog Remote Control > TC** in the context parameter menu to configure a TC output offset.

Enable
Enable or disable control via external voltage.
[1: enabled], [0: disabled]

Signal Input
Specify the BNC connector for the external voltage.
["Fine In 1", 0], ["Fine In 2", 1], ["Fast In 3", 2], ["Fast In 4", 4]

Factor
Specify the conversion factor for converting the external voltage [V] into a
TC output offset [K].

Example:

External voltage:	2 V
Factor:	-4
TC output offset:	-8 K

3 d. Select **Analog Remote Control > EOM** in the context parameter menu to configure a PC output offset for the intra-cavity EOM.

Enable
Enable or disable control via external voltage.
[1: enabled], [0: disabled]

Signal Input
Specify the BNC connector for the external voltage.
["Fine In 1", 0], ["Fine In 2", 1], ["Fast In 3", 2], ["Fast In 4", 4]

Factor
Specify the conversion factor for converting the external voltage [V] into a
PC output offset [V] applied to the slow electrode of the intra-cavity EOM.

Example:

External voltage:	2 V
Factor:	-3.5
PC output offset for intra-cavity EOM):	-7 V

Configuration via TOPAS DLC pro PC-GUI:

1. Select the Laser tab in the TOPAS PC-GUI.

2 a. To configure a CC output offset, click on the triangle in the CC section.

Enable
Enable or disable control via external voltage.
[1: enabled], [0: disabled]

ARC Signal Input
Specify the BNC connector for the external voltage.
["Fine In 1", 0], ["Fine In 2", 1], ["Fast In 3", 2], ["Fast In 4", 4]

ARC Factor
Specify the conversion factor for converting the external voltage [V] into a CC output offset [mA].

Example:

External voltage:	3 V
ARC Factor:	2
CC output offset:	6 mA

2 b. To configure a PC output offset, click on the triangle in the PC section.

Enable
Enable or disable control via external voltage.
[1: enabled], [0: disabled]

ARC Signal Input
Specify the BNC connector for the external voltage.
["Fine In 1", 0], ["Fine In 2", 1], ["Fast In 3", 2], ["Fast In 4", 4]

ARC Factor
Specify the conversion factor for converting the external voltage [V] into a PC output offset [V].

Example:

External voltage:	2 V
ARC Factor:	-3.5
PC output offset:	-7 V

2 c. To configure a TC output offset, click on the triangle in the TC section.

Enable
Enable or disable control via external voltage.
[1: enabled], [0: disabled]

ARC Signal Input
Specify the BNC connector for the external voltage.
["Fine In 1", 0], ["Fine In 2", 1], ["Fast In 3", 2], ["Fast In 4", 4]

ARC Factor
Specify the conversion factor for converting the external
voltage [V] into a TC output offset [K].

Example:

External voltage:	2 V
ARC Factor:	-4
TC output offset:	-8 K

2 d. To configure a PC output offset for the intra-cavity EOM, click on the triangle in the EOM section.

Enable
Enable or disable control via external voltage.
[1: enabled], [0: disabled]

ARC Signal Input
Specify the BNC connector for the external voltage.
["Fine In 1", 0], ["Fine In 2", 1], ["Fast In 3", 2], ["Fast In 4", 4]

ARC Factor
Specify the conversion factor for converting the external
voltage [V] into a PC output offset [V] applied to the slow electrode of the intra-cavity EOM.

Example:

External voltage:	2 V
ARC Factor:	-3.5
PC output offset for intra-cavity EOM):	-7 V

10.10.2 Analog Remote Control Configuration for Motor Scan (only DLC CTL)

Configuration via touchscreen:

1. On the DLC pro front panel, press the **Scan/Lock Mode** button several times or select the symbol to access the Wide Scan mode.

2. Press the **Parameter** button or tap the corresponding symbol to access the context parameter Menu.

3. Select **Analog Remote Control > Motor** in the context parameter menu to configure the analog motor remote control.

Enable
Enable analog motor remote control.
[1: enabled], [0: disabled].

Signal Input
Select signal input for analog motor remote control.
["Fine In 1", 0], ["Fine In 2", 1], ["Fast In 3", 2], ["Fast In 4", 4]

Factor
Enter input sensitivity factor for analog motor remote control in [nm/V].

Example:
Please configure the Motor ARC first, then enable the Analog Remote Control.

Set Wavelength:	960 nm
External voltage:	- 2 V
Factor:	2.5 nm/V
New Wavelength:	955 nm

If the external voltage jumps to - 1 V, the laser scans to 957.5 nm at the maximum speed.

Configuration via TOPAS DLC pro PC-GUI:

To configure the Motor Analog Remote Control, click on the triangle in the Motor Control section.

Analog Remote Control Enable
Enable analog motor remote control.
[1: enabled], [0: disabled].

ARC Signal Input
Select signal input for analog motor remote control.
["Fine In 1", 0], ["Fine In 2", 1], ["Fast In 3", 2], ["Fast In 4", 4]

ARC Factor
Enter input sensitivity factor for analog motor remote control in [nm/V].

Example:
Please configure the Motor ARC first, then enable the Analog Remote Control.

Set Wavelength:	960 nm
External voltage:	- 2 V
ARC Factor:	2.5 nm/V
New Wavelength:	955 nm

If the external voltage jumps to - 1 V, the laser scans to 957.5 nm at the maximum speed.

10.11 Air Pressure Compensation

In extended-cavity diode lasers (ECDLs), part of the cavity contains air. With changing air pressure, the index of refraction of air changes, and with that, the optical length of the air-filled part of the cavity changes. This causes a drift of the laser frequency.

Also, in the resonator, the residual reflectivity of the laser diode facet forms an etalon inside the laser cavity. In some ECDLs, the optical length of this etalon needs to be synchronized with the overall length of the cavity to ensure proper single-mode operation without mode-hops.

With release 1.6.0, TOPTICA introduces a pressure compensation feature that measures the ambient pressure and compensates pressure changes by adjusting the piezo voltage, thereby adjusting the mechanical cavity length in order to keep the optical cavity length constant. The correction is applied to the piezo voltage only and no feed forward is given to the laser diode current. This leaves the internal resonator (the laser diode itself) unaltered while the length change of the external resonator due to the air pressure change is compensated for. This procedure compensates the described effect to first order which is sufficient to eliminate mode-hops and to considerably reduce drift under nearly all practical circumstances.

- In the TOPAS DLC pro PC-GUI interface, the controls for the pressure compensation are located in the PC section of the Laser tab (please refer to section 6.14). The user can set the compensation **Factor** and **Enable/Disable** the compensation. The **Compensation Voltage**, that is currently added to the piezo voltage, and the actual **Air Pressure** are displayed for reference.

- In the touchscreen user interface, the pressure compensation controls can be found on the Parameter Menu screen (please refer to section 5.12).

- For remote control, the pressure compensation parameters are accessible via: laser1:dl:pressure-compensation:xxx.

The compensation **Factor** depends on the extended-cavity resonator type:

Laser Head	DL pro or Laser System with DL pro Master Oscillator						CTL
Resonator Type	A	B	C	D	E	F	n.a.
Compensation **Factor**	-0.165	-0.228	-0.102	-0.083	-0.038	-0.355	-0.368

From 2017 on, the resonator type of DL pro and TA pro laser heads is documented in section 05 and section 1.3, respectively, of the Production and Quality Control Data Sheet which is shipped along with the laser head. For older models and for DL-/TA-SHG/FHG pro laser systems, please contact TOPTICA Service for support to set the compensation **Factor**.

10.12 Screenshot Function for Touchscreen

The screenshot function allows to store screenshots of the actual touchscreen display on a USB flash drive. To take a screenshot, please perform the steps as described below:

1. Insert a USB flash drive in the USB connector on the DLC pro front panel.

2. Press the **Load/Save** button on the DLC pro front panel for 5 - 8 seconds. A beep indicates that a screenshot has been taken.

3. The screenshot is stored on the USB flash drive as a file named dlcpro-<*date*>-<*time*>.png.

10.13 Parameter List/Software Command List

The complete parameter tree of the DLC pro is described in detail in the Remote Command Reference for TCP/IP and USB. This document is available as a pdf file in the Documentations folder on the software USB flash drive supplied with the DLC pro.

10.14 Internal Handling and Storage of Operation Parameters

The operating parameters of the laser head are stored to be available after the DLC pro is switched on. In the following, the data handling is described.

- After the boot procedure of the DLC pro, the operating parameters for the connected laser head are set to the same values as at the time of the last save.

- To save operating parameters and make them available for the next restart, either press the **Load/ Save** button on the DLC pro front panel twice, click **Menu > Save Configuration** or use the **save** command in the Params tab in the PC-GUI.

- To return to the saved operating parameters, use the **load** command in the Params tab in the PC-GUI.

- In addition to the set of operating parameters managed in the way described above, another set of operating parameters is available, called factory settings. They serve as a safe backup. To return to these values, use the **restore** command followed by the **apply** command in the Params tab in the PC-GUI. Use the **save** command (or similar, see above) to ensure the DLC pro is set to these values after the next boot procedure.

- In rare cases, e.g., exchange of the laser diode, the factory settings need to be changed. To do so, use the **retrieve-now** command followed by the **store** command in the Params tab in the PC-GUI.
  Please note that the store command overwrites the factory settings parameters set by TOPTICA as documented in the Production and Quality Control Data Sheet. A warning message must be acknowledged.
  Use the **save** command (or similar, see above) to ensure the DLC pro is set to these values after the next boot procedure.

An overview of the data flow controlled by the discussed commands is shown in Figure 172. In case of an amplified laser system, the parameters of the Master Oscillator (dl) and the Amplifier (amp) are treated separately.

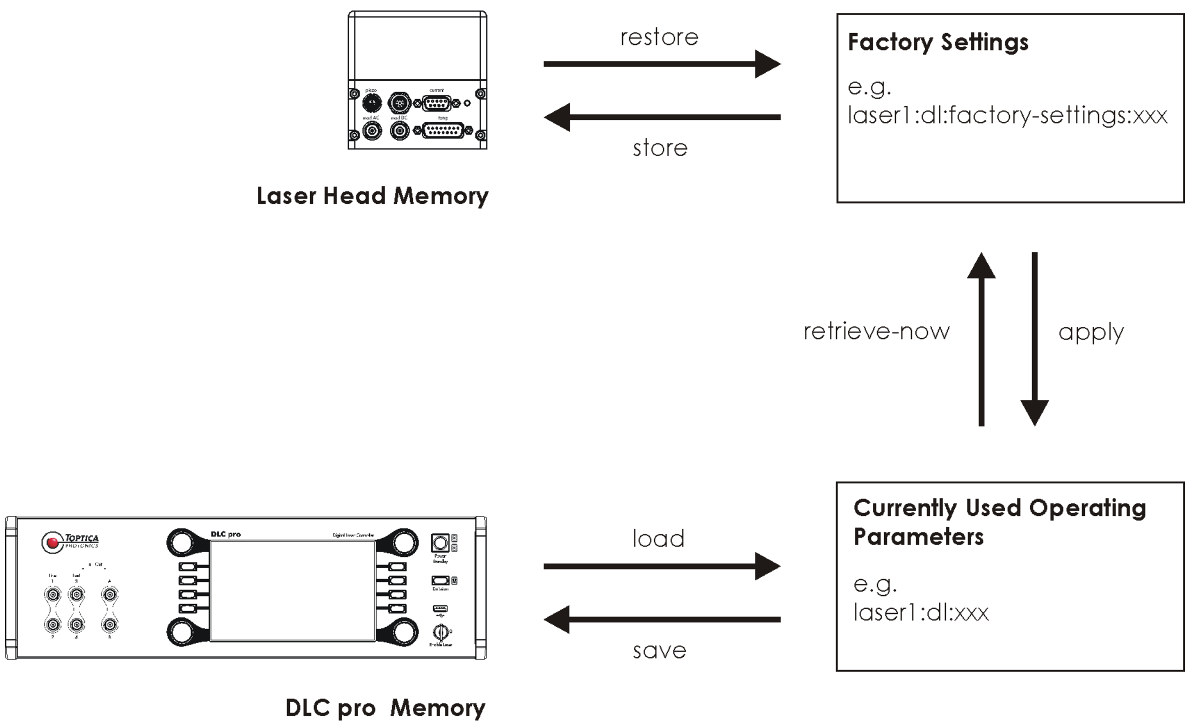


Figure 172 Internal handling and storage of operating parameters

Summary of the commands to handle the operating parameters in the Params tab of the PC-GUI:

NOTE ! [**save**], [**load**] and [**apply**] are accessible in the user level USER, for all other commands discussed here the user level MAINTENANCE is required (for changing the user level, please refer to section 6.11).

laser1:**save**	Saves the currently used operating parameters. The DLC pro laser system will reboot with these settings. Pressing the **Load/Save** button on the DLC pro front panel twice is has the same result.
laser1:**load**	The previously saved [laser1:**save**] operating parameters are resumed.
laser1:xxxx:**store**	Stores the factory settings parameters to the laser head, **use only e.g., after an exchange of the laser diode**. **Please note that this overwrites the factory settings parameters set by TOPTICA** as documented in the Production and Quality Control Data Sheet. A warning message must be acknowledged.
laser1:xxxx:**restore**	Restores the factory settings parameters to the values stored in the laser head [laser1:xxxx:**store**].
laser1:xxxx:factory-settings:**apply**	Loads and applies the factory settings parameters as currently used operating parameters.
laser1:xxxx:factory-settings:**retrieve-now**	Writes the currently used operating parameters into the factory settings.

10.15 System Messages

In case a malfunction occurs, the related system message and its code are displayed in the footer of the TOPAS DLC pro PC-GUI screen, and the red error indicator in the header lights up. The system message is also displayed in the window which appears after clicking on the error indicator in the header (see section 6.10).

On the touchscreen, the system message is displayed in the bottom right area. Tapping the bell symbol opens the system messages window where all current system messages are displayed. The system messages window is also accessible from the Home screen.

In case a safety-related issue leads to a condition where the laser cannot be switched on or has been switched off automatically, the Laser Radiation Emission Warning LED on the DLC pro front panel lights up red.

10.16 TOPAS DLC pro Software Update

Before installing a new release of the TOPAS DLC pro software, please uninstall the current version on your computer. Please follow the procedure described in section 6.2 to install the new software release.

10.17 DLC pro Firmware Update

NOTE !	When a DLC pro firmware update is performed, all connected devices (e.g. laser heads, FALC pro module) are also updated.

NOTE !	The software controlling the DLC pro hardware is divided into two main components: **System software** and **firmware**. They can be updated independently (for a system software update, please refer to section 10.18) and have different release cycles.

The firmware provides all the DLC pro specific functionality and is the part of the software that you as a user communicate with. The firmware itself consists of several individual components. It includes the code for all the programmable DLC pro hardware (FPGAs - "field programmable gate arrays"), the graphical user interface for the DLC pro touchscreen, and the device-control software as the main control center.

The file (*.fw) for updating the DLC pro firmware is provided for download on the TOPTICA website.

www.toptica.com > Company > Downloads > Software > DLC pro Software Update

Please note that **certain laser heads require additional firmware files** to be updated together with the file (*.fw) for updating the DLC pro.

Laser Head	**Additional Firmware Update File**
DL-/TA-SHG/FHG pro	nlo-system-update.fw
TOPO	nlo-system-update.fw

The additional files (*.fw) for updating the laser heads are also provided for download on the TOPTICA website.

www.toptica.com > Company > Downloads > Software > DLC pro Software Update

TOPTICA announces new versions by an email newsletter. You may subscribe by sending an email to dlcpro@toptica.com with subject “subscribe”.

NOTE !	With the shipment of the DLC pro, TOPTICA provides a USB flash drive containing the current system software and firmware versions, the DLC pro USB driver, and the TOPAS DLC pro PC-GUI.

NOTE !	In some cases, an update of the system software is required prior to a firmware update. If this is the case, the firmware update is aborted and the DLC pro will start with the previously installed firmware. Please refer to section 10.18 for instructions on the system software update.

10.17.1 Firmware Update via USB Flash Drive

Prerequisites:

- DLC pro switched off at the ON/OFF switch on the rear panel.

NOTE !	The firmware update starts automatically after a system software update (please refer to section 10.18).

NOTE !	Firmware updates can also be performed via the TOPAS DLC pro PC-GUI (please refer to section 10.17.2).

1. Create a directory **\toptica** on a FAT formatted USB flash drive. Copy the required firmware update file(s) (see section 10.17) to the **\toptica** directory on the USB flash drive.

2. Plug the USB flash drive into the USB connector on the DLC pro front panel (please refer to section 4.1).

3. Switch on the DLC pro at the ON/OFF switch on the rear panel. The **Firmware Installer** automatically starts the firmware update.

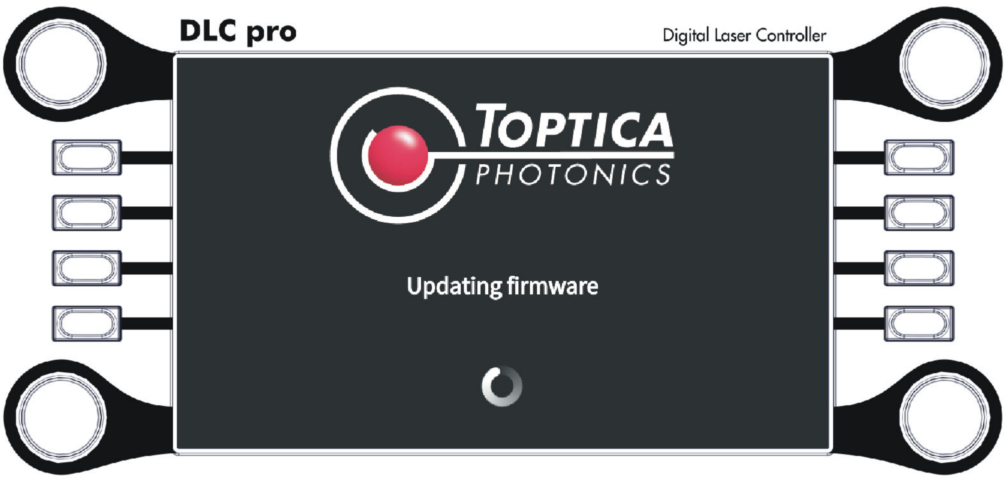


Figure 173 Touchscreen display during firmware installation

4. When the firmware update is complete, the following screen will appear:

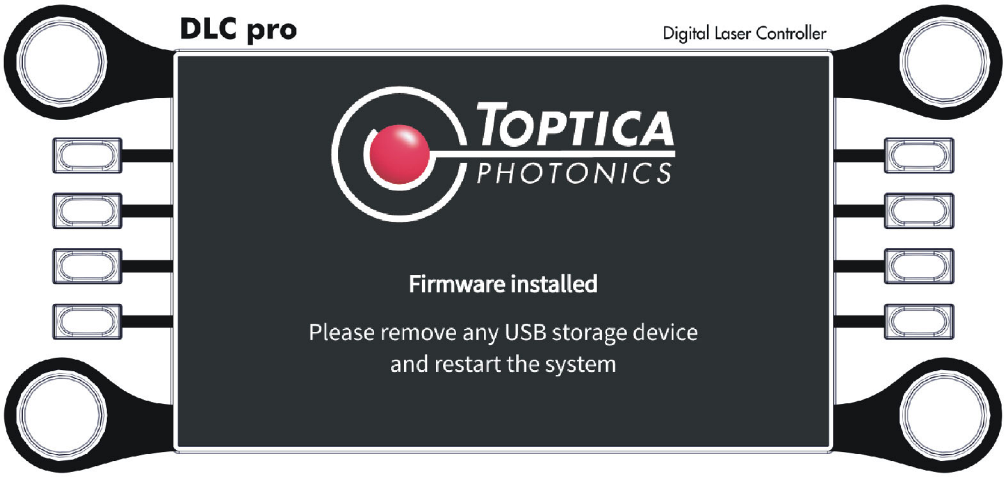


Figure 174 Touchscreen display when firmware installation is completed

4. Switch off the DLC pro and remove the USB flash drive. Then switch on the DLC pro again. After switching off, please wait for at least 10 seconds before switching the DLC pro on again.
The DLC pro starts and operates with the new firmware installed.

10.17.2 Firmware Update via TOPAS DLC pro PC-GUI

CAUTION ! While a firmware update is performed, please switch off the emission of all connected lasers.

Prerequisites:

- DLC pro connected to a computer with TOPAS DLC pro PC-GUI (please refer to section 6.11) via TCP/IP.
- Required firmware update file(s) (see section 10.17) downloaded and stored on the PC.

1. In the TOPAS DLC pro PC-GUI, select **Menu > Device Configuration > Firmware Update**.
The **Firmware Information** window displays details of the currently-installed firmware.

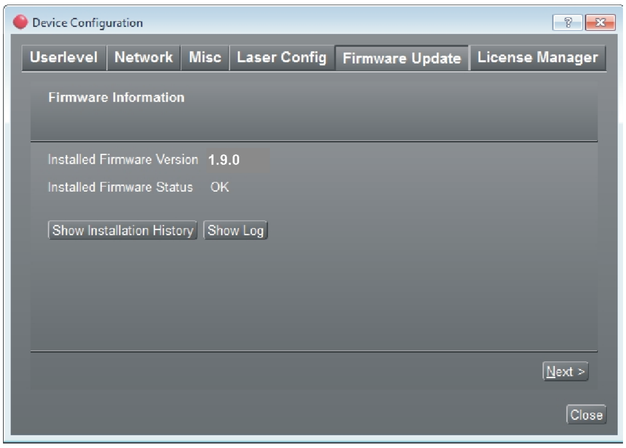


Figure 175 Device Configuration Window, section Firmware Update

2. Click **Next >** to open the **Upload Firmware Archives** window.

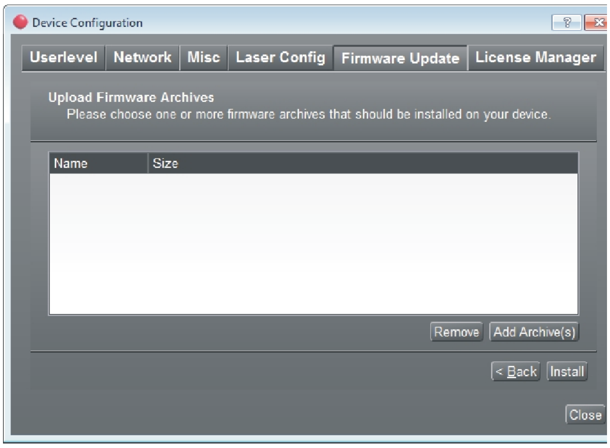


Figure 176 Upload Firmware Archives Window

3. Click **Add Archive(s)** and browse to the location of the downloaded firmware file(s).
Select the required firmware file(s).

