

DLC pro

Digital Laser Controller

Manual

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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 contact us in the following ways:

- Internet: toptica.com. In our support section, you can find a list of frequently asked questions and a service contact form.
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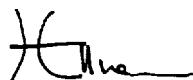
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Please have your product ID and serial number ready when contacting us, so we can quickly retrieve all relevant information.

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

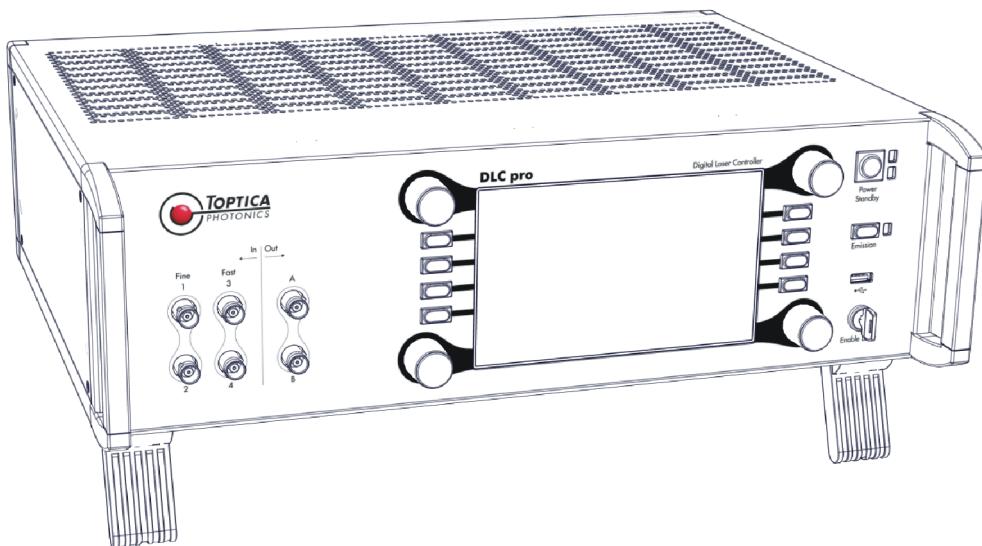


Figure 1 The Digital Laser Controller DLC pro

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 7 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 6.9.
- 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 5.11 and 6.19 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 10.18.
- **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 10.17.
- Subscribe to receive **email notifications** for such updates by sending an email with subject „subscribe“ to DLCpro@toptica.com. See section 10.16.
- The **status of frequency locks** is not only indicated by the TOPAS DLC pro PC-GUI and the touch-screen 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 10.11.
- 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 10.10), and **active power stabilization** (see section 5.3.6), to name just a few.

1.2 Design of the Digital Laser Controller DLC pro

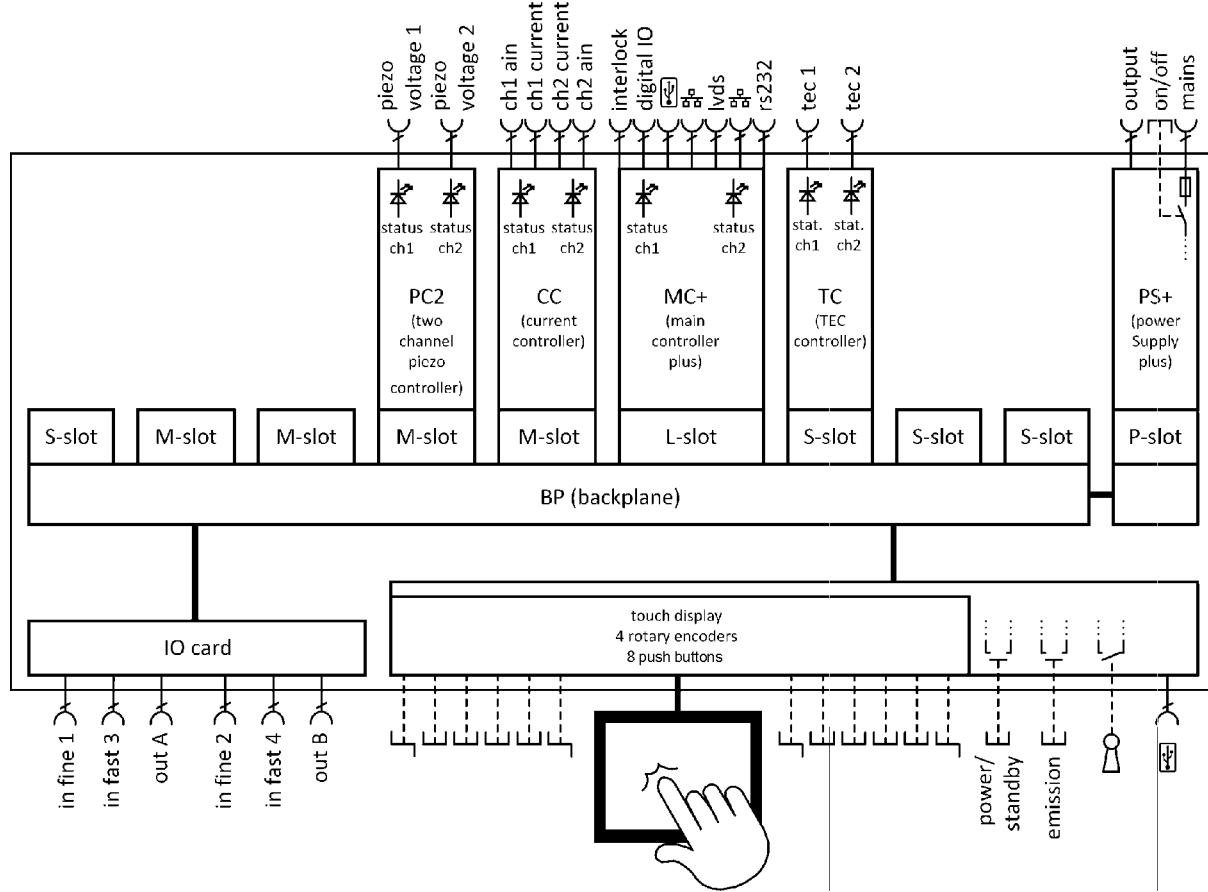


Figure 2 Block diagram of the DLC pro (example)

PS+	Power Supply Module
TC	Temperature Control Module
MC+	Main Controller
CC	Current Controller
PC2	Piezo Controller

S-slot	(Small slot)
M-slot	(Medium slot)
L-slot	(Large slot)
P-slot	(Power slot)

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 10.12).

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 10.3 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 is already installed.

The Digital Laser Controller DLC pro is capable to control two laser heads of the type DL pro or DFB pro. 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 5.7 and 5.8), 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 an additional Lock option installed, 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 10.4 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 ! 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 !  **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 ! The DLC pro and the laser head are both equipped with LEDs that indicate laser emission.

CAUTION ! (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 ! Before **connecting/disconnecting any cables** at the DLC pro or the connected laser

CAUTION ! 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 and section 4.5.5). 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 Safety Features

2.2.1 External Interlock Connector

The DLC pro provides an external interlock connector located at the MC+ module (see Figure 117). 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.

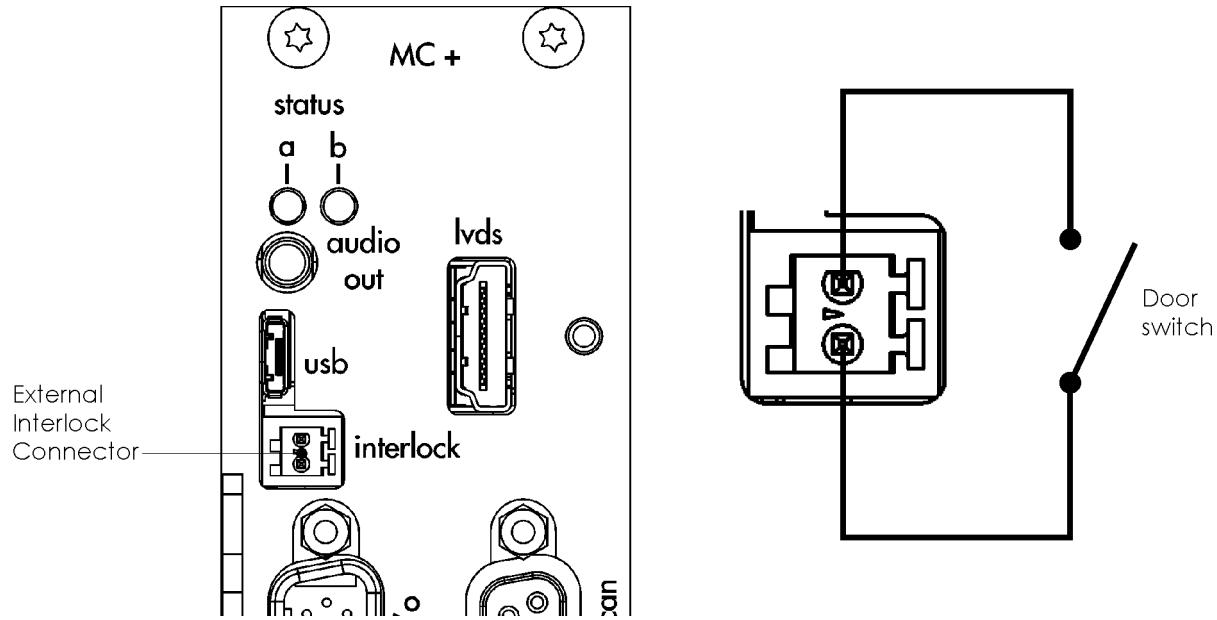


Figure 3 External interlock connector (Phoenix MC 0.5/2-G-2.5)

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.