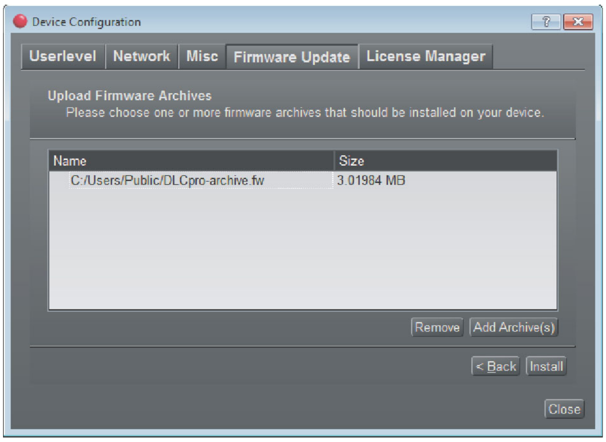


Figure 177 Firmware file selected

4. Click **Install**.

5. When the **Restart System** window prompts, click **OK** and switch off the DLC pro at the ON/OFF switch on the rear panel.

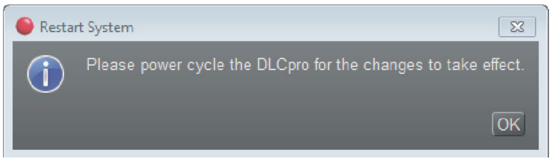


Figure 178 Restart System window

6. Switch on the DLC pro at the ON/OFF switch on the rear panel. The **Firmware Installer** automatically starts the firmware update.

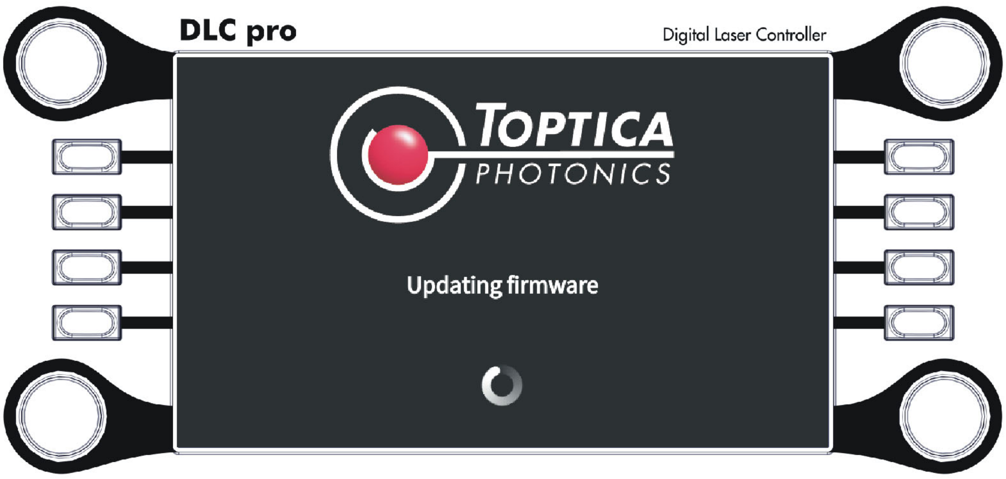


Figure 179 Touchscreen display during firmware installation

When the firmware update is complete, the following screen appears on the touchscreen:

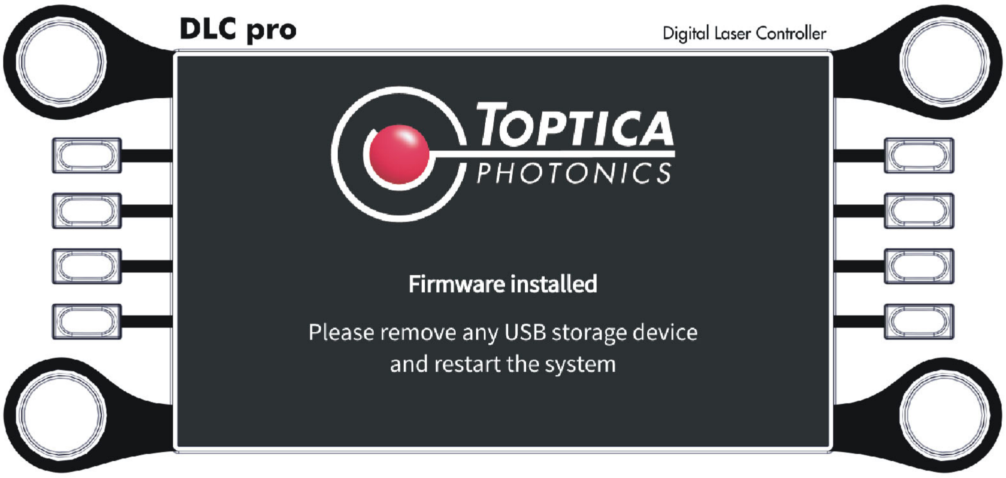


Figure 180 Touchscreen display when firmware installation is completed

7. Switch off the DLC pro. Wait for at least 10 seconds and switch on the DLC pro again. The DLC pro starts and operates with the new firmware installed.

10.18 DLC pro System Software Update

NOTE !	The software controlling the DLC pro hardware is divided into two main components: **System software** and **firmware**. They can be updated independently (for a firmware update, please refer to section 10.17) and have different release cycles.

The system software provides very fundamental functionality. It comprises the operating system as well as services and software libraries necessary for basic features like hardware access, graphics display, networking, USB support, firmware updates, and others.

The file for updating the DLC pro system software is provided for download on the TOPTICA website:

www.toptica.com > Company > Downloads > Software > DLC pro Software Update

File name: **dlcpro-system-software.img**
Do not rename the system software file.

NOTE !	With the shipment of the DLC pro, TOPTICA provides a USB flash drive that contains the current system software and firmware versions, the DLC pro USB driver, and the TOPAS DLC pro PC-GUI. **Do not rename the system software file.**

NOTE !	A firmware update (please refer to section 10.17) is required after each system software update. The firmware update starts automatically after the system software update.

Prerequisites:

- DLC pro switched off at the ON/OFF switch on the rear panel.

1. Create a directory **\toptica** on a FAT formatted USB flash drive. Copy the system software update file **and** the corresponding firmware update file (*.fw) to the **\toptica** directory on the USB flash drive.

2. Plug the USB flash drive into the USB connector on the DLC pro front panel (please refer to section 4.1).

3. Switch on the DLC pro and press the **Parameter** button on the DLC pro front panel until the **Preparing system software update** message is displayed on the touchscreen. The system software update starts automatically, and the following screen is displayed:

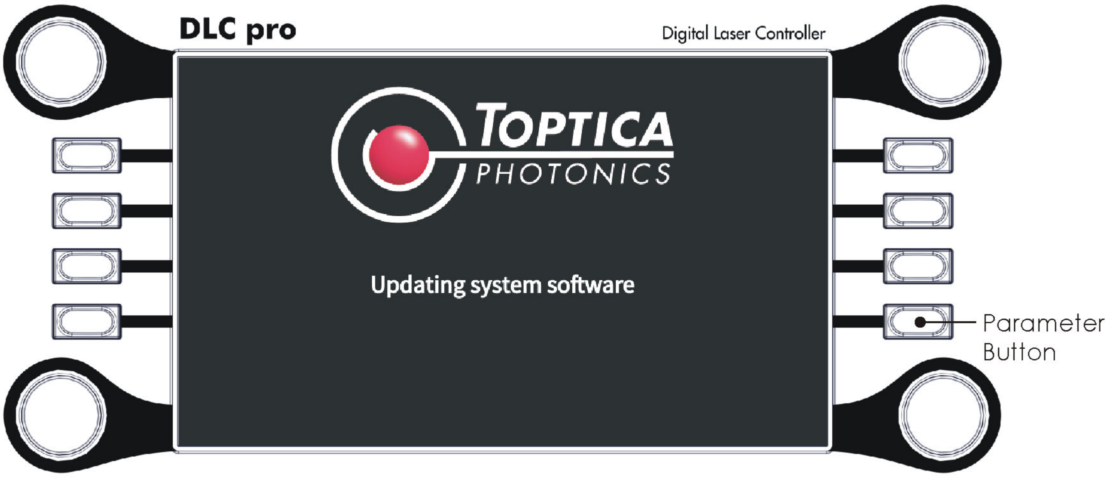


Figure 181 Touchscreen display during system software update

4. When the system software update is complete, the **Firmware Installer** automatically starts the firmware update (please refer to section 10.17).

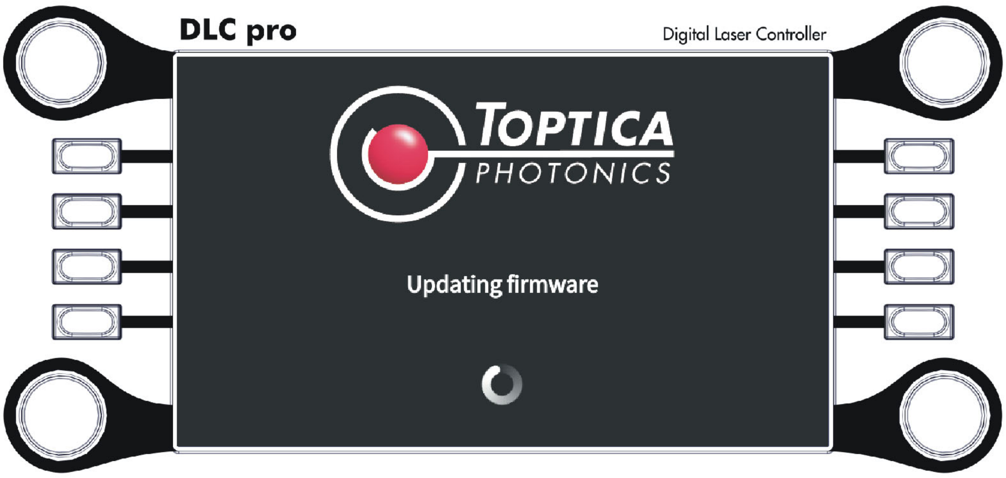


Figure 182 Touchscreen display during firmware installation

5. When the firmware update is complete, the following screen will appear:

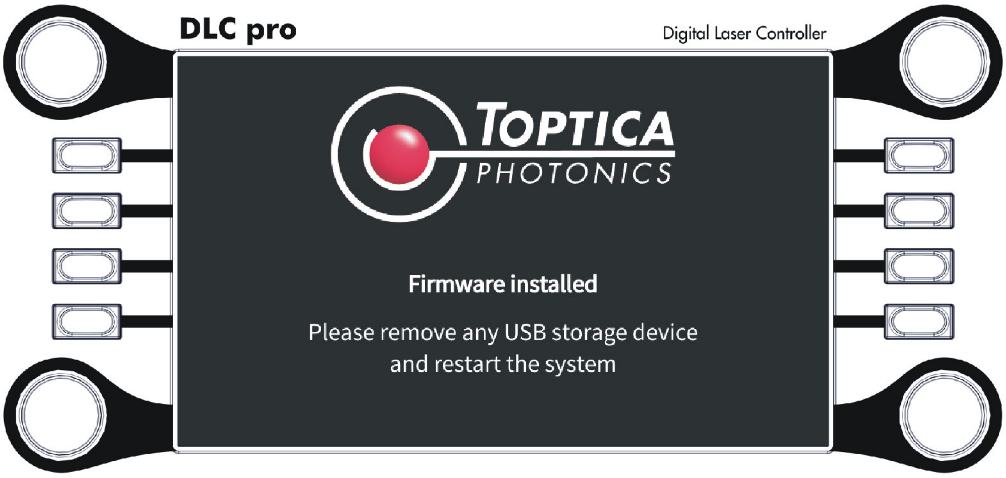


Figure 183 Touchscreen display when firmware installation is completed

6. Switch off the DLC pro and remove the USB flash drive. Then switch on the DLC pro again. After switching off, please wait for at least 10 seconds before switching the DLC pro on again.
The DLC pro starts and operates with the new system software.