2.2.2 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 !

2.2.3 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.

2.3 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 10.28).

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

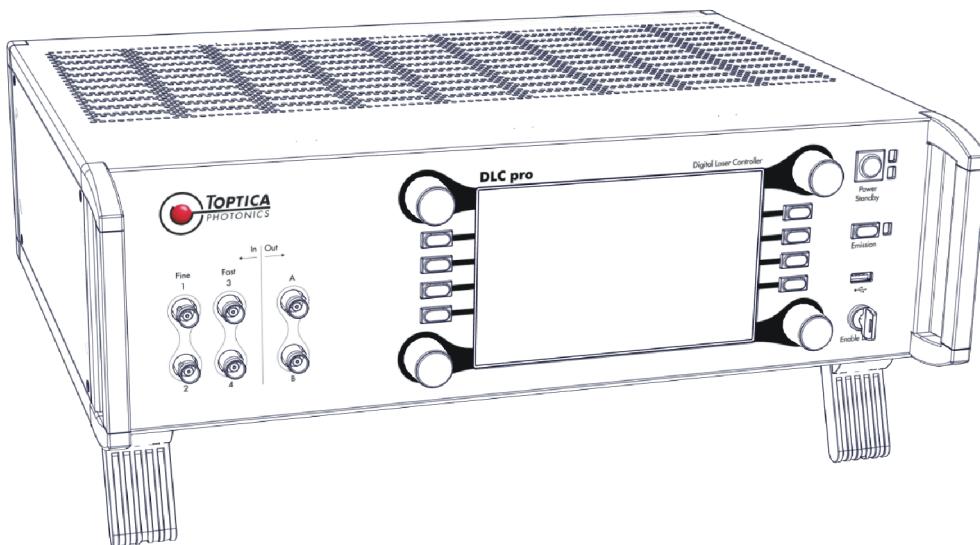


Figure 4 DLC pro Laser Control Electronics

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

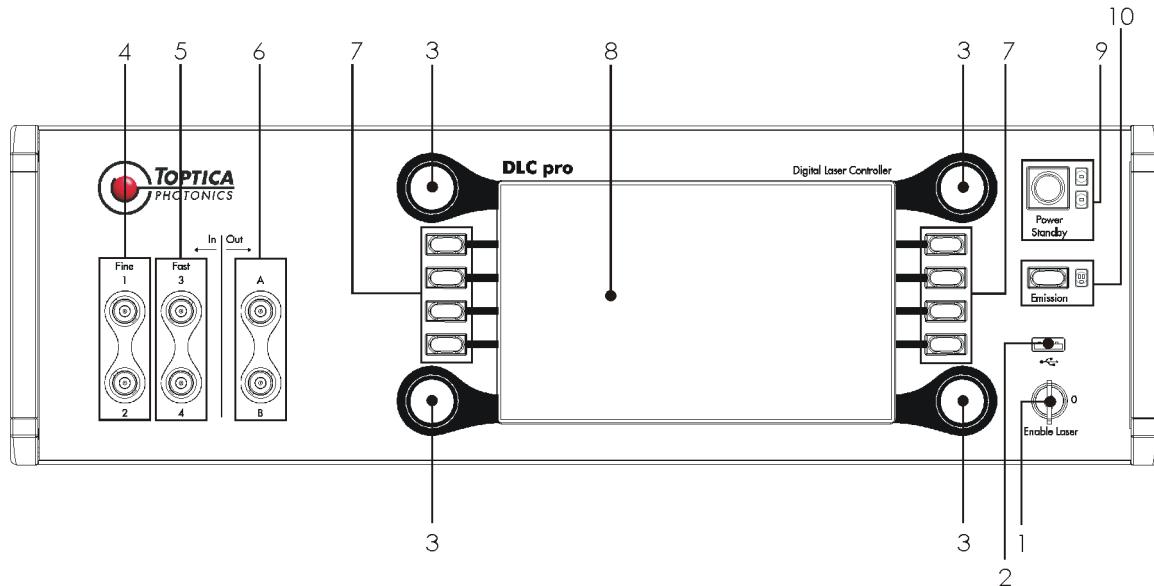


Figure 5 DLC pro front panel

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

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

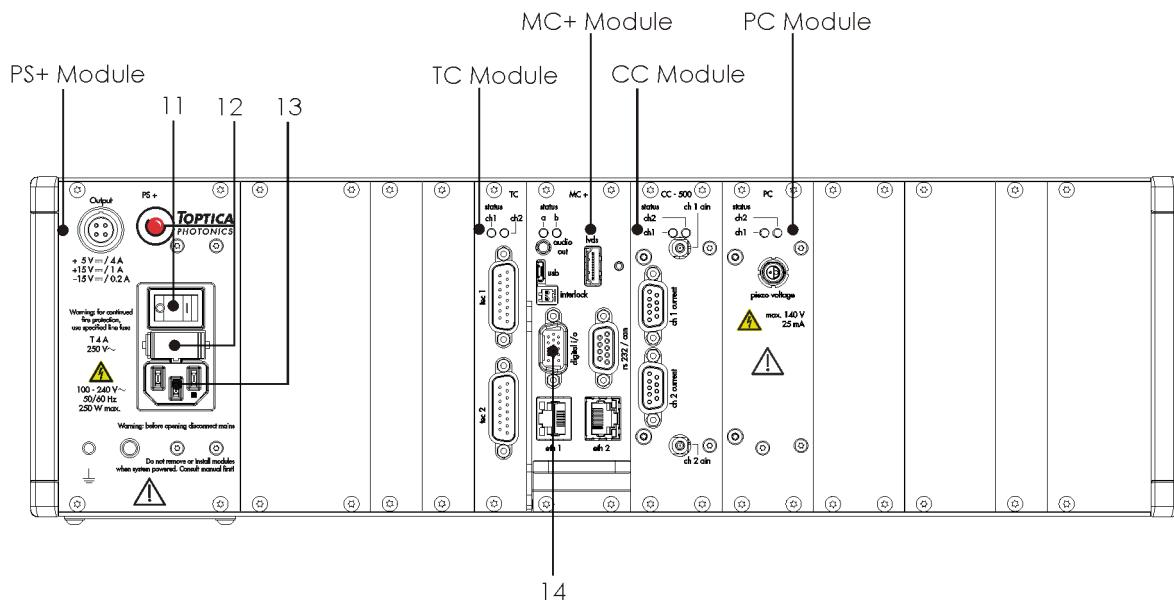


Figure 6 DLC pro rear panel (example DLC DL pro)

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 10.6 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 10.15 and 10.16). 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. A and B Output Voltage: - 4 V .. + 4 V at $\geq 100 \text{ k}\Omega$ 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	<p>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 5.11) or in the Params tab of the TOPAS DLC pro PC-GUI (please refer to section 6.19).</p> <p>Standby Touchscreen switches off. The standby status of the PC2/PC, CC, and TC modules is as configured.</p> <p>Power The operating parameters resume as they were set before switching to standby.</p> <p>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.</p>
10 Emission Push Button and Laser Radiation Emission Warning LED	<p>The Emission push button switches on/off (toggle function) one or more CC modules and thus laser emission for all laser channels is activated.</p> <p>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 5.7 and 5.8), 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 10.14). To switch on the laser again, press the push button twice to actively switch off/on the laser.</p> <p>DANGER ! When the Laser Radiation Emission Warning LED lights up white, be aware that there is laser emission.</p> <p>NOTE ! Laser emission can only be switched on with the Emission push button if:</p> <ul style="list-style-type: none"> • Laser 1 or laser 2 is enabled by the corresponding push buttons (see sections 5.7 and 5.8). • the external interlock circuit is closed (see section 2.2.1). • the key switch is in the Enable Laser position. • the CC modules are activated in the parameter menu (please refer to section 5.11) or in the Params tab of the TOPAS DLC pro PC-GUI (please refer to section 6.19). <p>NOTE ! During the boot procedure, the white Laser Radiation Emission Warning LED lights up for a short time as a function test.</p> <p>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.</p>
11 ON/OFF Switch	<p>ON/OFF switch for DLC pro laser driver electronics. For detailed description, please refer to sections 9.2.1 and 9.2.2.</p> <p>NOTE ! After switching off, please wait for at least 10 seconds before switching the DLC pro on again.</p>