10.19 Activating Option Licenses

To utilize some DLC pro functions or features, separate option licenses are required. When a option license is acquired, TOPTICA provides an option license key via e-mail or USB flash drive. The license key must be activated via the TOPAS DLC pro PC-GUI. If purchased along with the DLC pro, the licence is already installed.

Prerequisites:

- TOPAS DLC pro PC-GUI connected to DLC pro.
- Option license key provided by TOPTICA.

1. In the PC-GUI, select **Menu > Device Configuration > License Manager**.
A window shows the option licenses that are already installed on the DLC pro.

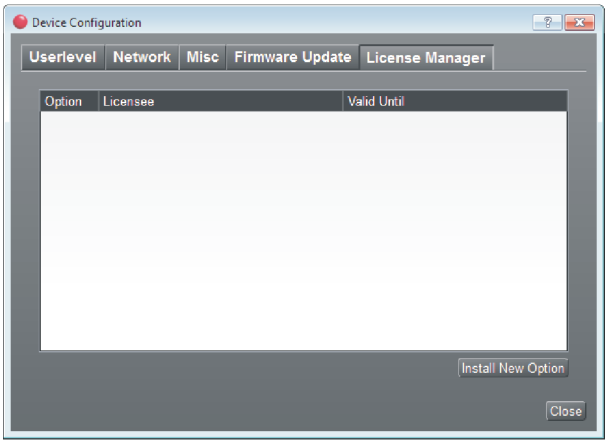


Figure 184 Device Configuration Section License Manager

2. Click **Install New Option.**
The **License Key** window opens.

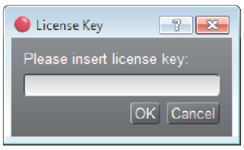


Figure 185 License Key window

3. Copy the License key information from the email or the USB flash drive to the PC clipboard.

Example for a License key:

--- License key: ---
hFviuU+D23LXeip21ll7ho6RYsKUGr5j8bT+MuULxq+jL3S3zRhJ8lopgc106YjQo5sOCi6o
tTuTwOVwc62RhcuXyKlkyh3WBp9+GhZYXiFN/oHsEjiKvmOxGfmBUpLPGEOCMHeaiM0pDwUc
G2Xpgnkz6vJKpdtH4twx7tAyR8vKZgE1xle7UUATNekcvML/6pqy3hc+ShV3eQBvsCvasO5J
AQn+ceFNAGmatuZBS7smbBHkDnPx1uhV1vJ8eaNGZTLpR54JgKkULr/wnGglt+QtepicFcBs
poq3gpthjrigCesYYldPgCBPjEhEeeX29W2dRX7RuBlg4PpfKFl9PjCMuu0jDXpruRexmL+b
B7w=

The license key information is the code written below --- License key: ---.

4. Paste the license key information into the **License Key** window and click **OK**.
When the **Option installed** message is displayed, click **OK.**
The **License Manager** window lists option type, licensee's name, and license validity of the newly-installed license.

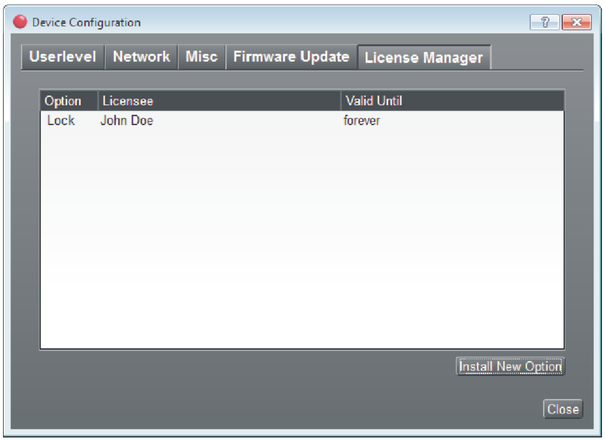


Figure 186 License Manager with Lock option installed (example)

5. Click **Close** to exit the window.

6. Close the TOPAS DLC pro PC-GUI and switch off the DLC pro.
Wait for at least 10 seconds and switch on the DLC pro again.
Run the TOPAS DLC pro PC-GUI. The DLC pro will now operate with the new option.

10.20 DLC pro Control via USB Connection

NOTE !	We recommend operating the DLC pro via Ethernet over using a USB connection due to the higher communication bandwidth. Using a USB to Ethernet adapter on the PC side allows fast communication while having a point-to-point connection between PC and DLC pro – without connecting the DLC pro to the local network or disconnecting the PC from it.

NOTE !	For DLC pro control via USB, the control computer must be connected to the USB connector at the MC+ module (rear panel, please refer to section 9.2.3) via a micro USB 2.0 cable with **connector type B**. The USB connector at the front panel of the DLC pro is not intended for controlling the DLC pro but for performing a firmware or system software update as described in sections 10.17 or 10.18.

10.20.1 USB Driver Installation

If the DLC pro is to be controlled by a computer via USB connection, the TOPAS DLC pro software requires a specific USB driver.

Together with the shipment of the DLC pro, TOPTICA provides a USB flash drive that contains the current system software and firmware versions, the DLC pro USB driver files, and the TOPAS DLC pro PC-GUI.

USB driver files:	**dlcpro-usb-serial.inf**	(Setup Information)
	dlcpro-usb-serial.cat	(Security Catalog)

USB driver files updates are provided on the TOPTICA website as part of the DLC pro software package:
www.toptica.com > Company > Downloads > Software > DLC pro Software Update

Prerequisites:

- Computer login with administrator privileges.
- Both DLC pro USB driver files copied to the computer, or
  USB flash drive with both DLC pro USB driver files connected to the computer.

1. Make sure that the DLC pro is switched on but not connected to the control computer via USB.

2. On the computer, browse to the directory that contains the DLC pro USB driver files, right-click **dlcpro-usb-serial.inf** (Setup Information), and click **Install**.

3. **Windows 8**: At the confirmation dialog window, select the option to install the driver.
Windows 10: Please confirm all security warning dialogs to install the driver.

The USB driver is installed.

4. Connect the control computer to the micro USB connector of the MC+ module on the DLC pro rear panel (please refer to section 9.2.3). Use a USB connection cable (micro USB 2.0 cable with connector type B). Wait until the new hardware is detected.

5. Start the TOPAS DLC pro PC-GUI and configure it for operation via USB connection as described in section 10.20.2.

10.20.2 Configuring TOPAS DLC pro for Operation via USB Connection

To control the DLC pro with a computer via USB connection, the TOPAS DLC pro PC-GUI must be configured accordingly.

Prerequisites:

- DLC pro and computer connected via USB connection.
- TOPAS DLC pro PC-GUI installed on the computer as described in section 6.2.
- DLC pro USB driver installed on the computer as described in section 10.20.1.
- DLC pro and computer switched on.

1. Start the TOPAS DLC pro PC-GUI on the computer.

2. Click **Menu > Connection Settings**.

3. Switch the Connection Settings to **Serial** and select the **Serial Port** according to the DLC pro USB driver installation. For DLC pro systems the **Baudrate** is fixed.

4. Click **OK** to save the settings.

10.21 License and Copyright Information associated with Third Party Software

This product incorporates certain third party software. The license and copyright information associated with this software is available on the Information screen (please refer to section 5.2.2).

This product contains software which, according to GNU General Public License Version 2 respectively 3, is subjected to disclosure. TOPTICA Photonics AG offers on request an entire copy of the corresponding machine-readable source code at cost price.

This product contains software covered by the GNU Lesser General Public License. Upon request, TOPTICA Photonics AG offers to grant the rights resulting from this license.

Please address your request to TOPTICA Photonics AG, Head of Development, Lochhamer Schlag 19, 82166 Graefelfing, Germany. This offer is valid during a 3-years-period beginning at the purchase date.

10.22 Declaration of CE Conformity DLC DL pro and DLC DFB pro

Konformitätserklärung

Declaration of Conformity / Declaration de Conformitè

TOPTICA PHOTONICS

QM-Formular:	F-173	Stand Formular:	15.12.2016	Version Formular:	10	Seite:	1 von 1

Wir / *We / Nous* — **TOPTICA Photonics AG**

Anschrift / *Address / Adresse* — **Lochhamer Schlag 19**
82166 Graefelfing
Germany

erklären in alleiniger Verantwortung, daß das Produkt / *declare under our sole responsibility, that the product / declarons sous notre seule responsibilité, que le produit*

Bezeichnung / *Name / Nom* — **DLC DL pro, DLC DL pro with Upgrade DLC pro 2nd DL, DLC DFB pro, DLC DFB pro L, DLC DFB pro BFY**

Artikelnr. / *Article No. / No. d'Article* — **DLC DL PRO xyz, DLC DL PRO HP xyz, DLC DFB pro, DLC DFB pro L, DLC DFB pro BFY, UPGR DLC PRO 2ND DL**

Beschreibung / *Description / Description* — **Tunable Diode Laser System DL pro with Digital Controller DLC pro, Tunable Diode Laser System DFB pro with Digital Controller DLC pro, Upgrade for Control of 2nd DL pro/DFB pro Laser Head**

mit den grundlegenden Anforderungen der Richtlinien / *fulfills the requirements of the standard and regulations of the directives / satisfait aux exigences des normes et directives*

2014/30/EU (Elektromagnetische Verträglichkeit), 2014/35/EU (Niederspannungsrichtlinie)
2011/65/EU (RoHS-Richtlinie)

übereinstimmt und damit den Bestimmungen entspricht. / *and therefore corresponds to the regulations of the directive. / et, ainsi, correspond au règlements de la directive.*

Angewendete harmonisierte Normen / *Applied harmonized standards: / Normes harmonisées appliquées*:

DIN EN 61326-1 — VDE 0843-20-1:2013-07 Elektrische Mess-, Steuer-, Regel- und Laborgeräte - EMV-Anforderungen - Teil 1: Allgemeine Anforderungen (IEC 61326-1:2012); Deutsche Fassung EN 61326-1:2013
Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements (IEC 61326-1:2012); German version EN 61326-1:2013

DIN EN 61010-1 — Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel- und Laborgeräte - Teil 1: Allgemeine Anforderungen (IEC 61010-1:2010 + Cor. :2011); Deutsche Fassung EN 61010-1:2010
Safety requirements for electrical equipment for measurement, control and laboratory use - Part 1: General requirements (IEC 61010-1:2010 + Cor. :2011); German version EN 61010-1:2010

DIN EN 60825-1 — Sicherheit von Lasereinrichtungen - Teil 1: Klassifizierung von Anlagen und Anforderungen (IEC 60825-1:2014); Deutsche Fassung EN 60825-1:2014
Safety of laser products - Part 1: Equipment classification and requirements (IEC 60825-1:2014); German version EN 60825-1:2014