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

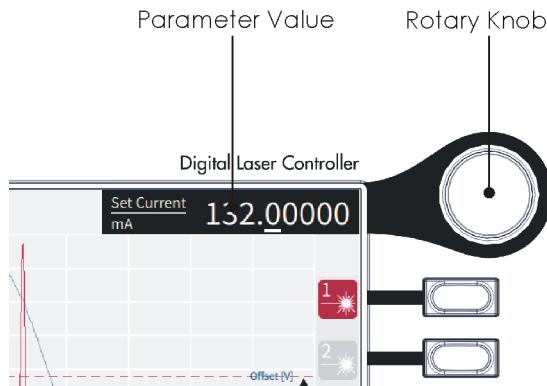


Figure 7 Rotary knob and corresponding parameter value

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 the top-left rotary knob (**Top left parameter**) can be selected in the context parameter menu which is available after pressing the **Parameter** button or tapping the corresponding symbol (see section 5.11).

4.4.2 Touchscreen

4.4.2.1 Gestures

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

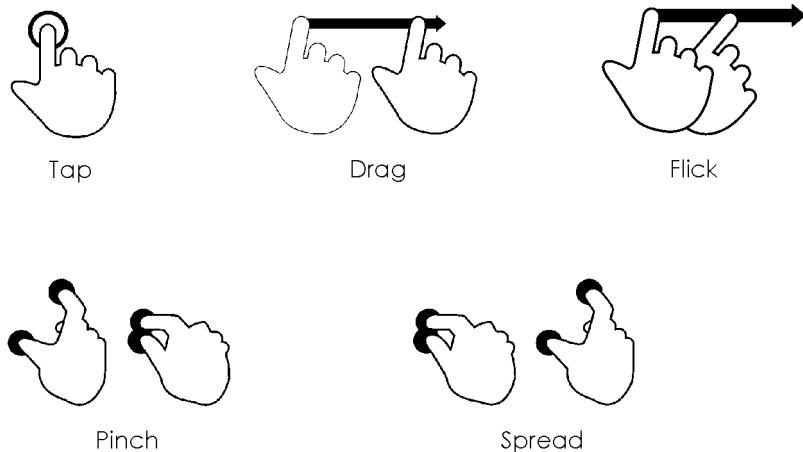


Figure 8 Gestures for touchscreen operation

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.

4.4.2.2 Numerical Editor

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

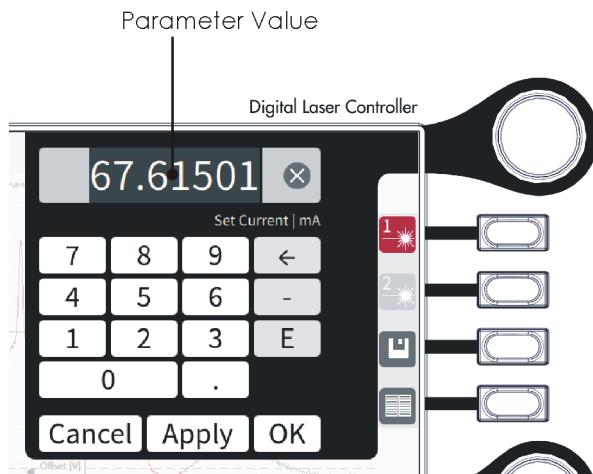


Figure 9 Parameter value and touchscreen keypad

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.

4.4.3 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 4.5.6 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 DL pro, TA pro, or CTL 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 4.4.2 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.

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.

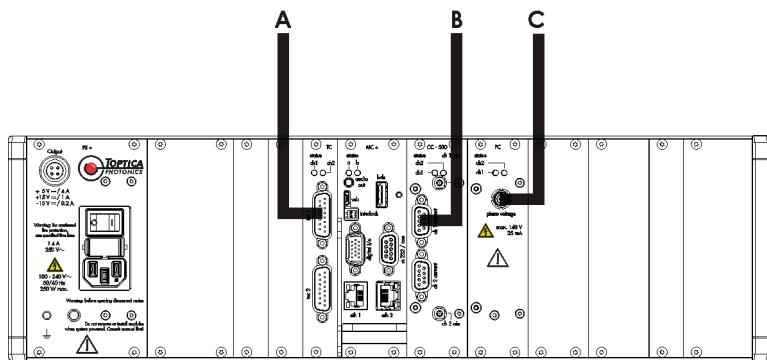


Figure 10 Basic cable connections between DLC pro and laser head (example DLC DL pro). The laser head is connected to DLC pro as laser 1

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:** The laser connected to the tec 1 connector of the TC module (see section 9.2.6) will be assigned as laser 1, the laser connected to the tec 2 connector as laser 2.
When only one laser should be used at a DLC pro for Dual-Laser-Operation, please connect it as laser 1 (tec 1 and ch 1 current connectors).
If laser 1 does not require a piezo control connection and laser 2 does, the piezo voltage connector (PC module, see section 9.2.7) or piezo voltage 1 connector (PC2 module, see section 9.2.8) is used for laser 2.

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.

1. 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 12) 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 Laser Configuration for DL pro Laser Heads without EEPROM

NOTE ! All TOPTICA DL pro and TA pro laser heads with serial number 20000 and higher are equipped with an EEPROM. If a laser head without EEPROM is detected, and the DLC pro is not configured for this type of laser head, a system message is displayed and the CC, PC, and TC modules are disabled.

The maximum currents *:cc:current-clip and *:cc:current-clip-limit as well as *:cc:voltage-clip (U_{max}) are set to 0 to protect the user from accidentally switching on the laser with potentially dangerous parameters.

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

CAUTION ! The DLC pro cannot detect if the user changes between different laser heads without EEPROM.

In this case, the user is responsible for changing the laser configuration accordingly.

For laser heads which are not equipped with an EEPROM, the operating parameters must be set in the TOPAS DLC pro PC-GUI as described below (SERVICE user level required, please refer to section 4.8).

CAUTION ! Check the adjusted parameters of the DLC pro before switching on the connected laser ! 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.

1. 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 12) is displayed on the touchscreen.
After power-up of the DLC pro, perform the following steps to set the operating parameters for the connected laser head.
2. Install and start TOPAS DLC pro PC-GUI. Establish a connection to the DLC pro. For details on the TOPAS DLC pro PC-GUI, please refer to section 6.
Change user level to SERVICE in **Menu > Device Configuration > Userlevel Section** (please refer to section 6.9).
3. Adjust the TC Set Temperature in **Menu > Device Configuration > Laser Config Section**. Enable the TC, and if necessary adjust the TC PID parameters in the Params tab of the TOPAS DLC pro PC-GUI to achieve good temperature stability (laser1:dl:tc:t-loop:p-gain, i-gain and d-gain).

4. In the Params tab of the TOPAS DLC pro PC-GUI, set laser1:dl:cc:current-clip-limit to the correct value.
Adjust CC Maximum Current, Set Current (I_{set}), and Maximum Voltage (U_{max}) in **Menu > Device Configuration > Laser Config Section** to the correct values for the connected laser head. **Please set the U_{max} value to the Voltage (DLC pro) specified in section 05 of the laser head Production and Quality Control Data Sheet.**
For laser diodes with positive polarity, please check the Polarity parameter. For negative laser diodes, remove the check-mark. Click **Save** to store the settings
5. Please change user level to USER after setting the parameters for safety reasons.
After configuring the laser head, please enable the CC module.

NOTE ! Laser heads without EEPROM: For safety reasons, the PC module can only be enabled after the CC module is enabled and the **Emission** push button on the DLC pro front panel is pressed. When turning off the laser current, the PC module is automatically disabled.

6. After all parameters have been set according to the specifications of the connected laser head, select **Menu > Save Configuration**. The settings will now be remembered until a change of the laser head is detected.
Please note that the DLC pro cannot detect if the user changes between different laser heads without EEPROM. In this case, the user is responsible for changing the laser configuration accordingly.
7. Please refer to the laser head manual for setting the Feed Forward.

4.5.6 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 2.2.1.

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 5.7 and 5.8 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 4.4.1).

NOTE! **For laser heads with EEPROM**, Feed Forward adjustment is normally not necessary unless the Set Current I_{set} or the Scan Frequency is changed considerably.
For laser heads without EEPROM, please adjust the Feed Forward as described in the laser head manual.

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 5.7 and 5.8 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/Standy** 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/Standy** 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 6.13) and optimize the scan by tuning I_{set} and T_{set} . Changing the Feed Forward is usually not required.

4.8 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 4.8.1). 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 4.8.2.
- 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** to change the user level (please refer to section 6.9).

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

4.8.1 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 4.8.2.

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.

4.8.2 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:

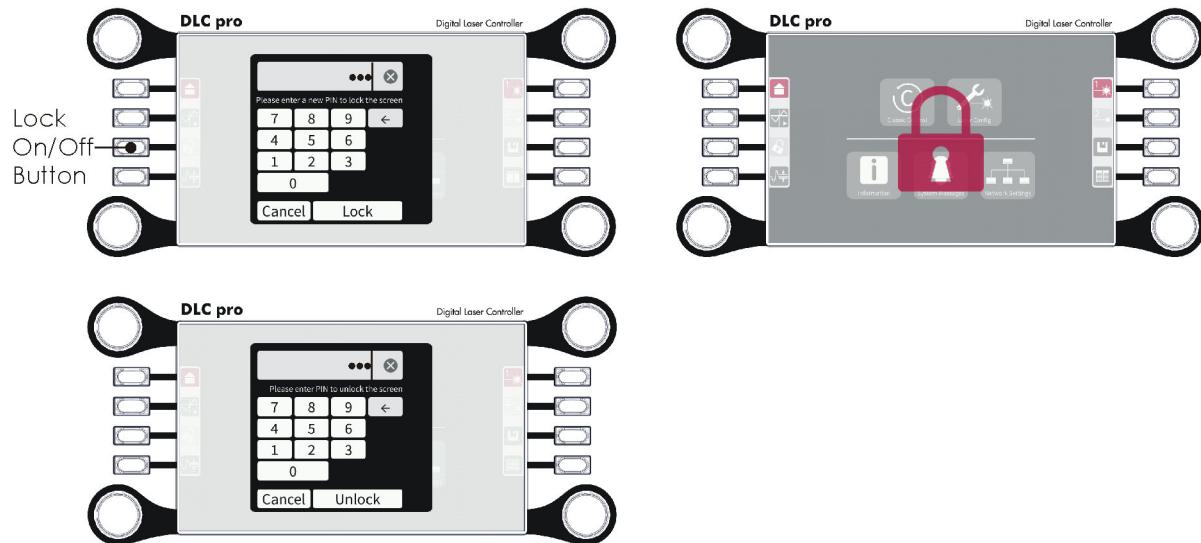


Figure 11 Locking the touchscreen and the operator controls at the DLC pro

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 touchscreen 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 10.28) to obtain the Master PIN.

4.9 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):

$0 \leq \text{current-set}, \text{current-act} \leq \text{current-clip} \leq \text{current-clip-limit} \leq \text{maximal current of supply}$

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.

4.10 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 5.10.1 and 6.9 for detailed information on how to load/save device parameter configurations via the DLC pro touchscreen or the TOPAS DLC pro PC-GUI.

4.11 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 10.13.
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 5.10.1).

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 6.9).

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 6.19), 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 10.11) 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 10.5 and 10.6. The license key must be activated via the TOPAS DLC pro PC-GUI (please refer to section 10.18). If purchased along with the DLC pro, the licence and the hardware is already installed.

The Digital Laser Controller DLC pro is capable to control two laser heads of the type DL pro or DFB pro. 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 5.7 and 5.8), 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.

5.2 Home Screen

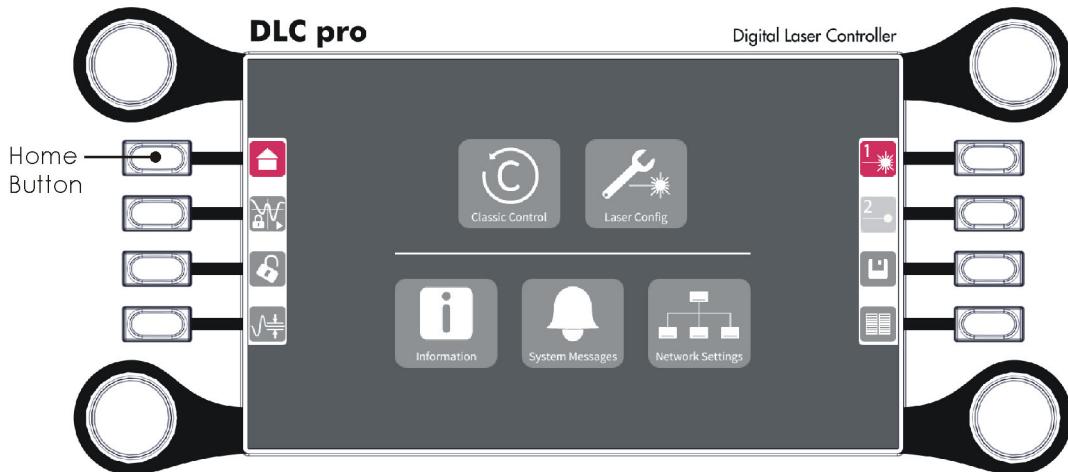


Figure 12 Home screen (example DLC DL pro)

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.

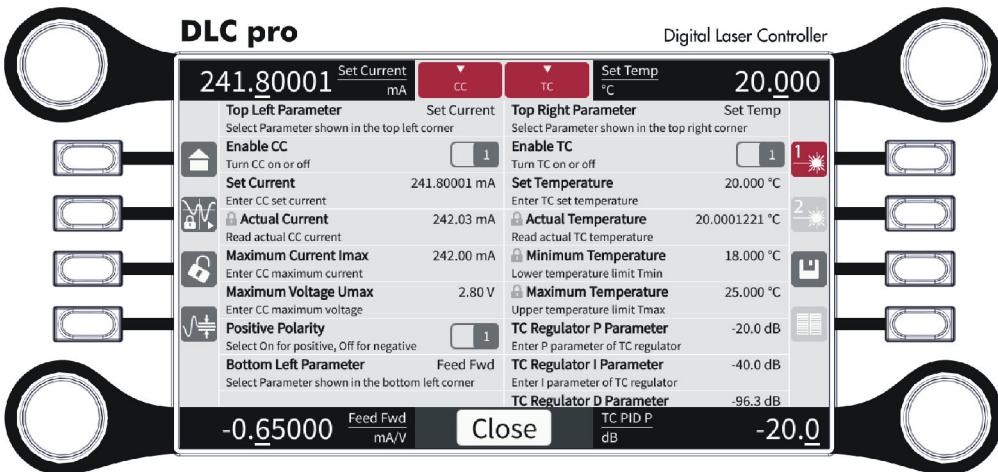


Figure 13 Classic Control showing operating parameters for CC module and TC module (example)

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 **Top** or **Bottom Right/Left Parameter** to assign the rotary knobs to various functions. The operating parameters displayed for each module are a selection from the complete parameter menu (please refer to section 5.11).

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:** 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** 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 heads.

NOTE ! This product incorporates certain third party software. The license and copyright information associated with this software is available after tapping **Legal Info**.



Figure 14 Information screen

5.2.3 System Messages

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

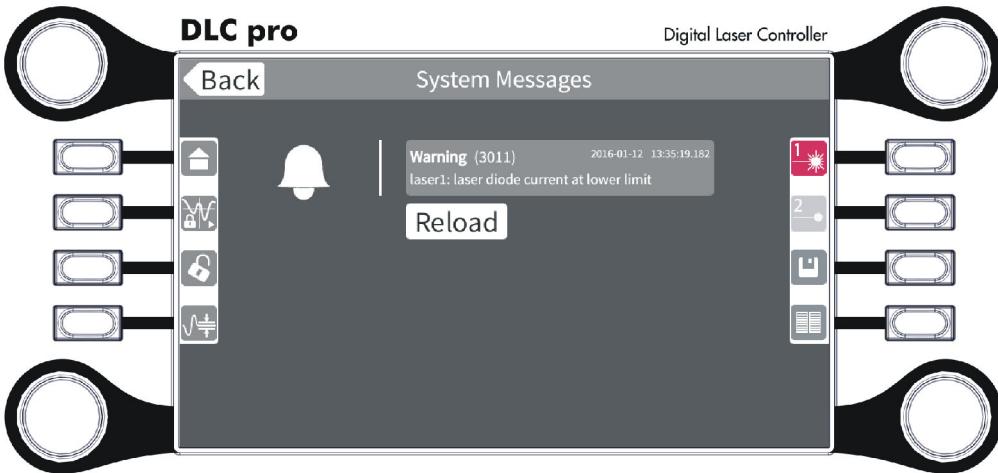


Figure 15 System Messages

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 noted 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 10.14). Tap **Reload** to refresh the displayed messages. Tap **Back** to return to the Home screen.