DIN EN 50581 — Technische Dokumentation zur Beurteilung von Elektro- und Elektronikgeräten hinsichtlich der Beschränkung gefährlicher Stoffe; Deutsche Fassung EN 50581:2012
Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances; German version EN 50581:2012

Durch nicht von uns autorisierte Änderungen am Produkt verliert diese Erklärung ihre Gültigkeit. / *Non authorized changes at the product result in the invalidity of this declaration. / Changements au produit, qui ne sont pas autorisées par nous, ont pour conséquence l'invalidité de cette declaration.*

Gräfelfing, den 02.08.2017

Dr. Thomas Weber
Vorstand

Ort und Datum der Ausstellung
Place and Date of Issue
Lieu et date d'établissement

Name und Unterschrift des Befugten
Name and Signature of authorized person
Nom et signature de la personne autorisée

10.23 Declaration of CE Conformity DLC TA pro

Konformitätserklärung

Declaration of Conformity / Declaration de Conformitè

QM-Formular:	F-173	Stand Formular:	15.12.2016	Version Formular:	10	Seite:	1 von 1

Wir / *We / Nous* **TOPTICA Photonics AG**

Anschrift / *Address / Adresse* **Lochhamer Schlag 19**
82166 Graefelfing
Germany

erklären in alleiniger Verantwortung, daß das Produkt / *declare under our sole responsibility, that the product / declarons sous notre seule responsibilité, que le produit*

Bezeichnung / *Name / Nom* **TA PRO with digital DLC pro controller**
Artikelnr. / *Article No. / No. d'Article* **DLC TA pro, DLC TA pro xyz, DLC TA pro HP, DLC TA pro DFB, DLC TA pro DFB xyz, DLC TA pro DFB HP**
Beschreibung / *Description / Description* **Tapered Amplifier Laser System**

mit den grundlegenden Anforderungen der Richtlinien / *fulfills the requirements of the standard and regulations of the directives / satisfait aux exigences des normes et directives*

2014/30/EU (Elektromagnetische Verträglichkeit), 2014/35/EU (Niederspannungsrichtlinie)
2011/65/EU (RoHS-Richtlinie)

übereinstimmt und damit den Bestimmungen entspricht. / *and therefore corresponds to the regulations of the directive. / et, ainsi, correspond au règlements de la directive.*

Angewendete harmonisierte Normen / *Applied harmonized standards: / Normes harmonisées appliquées*:

DIN EN 61326-1	VDE 0843-20-1:2013-07 Elektrische Mess-, Steuer-, Regel- und Laborgeräte - EMV-Anforderungen - Teil 1: Allgemeine Anforderungen (IEC 61326-1:2012); Deutsche Fassung EN 61326-1:2013 *Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements (IEC 61326-1:2012); German version EN 61326-1:2013*
DIN EN 61010-1	Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel- und Laborgeräte - Teil 1: Allgemeine Anforderungen (IEC 61010-1:2010 + Cor. :2011); Deutsche Fassung EN 61010-1:2010 *Safety requirements for electrical equipment for measurement, control and laboratory use - Part 1: General requirements (IEC 61010-1:2010 + Cor. :2011); German version EN 61010-1:2010*
DIN EN 60825-1	Sicherheit von Lasereinrichtungen - Teil 1: Klassifizierung von Anlagen und Anforderungen (IEC 60825-1:2014); Deutsche Fassung EN 60825-1:2014 *Safety of laser products - Part 1: Equipment classification and requirements (IEC 60825-1:2014); German version EN 60825-1:2014*
DIN EN 50581	Technische Dokumentation zur Beurteilung von Elektro- und Elektronikgeräten hinsichtlich der Beschränkung gefährlicher Stoffe; Deutsche Fassung EN 50581:2012 *Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances; German version EN 50581:2012*

Durch nicht von uns autorisierte Änderungen am Produkt verliert diese Erklärung ihre Gültigkeit. / *Non authorized changes at the product result in the invalidity of this declaration. / Changements au produit, qui ne sont pas autorisées par nous, ont pour conséquence l'invalidité de cette declaration.*

Gräfelfing, den 03.05.2017

Dr. Thomas Weber
Vorstand

Ort und Datum der Ausstellung
Place and Date of Issue
Lieu et date d'établissement

Name und Unterschrift des Befugten
Name and Signature of authorized person
Nom et signature de la personne autorisée

10.24 Declaration of CE Conformity DLC TA pro AL

Konformitätserklärung **Declaration of Conformity / Declaration de Conformitè**							TOPTICA PHOTONICS
QM-Formular:	**F-173**	Stand Formular:	**21.10.2020**	Version Formular:	**13**	Seite:	**1 von 1**

Wir / *We / Nous*	**TOPTICA Photonics AG**
Anschrift / *Address / Adresse*	**Lochhamer Schlag 19** **82166 Graefelfing** **Germany**

erklären in alleiniger Verantwortung, daß das Produkt / *declare under our sole responsibility, that the product / declarons sous notre seule responsibilité, que le produit*

Bezeichnung / *Name / Nom*	**TA pro AL with DLC pro digital controller**
Artikelnr. / Article No. / No. d'Article	**DLC TA pro AL, DLC TA pro AL xyz, DLC TA pro AL with any combination of up to two modules of MTA TA pro, MTA TA pro xyz, MTA TA pro DFB, MTA TA pro DFB xyz, MTA BoosTA pro, MTA BoosTA pro xyz, MTA DL pro xyz, MTA DFB pro xyz, MTA DL pro, MTA DFB pro** **„xyz" stands for either a particular TOP-Seller wavelength/configuration, a HP version or both**
Beschreibung / Description / Description	**Amplified Tunable Single-Mode Laser System**

mit den grundlegenden Anforderungen der Richtlinien / *fulfills the requirements of the standard and regulations of the directives / satisfait aux exigences des normes et directives*

2014/30/EU (Elektromagnetische Verträglichkeit), 2014/35/EU (Niederspannungsrichtlinie)
2011/65/EU and the amendment of Directive 2015/863 (RoHS-3 Richtlinie)

übereinstimmt und damit den Bestimmungen entspricht. / *and therefore corresponds to the regulations of the directive. / et, ainsi, correspond au règlements de la directive.*

Angewendete harmonisierte Normen / *Applied harmonized standards: / Normes harmonisées appliquées*:

DIN EN 61326-1	VDE 0843-20-1:2013-07 Elektrische Mess-, Steuer-, Regel- und Laborgeräte - EMV-Anforderungen - Teil 1: Allgemeine Anforderungen (IEC 61326-1:2012); Deutsche Fassung EN 61326-1:2013 *Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements (IEC 61326-1:2012); German version EN 61326-1:2013*
DIN EN 61010-1	Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel- und Laborgeräte - Teil 1: Allgemeine Anforderungen (IEC 61010-1:2010 + COR:2011 + A1:2016, modifiziert + A1:2016/COR1:2019); Deutsche Fassung EN 61010-1:2010 + A1:2019 + A1:2019/AC:2019 *Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements (IEC 61010-1:2010 + COR:2011 + A1:2016, modified + A1:2016/COR1:2019); German version EN 61010-1:2010 + A1:2019 + A1:2019/AC:2019*
DIN EN 60825-1	Sicherheit von Lasereinrichtungen - Teil 1: Klassifizierung von Anlagen und Anforderungen (IEC 60825-1:2014); Deutsche Fassung EN 60825-1:2014 *Safety of laser products - Part 1: Equipment classification and requirements (IEC 60825-1:2014); German version EN 60825-1:2014*
DIN EN IEC 63000	Technische Dokumentation zur Beurteilung von Elektro- und Elektronikgeräten hinsichtlich der Beschränkung gefährlicher Stoffe (IEC 63000:2016); Deutsche Fassung EN IEC 63000:2018 *Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances (IEC 63000:2016); German version EN IEC 63000:2018*

Durch nicht von uns autorisierte Änderungen am Produkt verliert diese Erklärung ihre Gültigkeit. / *Non authorized changes at the product result in the invalidity of this declaration. / Changements au produit, qui ne sont pas autorisées par nous, ont pour conséquence l'invalidité de cette declaration.*

Gräfelfing, den 02.07.2021	Dr. Wilhelm Kaenders Vorstand
Ort und Datum der Ausstellung *Place and Date of Issue* Lieu et date d'établissement	Name und Unterschrift des Befugten *Name and Signature of authorized person* Nom et signature de la personne autorisée

10.25 Declaration of CE Conformity DLC MTA pro

Konformitätserklärung

Declaration of Conformity / Declaration de Conformitè

QM-Formular:	F-173	Stand Formular:	21.10.2020	Version Formular:	13	Seite:	1 von 1

Wir / *We / Nous*	**TOPTICA Photonics AG**
Anschrift / *Address / Adresse*	**Lochhamer Schlag 19** **82166 Graefelfing** **Germany**

erklären in alleiniger Verantwortung, daß das Produkt / *declare under our sole responsibility, that the product / declarons sous notre seule responsibilité, que le produit*

Bezeichnung / *Name / Nom*	**MTA pro with DLC pro digital controller**
Artikelnr. / Article No. / No. d'Article	**DLC MTA pro, DLC MTA pro xyz, DLC MTA pro with any combination of up to two modules of MTA TA pro, MTA TA pro xyz, MTA TA pro DFB, MTA TA pro DFB xyz, MTA BoosTA pro, MTA BoosTA pro xyz,MTA DL pro xyz, MTA DFB pro xyz, MTA DL pro, MTA DFB pro** **„xyz“ stands for either a particular TOP-Seller wavelength/configuration, a HP version or both.**
Beschreibung / Description / Description	**Modular Amplified Tunable Single-Mode Laser System**

mit den grundlegenden Anforderungen der Richtlinien / *fulfills the requirements of the standard and regulations of the directives / satisfait aux exigences des normes et directives*

2014/30/EU (Elektromagnetische Verträglichkeit), 2014/35/EU (Niederspannungsrichtlinie)
2011/65/EU and the amendment of Directive 2015/863 (RoHS-3 Richtlinie)

übereinstimmt und damit den Bestimmungen entspricht. / *and therefore corresponds to the regulations of the directive. / et, ainsi, correspond au règlements de la directive.*

Angewendete harmonisierte Normen / *Applied harmonized standards: / Normes harmonisées appliquées*:

DIN EN 61326-1	VDE 0843-20-1:2013-07 Elektrische Mess-, Steuer-, Regel- und Laborgeräte - EMV-Anforderungen - Teil 1: Allgemeine Anforderungen (IEC 61326-1:2012); Deutsche Fassung EN 61326-1:2013 *Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements (IEC 61326-1:2012); German version EN 61326-1:2013*
DIN EN 61010-1	Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel- und Laborgeräte - Teil 1: Allgemeine Anforderungen (IEC 61010-1:2010 + COR:2011 + A1:2016, modifiziert + A1:2016/COR1:2019); Deutsche Fassung EN 61010-1:2010 + A1:2019 + A1:2019/AC:2019 *Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements (IEC 61010-1:2010 + COR:2011 + A1:2016, modified + A1:2016/COR1:2019); German version EN 61010-1:2010 + A1:2019 + A1:2019/AC:2019*
DIN EN 60825-1	Sicherheit von Lasereinrichtungen - Teil 1: Klassifizierung von Anlagen und Anforderungen (IEC 60825-1:2014); Deutsche Fassung EN 60825-1:2014 *Safety of laser products - Part 1: Equipment classification and requirements (IEC 60825-1:2014); German version EN 60825-1:2014*
DIN EN IEC 63000	Technische Dokumentation zur Beurteilung von Elektro- und Elektronikgeräten hinsichtlich der Beschränkung gefährlicher Stoffe (IEC 63000:2016); Deutsche Fassung EN IEC 63000:2018 *Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances (IEC 63000:2016); German version EN IEC 63000:2018*

Durch nicht von uns autorisierte Änderungen am Produkt verliert diese Erklärung ihre Gültigkeit. / *Non authorized changes at the product result in the invalidity of this declaration. / Changements au produit, qui ne sont pas autorisées par nous, ont pour conséquence l'invalidité de cette declaration.*

Gräfelfing, den 02.07.2021	Dr. Wilhelm Kaenders Vorstand
Ort und Datum der Ausstellung *Place and Date of Issue* Lieu et date d'établissement	Name und Unterschrift des Befugten *Name and Signature of authorized person* Nom et signature de la personne autorisée

10.26 Declaration of CE Conformity DLC BoosTA pro/Seed Laser + BoosTA pro Combination

Konformitätserklärung

Declaration of Conformity / Declaration de Conformitè

TOPTICA PHOTONICS

QM-Formular:	F-173	Stand Formular:	25.07.2019	Version Formular:	11	Seite:	1 von 1

Wir / *We / Nous* — **TOPTICA Photonics AG**

Anschrift / *Address / Adresse* — **Lochhamer Schlag 19**
82166 Graefelfing
Germany

erklären in alleiniger Verantwortung, daß das Produkt / *declare under our sole responsibility, that the product / declarons sous notre seule responsibilité, que le produit*

Bezeichnung / *Name / Nom* — **DLC pro with BoosTA pro, DLC DL pro with BoosTA pro, DLC DFB pro with BoosTA pro, DLC CTL with BoosTA pro**

Artikelnr. / *Article No. / No. d'Article* — **DLC BoosTA pro, DLC BoosTA pro HP, DLC DL pro xyz, DLC DFB pro xyz, DLC CTL xyz, BoosTA pro, UPGR DLC pro TA, UPGR DLC pro TA HP**

Beschreibung / *Description / Description* — **Tunable Diode Laser System DL pro/DFB pro/CTL with Digital Controller DLC pro and with Optical Amplifier BoosTA pro, Optical Amplifier System DLC BoosTA pro**

mit den grundlegenden Anforderungen der Richtlinien / *fulfills the requirements of the standard and regulations of the directives / satisfait aux exigences des normes et directives*

2014/30/EU (Elektromagnetische Verträglichkeit), 2014/35/EU (Niederspannungsrichtlinie)
2011/65/EU and the amendment of Directive 2015/863 (RoHS-3 Richtlinie)

übereinstimmt und damit den Bestimmungen entspricht. / *and therefore corresponds to the regulations of the directive. / et, ainsi, correspond au règlements de la directive.*

Angewendete harmonisierte Normen / *Applied harmonized standards: / Normes harmonisées appliquées*:

DIN EN 61326-1	VDE 0843-20-1:2013-07 Elektrische Mess-, Steuer-, Regel- und Laborgeräte - EMV-Anforderungen - Teil 1: Allgemeine Anforderungen (IEC 61326-1:2012); Deutsche Fassung EN 61326-1:2013 *Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements (IEC 61326-1:2012); German version EN 61326-1:2013*
DIN EN 61010-1	Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel- und Laborgeräte - Teil 1: Allgemeine Anforderungen (IEC 61010-1:2010 + Cor. :2011); Deutsche Fassung EN 61010-1:2010 *Safety requirements for electrical equipment for measurement, control and laboratory use - Part 1: General requirements (IEC 61010-1:2010 + Cor. :2011); German version EN 61010-1:2010*
DIN EN 60825-1	Sicherheit von Lasereinrichtungen - Teil 1: Klassifizierung von Anlagen und Anforderungen (IEC 60825-1:2014); Deutsche Fassung EN 60825-1:2014 *Safety of laser products - Part 1: Equipment classification and requirements (IEC 60825-1:2014); German version EN 60825-1:2014*
DIN EN 50581	Technische Dokumentation zur Beurteilung von Elektro- und Elektronikgeräten hinsichtlich der Beschränkung gefährlicher Stoffe; Deutsche Fassung EN 50581:2012 *Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances; German version EN 50581:2012*

Durch nicht von uns autorisierte Änderungen am Produkt verliert diese Erklärung ihre Gültigkeit. / *Non authorized changes at the product result in the invalidity of this declaration. / Changements au produit, qui ne sont pas autorisées par nous, ont pour conséquence l'invalidité de cette declaration.*

Gräfelfing, den 25.03.2020

Ort und Datum der Ausstellung
Place and Date of Issue
Lieu et date d'établissement

Dr. Wilhelm Kaenders
Vorstand

Name und Unterschrift des Befugten
Name and Signature of authorized person
Nom et signature de la personne autorisée

10.27 Declaration of CE Conformity DLC CTL

Konformitätserklärung

Declaration of Conformity / Declaration de Conformitè

TOPTICA PHOTONICS

QM-Formular:	F-173	Stand Formular:	15.12.2016	Version Formular:	10	Seite:	1 von 1

Wir / *We / Nous*	**TOPTICA Photonics AG**
Anschrift / *Address / Adresse*	**Lochhamer Schlag 19** **82166 Graefelfing** **Germany**

erklären in alleiniger Verantwortung, daß das Produkt / *declare under our sole responsibility, that the product / declarons sous notre seule responsibilité, que le produit*

Bezeichnung / *Name / Nom*	**DLC CTL**
Artikelnr. / *Article No. / No. d'Article*	**DLC CTL xyz**
Beschreibung / *Description / Description*	**Continuously Tunable Laser, complete system**

mit den grundlegenden Anforderungen der Richtlinien / *fulfills the requirements of the standard and regulations of the directives / satisfait aux exigences des normes et directives*

2014/30/EU (Elektromagnetische Verträglichkeit), 2014/35/EU (Niederspannungsrichtlinie)
2011/65/EU (RoHS-Richtlinie)

übereinstimmt und damit den Bestimmungen entspricht. / *and therefore corresponds to the regulations of the directive. / et, ainsi, correspond au règlements de la directive.*

Angewendete harmonisierte Normen / *Applied harmonized standards: / Normes harmonisées appliquées*:

DIN EN 61326-1	VDE 0843-20-1:2013-07 Elektrische Mess-, Steuer-, Regel- und Laborgeräte - EMV-Anforderungen - Teil 1: Allgemeine Anforderungen (IEC 61326-1:2012); Deutsche Fassung EN 61326-1:2013 *Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements (IEC 61326-1:2012); German version EN 61326-1:2013*
DIN EN 61010-1	Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel- und Laborgeräte - Teil 1: Allgemeine Anforderungen (IEC 61010-1:2010 + Cor. :2011); Deutsche Fassung EN 61010-1:2010 *Safety requirements for electrical equipment for measurement, control and laboratory use - Part 1: General requirements (IEC 61010-1:2010 + Cor. :2011); German version EN 61010-1:2010*
DIN EN 60825-1	Sicherheit von Lasereinrichtungen - Teil 1: Klassifizierung von Anlagen und Anforderungen (IEC 60825-1:2014); Deutsche Fassung EN 60825-1:2014 *Safety of laser products - Part 1: Equipment classification and requirements (IEC 60825-1:2014); German version EN 60825-1:2014*
DIN EN ISO 11252	Laser und Laseranlagen - Lasergerät - Mindestanforderungen an die Dokumentation (ISO 11252:2013); Deutsche Fassung EN ISO 11252:2013 *Lasers and laser-related equipment- Laser device- Minimum requirements for documentation (ISO 11252:2013); German version EN ISO 11252:2013*
DIN EN 50581	Technische Dokumentation zur Beurteilung von Elektro- und Elektronikgeräten hinsichtlich der Beschränkung gefährlicher Stoffe; Deutsche Fassung EN 50581:2012 *Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances; German version EN 50581:2012*

Durch nicht von uns autorisierte Änderungen am Produkt verliert diese Erklärung ihre Gültigkeit. / *Non authorized changes at the product result in the invalidity of this declaration. / Changements au produit, qui ne sont pas autorisées par nous, ont pour conséquence l'invalidité de cette declaration.*

Gräfelfing, den 15.12.2016	Dr. Thomas Weber Vorstand
Ort und Datum der Ausstellung *Place and Date of Issue* Lieu et date d'établissement	Name und Unterschrift des Befugten *Name and Signature of authorized person* Nom et signature de la personne autorisée

10.28 Declaration of CE Conformity DLC MSHG pro

Konformitätserklärung **Declaration of Conformity / Declaration de Conformitè**							TOPTICA PHOTONICS
QM-Formular:	**F-173**	Stand Formular:	**30.07.2020**	Version Formular:	**12**	Seite:	**1 von 1**

Wir / *We / Nous*	**TOPTICA Photonics AG**
Anschrift / *Address / Adresse*	**Lochhamer Schlag 19** **82166 Graefelfing** **Germany**

erklären in alleiniger Verantwortung, daß das Produkt / *declare under our sole responsibility, that the product / declarons sous notre seule responsibilité, que le produit*

Bezeichnung / *Name / Nom*	**MSHG pro with DLC pro digital controller**
Artikelnr. / Article No. / No. d'Article	**DLC DL-MSHG PRO, DLC TA-MSHG PRO**
Beschreibung / Description / Description	**Modular Frequency-Doubled Tunable Laser System**

mit den grundlegenden Anforderungen der Richtlinien / *fulfills the requirements of the standard and regulations of the directives / satisfait aux exigences des normes et directives*

2014/30/EU (Elektromagnetische Verträglichkeit), 2014/35/EU (Niederspannungsrichtlinie)
2011/65/EU and the amendment of Directive 2015/863 (RoHS-3 Richtlinie)

übereinstimmt und damit den Bestimmungen entspricht. / *and therefore corresponds to the regulations of the directive. / et, ainsi, correspond au règlements de la directive.*

Angewendete harmonisierte Normen / *Applied harmonized standards: / Normes harmonisées appliquées*:

DIN EN 61326-1	VDE 0843-20-1:2013-07 Elektrische Mess-, Steuer-, Regel- und Laborgeräte - EMV-Anforderungen - Teil 1: Allgemeine Anforderungen (IEC 61326-1:2012); Deutsche Fassung EN 61326-1:2013 *Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements (IEC 61326-1:2012); German version EN 61326-1:2013*
DIN EN 61010-1	Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel- und Laborgeräte - Teil 1: Allgemeine Anforderungen (IEC 61010-1:2010 + Cor. :2011); Deutsche Fassung EN 61010-1:2010 *Safety requirements for electrical equipment for measurement, control and laboratory use - Part 1: General requirements (IEC 61010-1:2010 + Cor. :2011); German version EN 61010-1:2010*
DIN EN 60825-1	Sicherheit von Lasereinrichtungen - Teil 1: Klassifizierung von Anlagen und Anforderungen (IEC 60825-1:2014); Deutsche Fassung EN 60825-1:2014 *Safety of laser products - Part 1: Equipment classification and requirements (IEC 60825-1:2014); German version EN 60825-1:2014*
DIN EN IEC 63000	Technische Dokumentation zur Beurteilung von Elektro- und Elektronikgeräten hinsichtlich der Beschränkung gefährlicher Stoffe (IEC 63000:2016); Deutsche Fassung EN IEC 63000:2018 *Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances (IEC 63000:2016); German version EN IEC 63000:2018*