NOTE ! Only current system messages are displayed on the touchscreen. For checking all system messages since the last boot procedure, 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 display window and select **Message Log**.

5.2.4 Network Settings

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

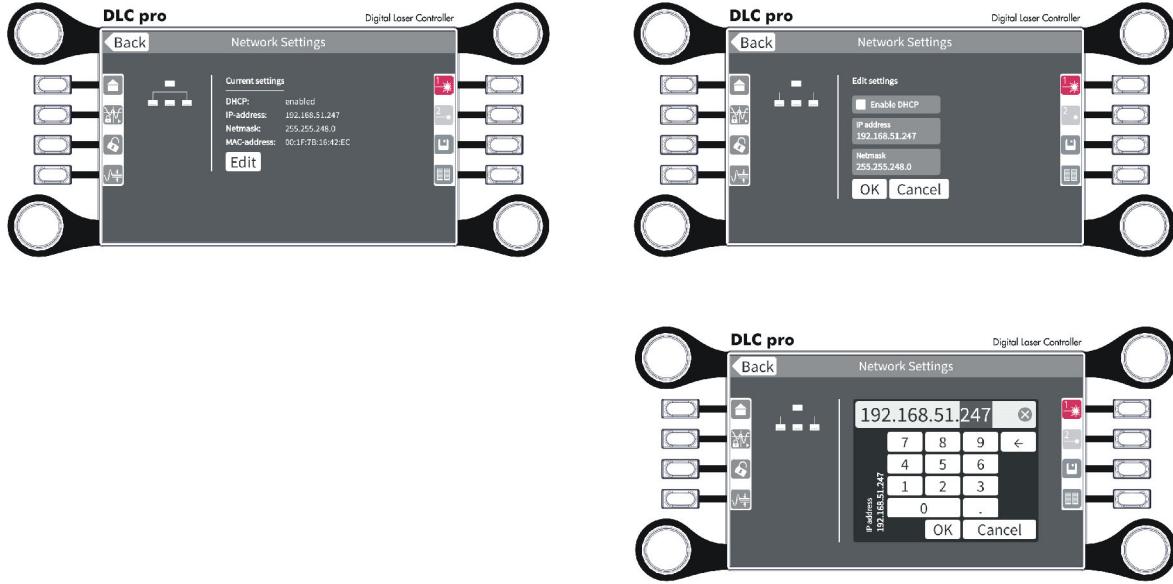


Figure 16 Network Settings

In the first window (Figure 16 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 16 top right) for changing the network settings.
Edit Settings Window	Tap the setting to be changed. A numerical editor (Figure 16 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., "192.168.1.1"). 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.

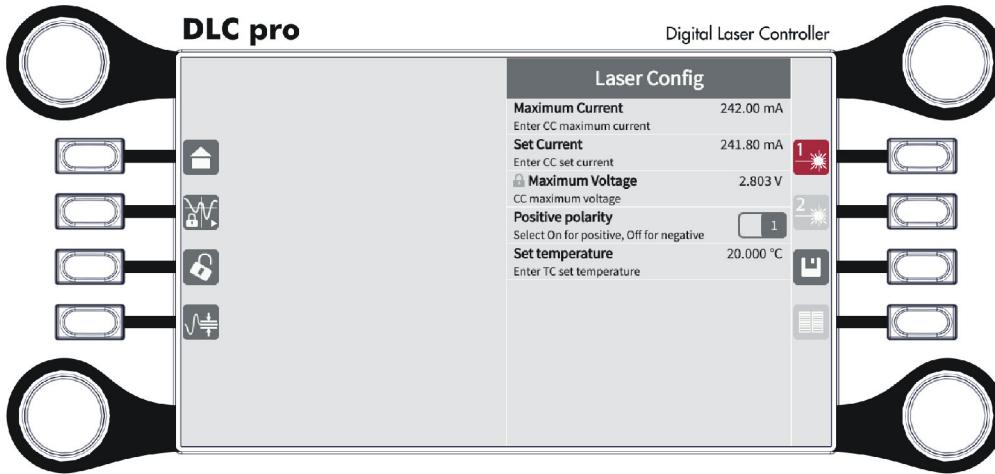


Figure 17 Laser Config screen (example DLC DL pro/DLC DFB pro)

NOTE ! **DLC TA pro:** Configuration of the TA pro 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 5.7 and 5.8). Depending on whether the laser has an EEPROM or not (please refer to sections 4.5.4 and 4.5.5), 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
Set Current	I_{set}
Maximum Voltage	U_{max}

For laser heads without EEPROM (see section 4.5.5), please note:

Please set the U_{max} value to the Voltage (DLC pro) specified in section 05 of the laser head Production and Quality Control Data Sheet.

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 touchscreen. 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 ! 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.

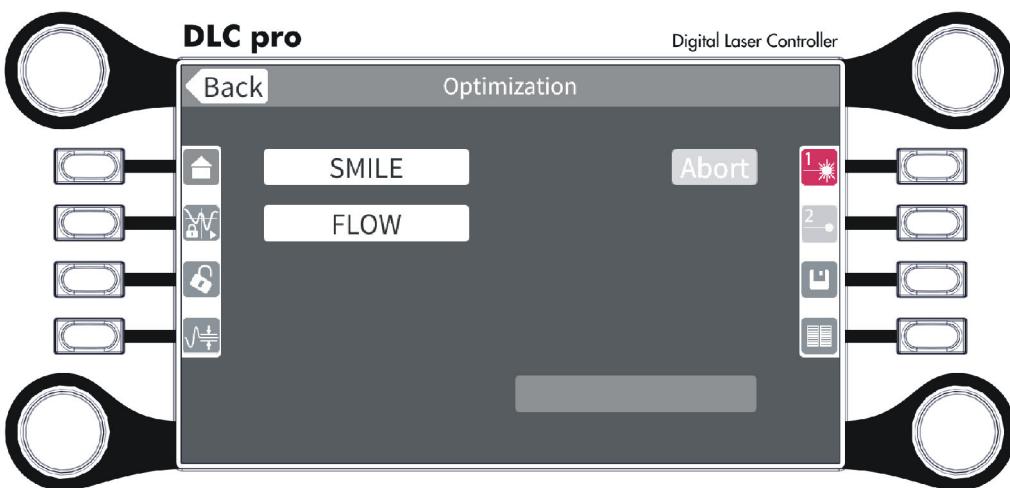


Figure 18 Optimization screen (DLC CTL)

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 (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.

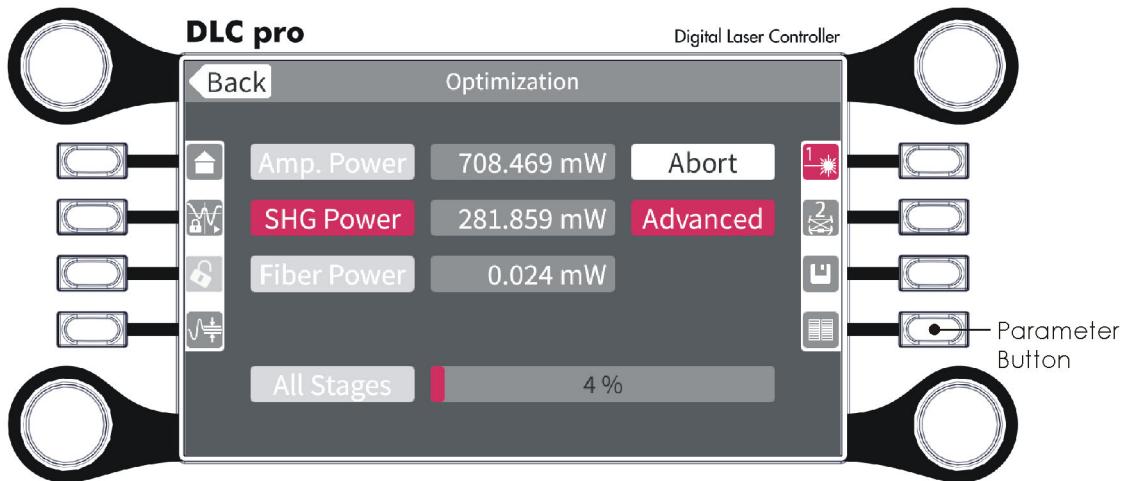


Figure 19 Optimization screen (example DLC DL-/TA-FHG pro system with AutoAlign option)

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.