Durch nicht von uns autorisierte Änderungen am Produkt verliert diese Erklärung ihre Gültigkeit. / *Non authorized changes at the product result in the invalidity of this declaration. / Changements au produit, qui ne sont pas autorisées par nous, ont pour conséquence l'invalidité de cette declaration.*

Gräfelfing, den 24.09.2020	Dr. Wilhelm Kaenders Vorstand
Ort und Datum der Ausstellung *Place and Date of Issue* Lieu et date d'établissement	Name und Unterschrift des Befugten *Name and Signature of authorized person* Nom et signature de la personne autorisée

10.29 Declaration of CE Conformity DLC DL-/TA-SHG pro

Konformitätserklärung

Declaration of Conformity / Declaration de Conformitè

QM-Formular:	F-173	Stand Formular:	15.12.2016	Version Formular:	10	Seite:	1 von 1

Wir / *We / Nous* — **TOPTICA Photonics AG**

Anschrift / *Address / Adresse* — **Lochhamer Schlag 19**
82166 Graefelfing
Germany

erklären in alleiniger Verantwortung, daß das Produkt / *declare under our sole responsibility, that the product / declarons sous notre seule responsibilité, que le produit*

Bezeichnung / *Name / Nom*	**DLC DL-/TA-SHG pro**
Artikelnr. / *Article No. / No. d'Article*	**DLC DL-SHG pro, DLC TA-SHG pro**
Beschreibung / *Description / Description*	**Frequency Doubled High Power Laser DL-SHG pro with 19" DLC pro control rack**

mit den grundlegenden Anforderungen der Richtlinien / *fulfills the requirements of the standard and regulations of the directives / satisfait aux exigences des normes et directives*

2014/30/EU (Elektromagnetische Verträglichkeit), 2014/35/EU (Niederspannungsrichtlinie)
2011/65/EU (RoHS-Richtlinie)

übereinstimmt und damit den Bestimmungen entspricht. / *and therefore corresponds to the regulations of the directive. / et, ainsi, correspond au règlements de la directive.*

Angewendete harmonisierte Normen / *Applied harmonized standards: / Normes harmonisées appliquées*:

DIN EN 61326-1	VDE 0843-20-1:2013-07 Elektrische Mess-, Steuer-, Regel- und Laborgeräte - EMV-Anforderungen - Teil 1: Allgemeine Anforderungen (IEC 61326-1:2012); Deutsche Fassung EN 61326-1:2013 *Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements (IEC 61326-1:2012); German version EN 61326-1:2013*
DIN EN 61010-1	Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel- und Laborgeräte - Teil 1: Allgemeine Anforderungen (IEC 61010-1:2010 + Cor. :2011); Deutsche Fassung EN 61010-1:2010 *Safety requirements for electrical equipment for measurement, control and laboratory use - Part 1: General requirements (IEC 61010-1:2010 + Cor. :2011); German version EN 61010-1:2010*
DIN EN 60825-1	Sicherheit von Lasereinrichtungen - Teil 1: Klassifizierung von Anlagen und Anforderungen (IEC 60825-1:2014); Deutsche Fassung EN 60825-1:2014 *Safety of laser products - Part 1: Equipment classification and requirements (IEC 60825-1:2014); German version EN 60825-1:2014*
DIN EN ISO 11252	Laser und Laseranlagen - Lasergerät - Mindestanforderungen an die Dokumentation (ISO 11252:2013); Deutsche Fassung EN ISO 11252:2013 *Lasers and laser-related equipment- Laser device- Minimum requirements for documentation (ISO 11252:2013); German version EN ISO 11252:2013*
DIN EN 50581	Technische Dokumentation zur Beurteilung von Elektro- und Elektronikgeräten hinsichtlich der Beschränkung gefährlicher Stoffe; Deutsche Fassung EN 50581:2012 *Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances; German version EN 50581:2012*

Durch nicht von uns autorisierte Änderungen am Produkt verliert diese Erklärung ihre Gültigkeit. / *Non authorized changes at the product result in the invalidity of this declaration. / Changements au produit, qui ne sont pas autorisées par nous, ont pour conséquence l'invalidité de cette declaration.*

Gräfelfing, den 15.12.2016

Dr. Thomas Weber
Vorstand

Ort und Datum der Ausstellung
Place and Date of Issue
Lieu et date d'établissement

Name und Unterschrift des Befugten
Name and Signature of authorized person
Nom et signature de la personne autorisée

10.30 Declaration of CE Conformity DLC DL-/TA-FHG pro

Konformitätserklärung

Declaration of Conformity / Declaration de Conformitè

QM-Formular:	F-173	Stand Formular:	30.05.2016	Version Formular:	09	Seite:	1 von 1

Wir / *We / Nous* — **TOPTICA Photonics AG**

Anschrift / *Address / Adresse* — **Lochhamer Schlag 19**
82166 Graefelfing
Germany

erklären in alleiniger Verantwortung, daß das Produkt / *declare under our sole responsibility, that the product / declarons sous notre seule responsibilité, que le produit*

Bezeichnung / *Name / Nom*	**DLC DL-FHG PRO, DLC TA-FHG PRO**
Artikelnr. / *Article No. / No. d'Article*	**DLC DL-FHG PRO, DLC TA-FHG PRO**
Beschreibung / *Description / Description*	**Frequency-Quadrupled, High Power Laser with 19" DLC pro control rack**

mit den grundlegenden Anforderungen der Richtlinien / *fulfills the requirements of the standard and regulations of the directives / satisfait aux exigences des normes et directives*

2014/30/EU (Elektromagnetische Verträglichkeit), 2014/35/EU (Niederspannungsrichtlinie)
2011/65/EU (RoHS-Richtlinie)

übereinstimmt und damit den Bestimmungen entspricht. / *and therefore corresponds to the regulations of the directive. / et, ainsi, correspond au règlements de la directive.*

Angewendete harmonisierte Normen / *Applied harmonized standards: / Normes harmonisées appliquées*:

DIN EN 61326-1	VDE 0843-20-1:2013-07 Elektrische Mess-, Steuer-, Regel- und Laborgeräte - EMV-Anforderungen - Teil 1: Allgemeine Anforderungen (IEC 61326-1:2012); Deutsche Fassung EN 61326-1:2013 *Electrical equipment for measurement, control and laboratory use - EMC requirements – Part 1: General requirements (IEC 61326-1:2005); German version EN 61326-1:2006*
DIN EN 61010-1	Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel- und Laborgeräte - Teil 1: Allgemeine Anforderungen (IEC 61010-1:2010 + Cor. :2011); Deutsche Fassung EN 61010-1:2010 *Safety requirements for electrical equipment for measurement, control and laboratory use - Part 1: General requirements (IEC 61010-1:2010 + Cor. :2011); German version EN 61010-1:2010*
DIN EN 60825-1	Sicherheit von Lasereinrichtungen - Teil 1: Klassifizierung von Anlagen und Anforderungen (IEC 60825-1:2014); Deutsche Fassung EN 60825-1:2014 *Safety of laser products - Part 1: Equipment classification and requirements (IEC 60825-1:2014); German version*
DIN EN 50581	Technische Dokumentation zur Beurteilung von Elektro- und Elektronikgeräten hinsichtlich der Beschränkung gefährlicher Stoffe; Deutsche Fassung EN 50581:2012 *Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances; German version EN 50581:2012*

Durch nicht von uns autorisierte Änderungen am Produkt verliert diese Erklärung ihre Gültigkeit. / *Non authorized changes at the product result in the invalidity of this declaration. / Changements au produit, qui ne sont pas autorisées par nous, ont pour conséquence l'invalidité de cette declaration.*

Gräfelfing, den 11.07.2016

Dr. Thomas Weber
Vorstand

Ort und Datum der Ausstellung
Place and Date of Issue
Lieu et date d'établissement

Name und Unterschrift des Befugten
Name and Signature of authorized person
Nom et signature de la personne autorisée

10.31 Declaration of CE Conformity DLC TOPO

Declaration of Conformity **Konformitätserklärung / Declaration de Conformitè**				TOPTICA PHOTONICS			
QM-Form:	**IF-173**	Date of Form:	**25.07.2019**	Form Version:	**1**	Page	**1 of 1**

We / *Wir / Nous*	**TOPTICA Photonics, Inc.**
Address / *Anschrift / Adresse*	**5847 County Road 41** **Farmington, NY 14424** **USA**

declare under our sole responsibility, that the product / *erklären in alleiniger Verantwortung, daß das Produkt / declarons sous notre seule responsibilité, que le produit*

Name / *Bezeichnung / Nom*	**TOPO**
Article No. / *Artikelnr. / No. d'Article*	**DLC TOPO**
Description / *Beschreibung / Description*	**Frequency Converted High Power Laser**

fulfills the requirements of the standard and regulations of the directives / *mit den grundlegenden Anforderungen der Richtlinien / satisfait aux exigences des normes et directives*

2014/30/EU (Electromagnetic Compatibility), 2014/35/EU (Low Voltage Directive)
2011/65/EU and the amendment of Directive 2015/863 (RoHS-3 Guideline)

and therefore corresponds to the regulations of the directive. / *übereinstimmt und damit den Bestimmungen entspricht. / et, ainsi, correspond au règlements de la directive.*

Applied harmonized standards: / *Angewendete harmonisierte Normen / Normes harmonisées appliquées*:

DIN EN 61326-1	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements (IEC 61326-1:2012); German version EN 61326-1:2013 *VDE 0843-20-1:2013-07 Elektrische Mess-, Steuer-, Regel- und Laborgeräte - EMV-Anforderungen - Teil 1: Allgemeine Anforderungen (IEC 61326-1:2012); Deutsche Fassung EN 61326-1:2013*
DIN EN 61010-1	Safety requirements for electrical equipment for measurement, control and laboratory use - Part 1: General requirements (IEC 61010-1:2010 + Cor. :2011); German version EN 61010-1:2010 *Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel- und Laborgeräte - Teil 1: Allgemeine Anforderungen (IEC 61010-1:2010 + Cor. :2011); Deutsche Fassung EN 61010-1:2010*
DIN EN 60825-1	Safety of laser products - Part 1: Equipment classification and requirements (IEC 60825-1:2014); German version EN 60825-1:2014 *Sicherheit von Lasereinrichtungen - Teil 1: Klassifizierung von Anlagen und Anforderungen (IEC 60825-1:2014); Deutsche Fassung EN 60825-1:2014*
DIN EN ISO 11252	Lasers and laser-related equipment- Laser device- Minimum requirements for documentation (ISO 11252:2013); German version EN ISO 11252:2013 *Laser und Laseranlagen - Lasergerät - Mindestanforderungen an die Dokumentation (ISO 11252:2013); Deutsche Fassung EN ISO 11252:2013*
DIN EN 50581	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances; German version EN 50581:2012 *Technische Dokumentation zur Beurteilung von Elektro- und Elektronikgeräten hinsichtlich der Beschränkung gefährlicher Stoffe; Deutsche Fassung EN 50581:2012*

Non authorized changes at the product result in the invalidity of this declaration. / *Durch nicht von uns autorisierte Änderungen am Produkt verliert diese Erklärung ihre Gültigkeit. / Changements au produit, qui ne sont pas autorisées par nous, ont pour conséquence l'invalidité de cette declaration.*