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 5.2.7.1) 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

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)

5.2.8 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.

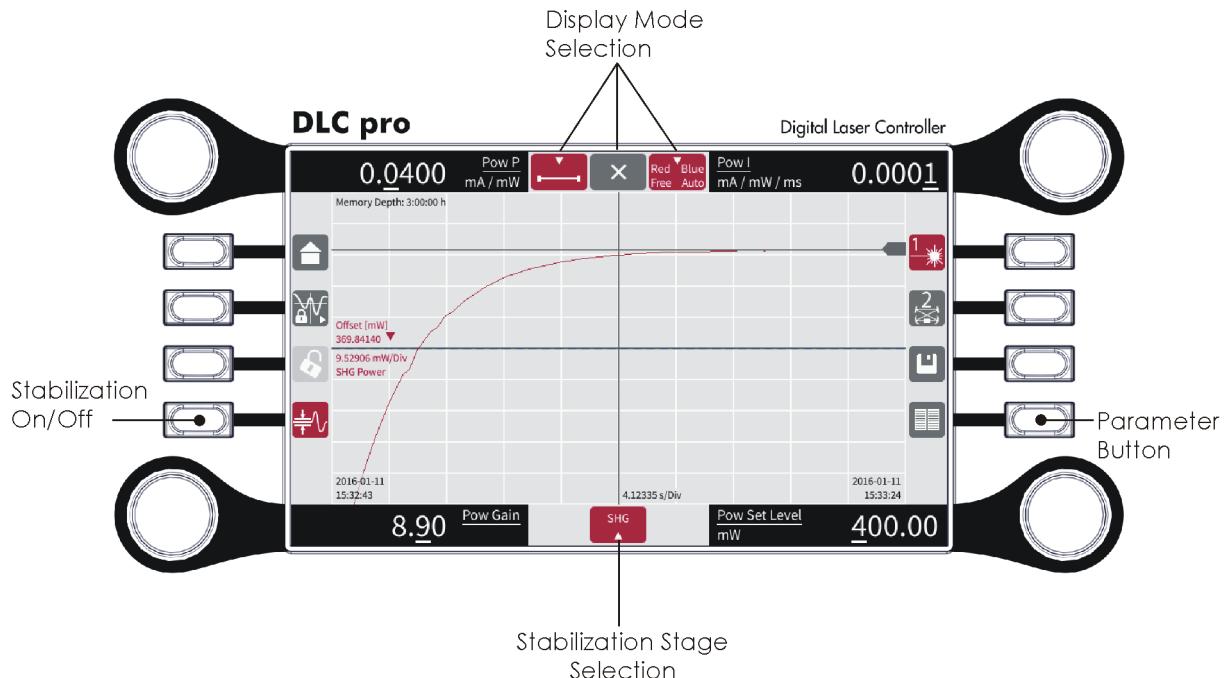


Figure 20 Stabilization screen (example DLC TA-SHG pro)

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 5.2.8.1) 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).

5.2.8.1 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* μ s]

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 ChannelSelect 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 separate 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 10.18). If purchased along with the DLC pro, the licence is already installed. Otherwise a 30-day trial licence is provided on the USB flash drive in the Options Folder.

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 feedback 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 21).



Scan

Scan: Parameters for the scan function.



Lockpoint: Parameters for identifying lock point candidates. Tap the desired **Lockpoint Candidate** to select it. The selection is indicated by an additional red circle as shown in Figure 22.

NOTE ! When **Lock Settings > Lock Without Lockpoint** is enabled in the context parameter menu, no lock point 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.

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 21).



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 21).

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.

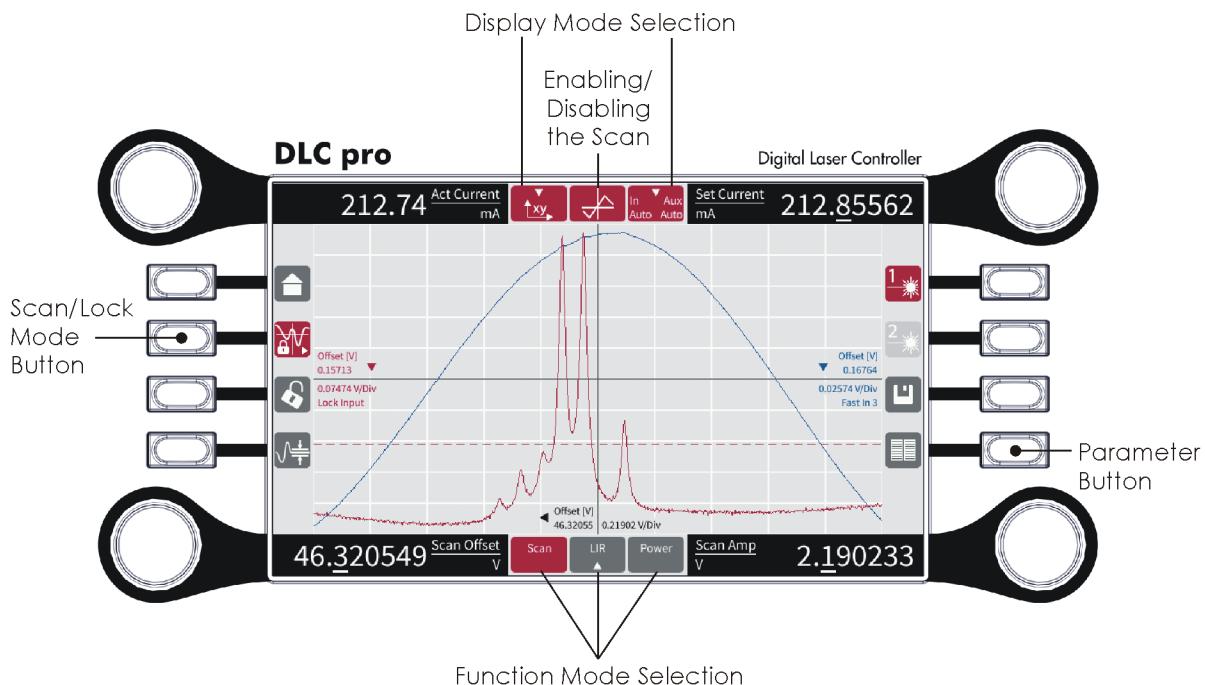


Figure 21 Touchscreen in Scan function mode (example)

Enter Scan function mode by pressing the **Scan/Lock Mode** button several times until display and rotary knob assignment change as shown in Figure 21 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 5.7 and 5.8).

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.

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 in the context parameter menu (please refer to section 5.3.8).

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 **Top left parameter > Actual Current**.
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 6.19) or via software commands (see section 10.12).

<code>laser-common:scan:sync-laser1/2</code>	Select the lasers to be synchronized.
<code>laser-common:scan:frequency</code>	Enter the common scan frequency.
<code>laser-common:scan:sync</code>	When the command is executed, the scan generators of all selected lasers are set to the common scan frequency.
<code>laser-common:scan:save</code>	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 separate 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 10.18). If purchased along with the DLC pro, the licence is already installed. Otherwise a 30-day trial licence is provided on the USB flash drive in the Options Folder.

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 lock point 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.

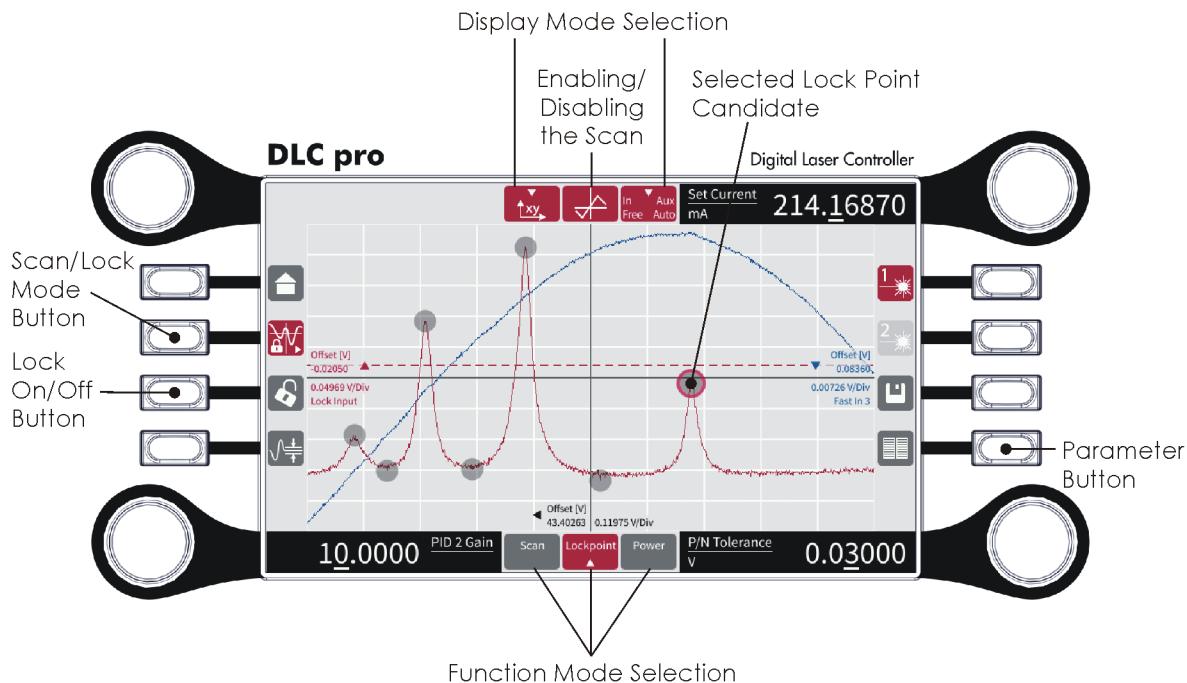


Figure 22 Touchscreen in Lockpoint function mode (example). Lock point candidates for Top of Fringe lock type shown

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 22 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 5.7 and 5.8).

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 lock point 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, CTL Power	Laser diode current is controlled
TA pro:	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

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 5.6). 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 5.2.8). 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 5.7 and 5.8) 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 5.6) 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 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 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 **Top left parameter** in the context parameter menu:
Feed Forward [mA/V]
[mA/K] only DLC DFB pro and laser systems with DFB pro Master Oscillator
Set Temperature [$^{\circ}$ C] for optimization,
Display of **Actual Current** [mA].
Amplifier Set Current [mA] (only DLC TA pro).
Amplifier Feed Forward [mA/V] (only DLC TA pro).
Scan Offset [V] if laser is scanned with piezo.
This parameter is displayed in X-direction on the touchscreen.
- **Bottom-left:** Laser Diode **Set Current** [mA].
- **Top-right:** **Scan Amplitude** [V] if laser is scanned with piezo.
- **Bottom-right:** 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 lock point with or without lock point candidates.
Side of Fringe lock type: In the **xy** signal display mode, lock point candidates are displayed where the signal crosses the displayed **Lock Level**.
Top of Fringe lock type: no function.
- **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 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.

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.
- **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:** No function.
- **Bottom-right:** **Mod Amp [dBm]**: Amplitude of the modulation signal.

5.3.7.7 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]

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]

Scan Output

Select scan output channel

["PC Voltage", 50], ["CC Current", 51], ["Out A", 20], ["Out B", 21]

["TC Set Temperature", 56] only DLC DFB pro and laser systems with DFB pro Master Oscillator

laser1:scan:output-channel (integer)

Scan Shape

Select scan shape

["Triangle", 1], ["Sine", 0]

laser1:scan:signal-type (integer)

Feed Forward (DLC TA pro 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 10.9.1 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)

CC

Analog CC remote control

Please refer to section 10.9.1 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 10.9.1 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 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
 Actual output power in [mW]
 laser1:amp:pd:amp:power (real)

Minimum Output Power

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

Maximum Output Power

Enter maximum output power of the TA pro
 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)

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)

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)

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]
 laser1:dl:lock:pid1:output-channel (integer)

Sign Positive

Select on for positive, off for negative

[1: on], [0: off]

laser1:dl:lock:pid1:sign (boolean)

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]
laser1:dl:lock:pid2:output-channel (integer)

Sign Positive

Select on for positive, off for negative
[1: on], [0: off]
laser1:dl:lock:pid2:sign (boolean)

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.

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* μ s]

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)

Actual Level

Actual power level [mW]

laser1:power-stabilization:input-channel-value-act (real)

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 ChannelSelect 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 6.17.3)

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 6.17.3)

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 Aln1], [52], [CC Aln2], [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

[Amp. Current], [63], [AMP Aln], [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)

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 Aln1], [52], [CC Aln2], [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

[Amp. Current], [63], [AMP Aln], [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)

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: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 10.10 for further information on the pressure compensation.

Pressure Comp. Voltage

Shows pressure compensation voltage

laser1:dl:pressure-compensation:compensation-voltage (real)

Top Left Parameter

Select the top left parameter in Scan function mode

Only DLC DL pro: ["None"], ["Feed Forward"], ["Set Temperature"], ["Actual Current"]

Only DLC TA pro and DLC TA-SHG/FHG pro: ["None"], ["Actual Master Current"],
["Master Feed Forward"], ["Master Set Temperature"], ["Amplifier Current"],
["Amplifier Feed Forward"]

Only DLC CTL: ["Actual Current"], ["Set Wavelength"]

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 10.18).
- 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.

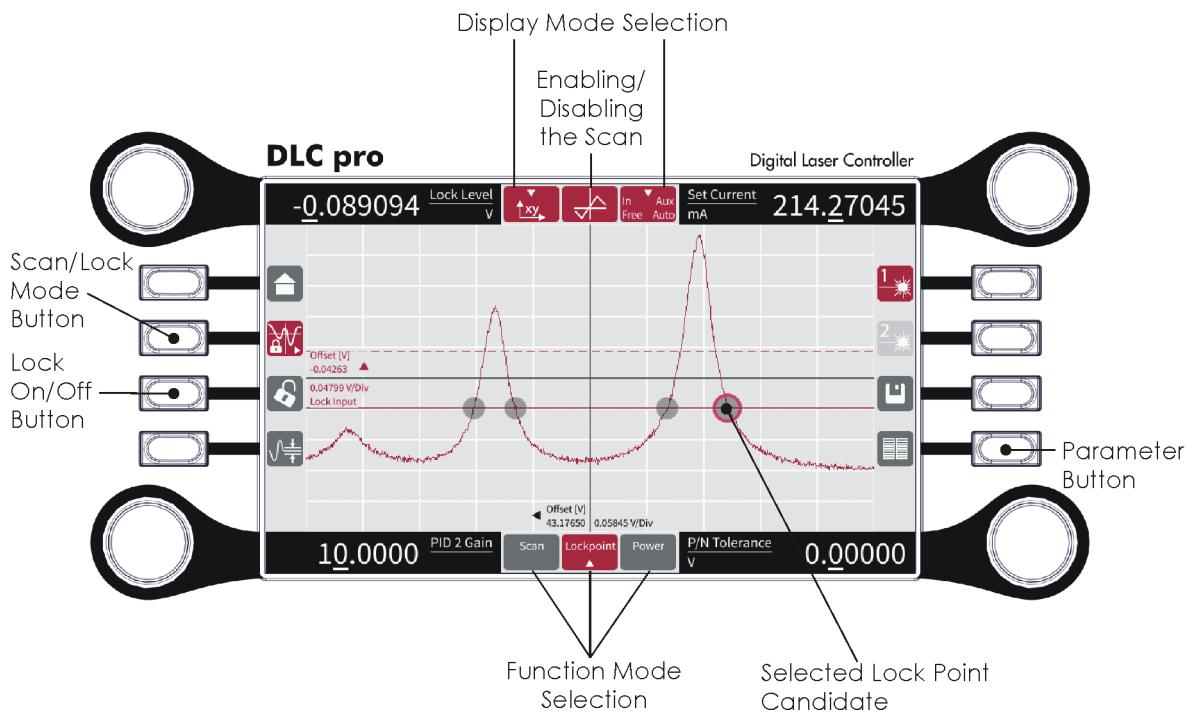


Figure 23 Touchscreen in Lockpoint function mode; lock point candidates for Side of Fringe lock type (example)

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 lock point (**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 lock point and the lock point in the spectrum is clearly visible on the display.