Farmington, NY 09.10.2019	Mark Tolbert CEO
Place and Date of Issue *Ort und Datum der Ausstellung* Lieu et date d'établissement	Name and Signature of authorized person *Name und Unterschrift des Befugten* Nom et signature de la personne autorisée

10.32 Declaration of CE Conformity DLC MDL pro

Konformitätserklärung **Declaration of Conformity / Declaration de Conformitè**							TOPTICA PHOTONICS
QM-Formular:	**F-173**	Stand Formular:	**15.12.2016**	Version Formular:	**10**	Seite:	**1 von 1**

Wir / *We / Nous*	**TOPTICA Photonics AG**
Anschrift / *Address / Adresse*	**Lochhamer Schlag 19** **82166 Graefelfing** **Germany**

erklären in alleiniger Verantwortung, daß das Produkt / *declare under our sole responsibility, that the product / declarons sous notre seule responsibilité, que le produit*

Bezeichnung / *Name / Nom*	**DLC MDL pro**
Artikelnr. / *Article No. / No. d'Article*	**DLC MDL pro Ca+** **DLC MDL pro Yb+** **DLC MDL pro with any combination of up to four modules of MDL pro xyz, MDL pro xyz HP, MDL DL pro, MDL DL pro HP or MDL DFB pro**
Beschreibung / *Description / Description*	**Configurable multi tunable diode laser system**

mit den grundlegenden Anforderungen der Richtlinien / *fulfills the requirements of the standard and regulations of the directives / satisfait aux exigences des normes et directives*

2014/30/EU (Elektromagnetische Verträglichkeit), 2014/35/EU (Niederspannungsrichtlinie)
2011/65/EU (RoHS-Richtlinie)

übereinstimmt und damit den Bestimmungen entspricht. / *and therefore corresponds to the regulations of the directive. / et, ainsi, correspond au règlements de la directive.*

Angewendete harmonisierte Normen / *Applied harmonized standards: / Normes harmonisées appliquées*:

DIN EN 61326-1	VDE 0843-20-1:2013-07 Elektrische Mess-, Steuer-, Regel- und Laborgeräte - EMV-Anforderungen - Teil 1: Allgemeine Anforderungen (IEC 61326-1:2012); Deutsche Fassung EN 61326-1:2013 *Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements (IEC 61326-1:2012); German version EN 61326-1:2013*
DIN EN 61010-1	Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel- und Laborgeräte - Teil 1: Allgemeine Anforderungen (IEC 61010-1:2010 + Cor. :2011); Deutsche Fassung EN 61010-1:2010 *Safety requirements for electrical equipment for measurement, control and laboratory use - Part 1: General requirements (IEC 61010-1:2010 + Cor. :2011); German version EN 61010-1:2010*
DIN EN 60825-1	Sicherheit von Lasereinrichtungen - Teil 1: Klassifizierung von Anlagen und Anforderungen (IEC 60825-1:2014); Deutsche Fassung EN 60825-1:2014 *Safety of laser products - Part 1: Equipment classification and requirements (IEC 60825-1:2014); German version EN 60825-1:2014*
DIN EN 50581	Technische Dokumentation zur Beurteilung von Elektro- und Elektronikgeräten hinsichtlich der Beschränkung gefährlicher Stoffe; Deutsche Fassung EN 50581:2012 *Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances; German version EN 50581:2012*

Durch nicht von uns autorisierte Änderungen am Produkt verliert diese Erklärung ihre Gültigkeit. / *Non authorized changes at the product result in the invalidity of this declaration. / Changements au produit, qui ne sont pas autorisées par nous, ont pour conséquence l'invalidité de cette declaration.*

Gräfelfing, den 16.10.2017	Dr. Thomas Weber Vorstand
Ort und Datum der Ausstellung *Place and Date of Issue* Lieu et date d'établissement	Name und Unterschrift des Befugten *Name and Signature of authorized person* Nom et signature de la personne autorisée

10.33 DLC pro Main Dimensions

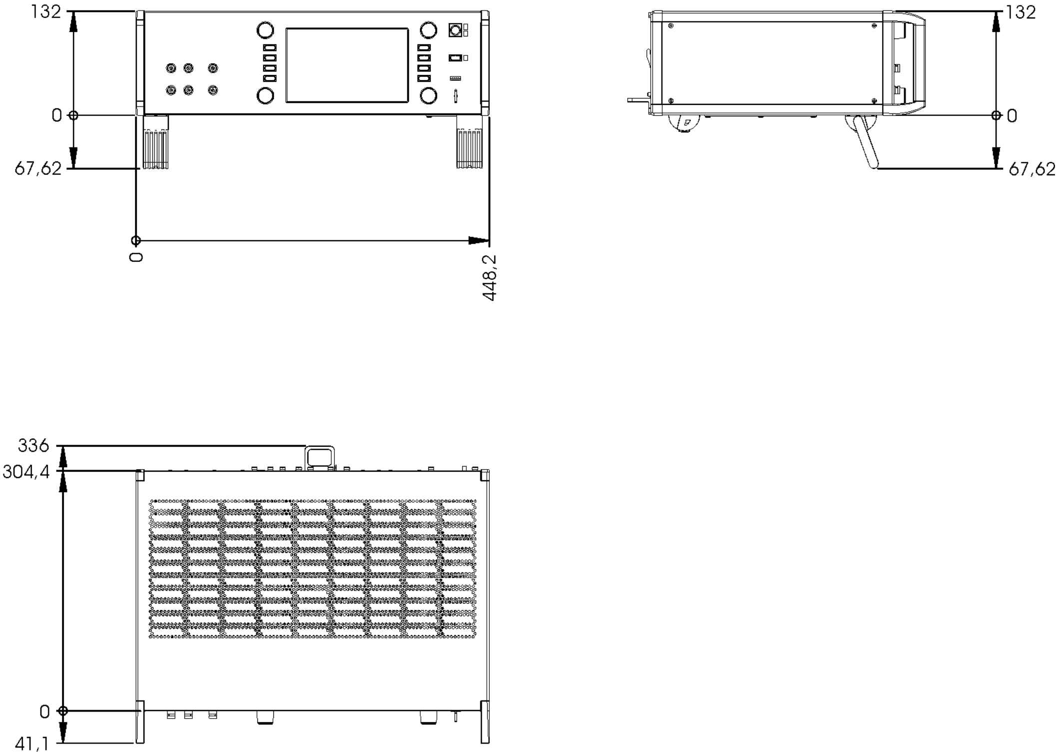


Figure 187 DLC pro main dimensions

10.34 EU Legislation for Electrical and Electronic Equipment (EEE)

Companies selling electrical and electronic goods in the European Union must conform to the EU legislation for electrical and electronic equipment (EEE), which includes the Waste Electrical and Electronic Equipment Directive (WEEE). Assigned duties affect product design of the equipment, disposal of used appliances as well as organizational responsibilities, i.e. product registration.

There are different requirements for household WEEE and that which is sold business to business (B2B). All equipment TOPTICA Photonics AG handles is classed as B2B. TOPTICA is registered at the Competent Authority (Stiftung Elektro-Altgeräte Register EAR) under No. DE70442884.

At end-of life return your product back to TOPTICA. TOPTICA will dispose used equipment in such a manner as to meet all relevant local, country and EU requirements and guideline.

To return products please mark them clearly with "intended for disposal" and send them to the following address:

TOPTICA Photonics AG
Lochhamer Schlag 19

D-82166 Graefelfing

10.35 Guarantee and Service

On the following page, you will find the **Guarantee Registration Form** in which the warranty conditions are defined. Please complete in the Guarantee Registration Form immediately after you receive your device and return it to TOPTICA Photonics AG by mail or fax.

As a first step toward obtaining technical support, please contact your local distributor or visit the support pages on our web site: http://www.toptica.com/support/.

In case you wish to return a product for diagnosis and/or repair, please contact us prior to sending it so we can issue a **Return Material Authorization** (RMA) number for you.

You can always contact TOPTICA service on the Internet by

- Email: service@toptica.com
- Web form: service.toptica.com

The service department at our headquarters in Munich can be reached by phone

- Tel: +49 89 85837150

For up-to-date phone numbers and addresses of our regional offices please refer to our web site: www.toptica.com/contact-us/

Guarantee Registration Form

QM form: F-015	Status of form: 13.10.2015	Version of form: 02	Page: 1 of 1

return to

TOPTICA Photonics AG
Customer Service
Lochhamer Schlag 19
D- 82166 Graefelfing/Munich
Germany

FAX: +49 89 85837-200

sender:

____
____
____
____
____

Guarantee Conditions

The products of TOPTICA Photonics AG are produced with the greatest possible care using high-quality components and are checked in detail before being delivered. Therefore, as the manufacturer, TOPTICA Photonics AG gives a guarantee of durability according to the following terms:

1. **TOPTICA Photonics AG guarantees the buyer that there will be no defects in the product based on defective material or processing, for a period of 12 months from first delivery (guarantee period).** Natural wear and tear as well as defects resulting from improper use or use contrary to the specifications, from failure to observe operating instructions, from insufficient maintenance and care or from modifications, interventions or attempted repairs that are neither carried out nor authorized by TOPTICA Photonics AG, are not covered by the guarantee.
2. **Unless expressively stated in the order acknowledgement or the invoice semiconductor light emitting devices like laser diodes, tapered amplifier chips, Terahertz transmitters and receivers etc. whether sold as single parts or integrated in systems are not covered by the guarantee.**
3. If a defect covered by the guarantee arises during the guarantee period, TOPTICA Photonics AG shall rectify such defect within a reasonable period at its own discretion by repairing or replacing the product or the defective part.
4. The guarantee period shall commence upon delivery of the product by TOPTICA Photonics AG or by a third party that obtained the product directly from TOPTICA Photonics AG for the purpose of selling it to the buyer.
   The claim under the guarantee shall be excluded if the defect is not notified to TOPTICA Photonics AG in writing immediately after having been discovered, and no later than one month after expiry of the guarantee period.
   For the purpose of rectifying a defect covered by the guarantee, the product or the relevant part shall be sent to TOPTICA Photonics AG at the expense and risk of the buyer. The product shall be returned at the expense and risk of TOPTICA Photonics AG.
5. No claims may be derived from this guarantee other than claims for rectification of the defects falling within the scope hereof, in accordance with the present terms. In particular, the buyer is not entitled under this guarantee to claim damages or a reduction in price from TOPTICA Photonics AG, or to rescind the contract. Potential, more far-reaching claims of the buyer against its seller shall not be affected by this guarantee.
6. **Important!: The obligation of TOPTICA Photonics AG under this guarantee is subject to the condition that the buyer gives his/her express consent to them by sending the signed duplicate of this form to TOPTICA Photonics AG immediately after delivery, also truthfully indicating the model number, the serial number and the date on which the product was delivered.**
7. The buyer may not assign claims under this guarantee to third parties without the prior written consent of TOPTICA Photonics AG.
8. This guarantee is governed by substantive German law to the exclusion of the provisions of the UN-Convention on Contracts for the International Sale of Goods (CISG). The Regional Court [Landgericht] Munich I shall be the court of exclusive international, local and subject-matter jurisdiction for legal disputes arising under or in connection with this guarantee.

I request the above mentioned guarantee for the purchased products and herewith consent to the above mentioned Guarantee Conditions:

Model No.: ____________________ Date: ________________________

Serial No.: ____________________ Signature: ________________________

Date of Delivery: ____________________ Name/Title: ________________________

To be completed by the buyer and returned to TOPTICA Photonics AG by mail or fax (+49 - 89 – 85837 – 200).