NOTE ! The current lock voltage level is displayed as a red line. Lock point 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 lock point candidates:** Select the lockpoint by tapping on the **Lock point Candidate**. For a clearer display, unwanted lock point candidates can be deselected in the context parameter menu (**Lock Settings > Positive-Edge/Negative-Edge Lock Candidates**).

Locking without lock point 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 5.5).
Locking with lock point candidates: The laser scans to the selected lock point. When the scan reaches the lock point, the scan stops, and the PID controller(s) switch on.
10. **Locking without lock point 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 modes by tapping on the **PID** symbols.

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 68).

To unlock the laser:

1. Press the **Lock On/Off** button or tap the corresponding symbol (see section 5.5). The PID controller(s) switch(es) OFF, and the scan starts again.

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 6.9) 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.

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 10.18).
- **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.

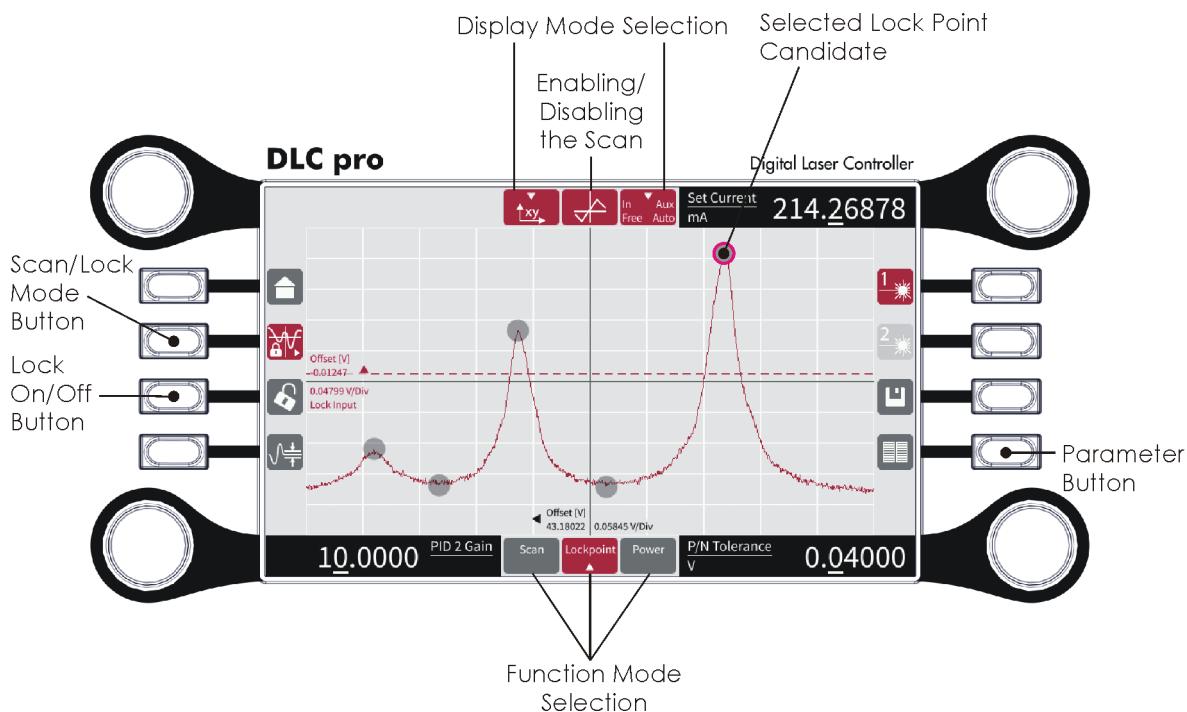


Figure 24 Touchscreen in Lockpoint function mode; lock point candidates for Top of Fringe lock type (example)

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**) 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.
 Lock point 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 lock point (**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 lock point 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**).

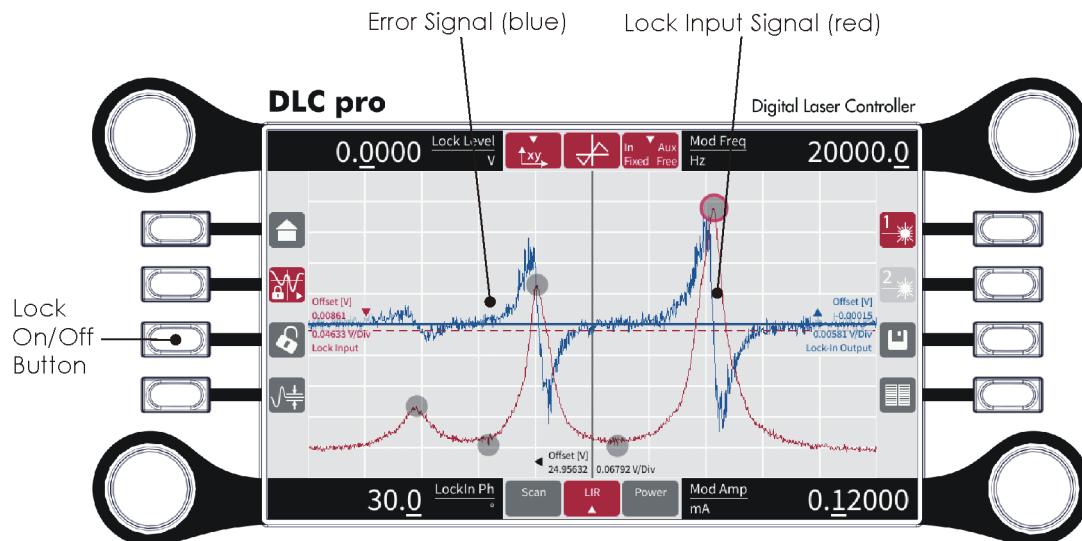


Figure 25 Error signal (blue) and Lock Input signal (red) displayed in LIR lock function mode

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:
 - Lock point is in signal valley: rising flank of the blue Error signal.
 - Lock point 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 lock point candidates: Select the lock point by tapping on the **Lockpoint Candidate**. For a clearer display, unwanted lock point candidates can be deselected in the context parameter menu (**Lock Settings > Peak/Trough Lock Candidates**).

Locking without lock point 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 5.5).
Locking with lock point candidates: The laser scans to the selected lock point. When the scan reaches the lock point, the scan stops, and the PID controller(s) switch on.

Locking without lock point 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 68).

To unlock the laser:

1. Press the **Lock On/Off** button or tap the corresponding symbol (see section 5.5).
The PID controller(s) switch(es) off, and the scan starts again.

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 27). 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 26).

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.

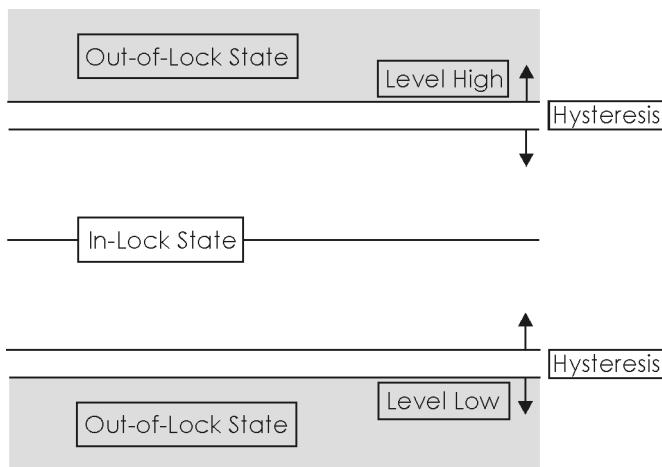


Figure 26 ReLock window

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 \geq **Level Low + 2 x Hysteresis**.

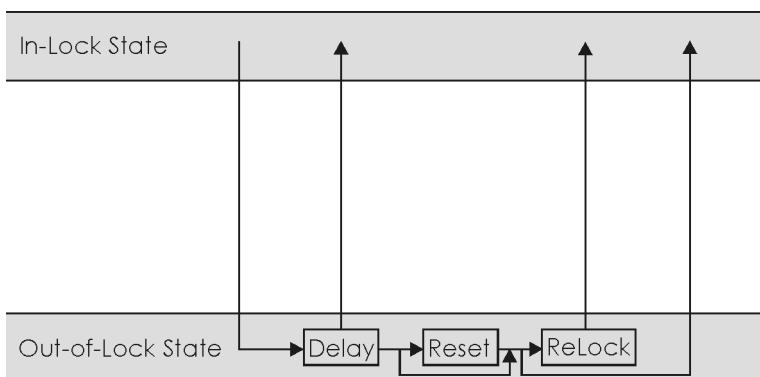


Figure 27 DLC pro ReLock procedure (schematic)

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).

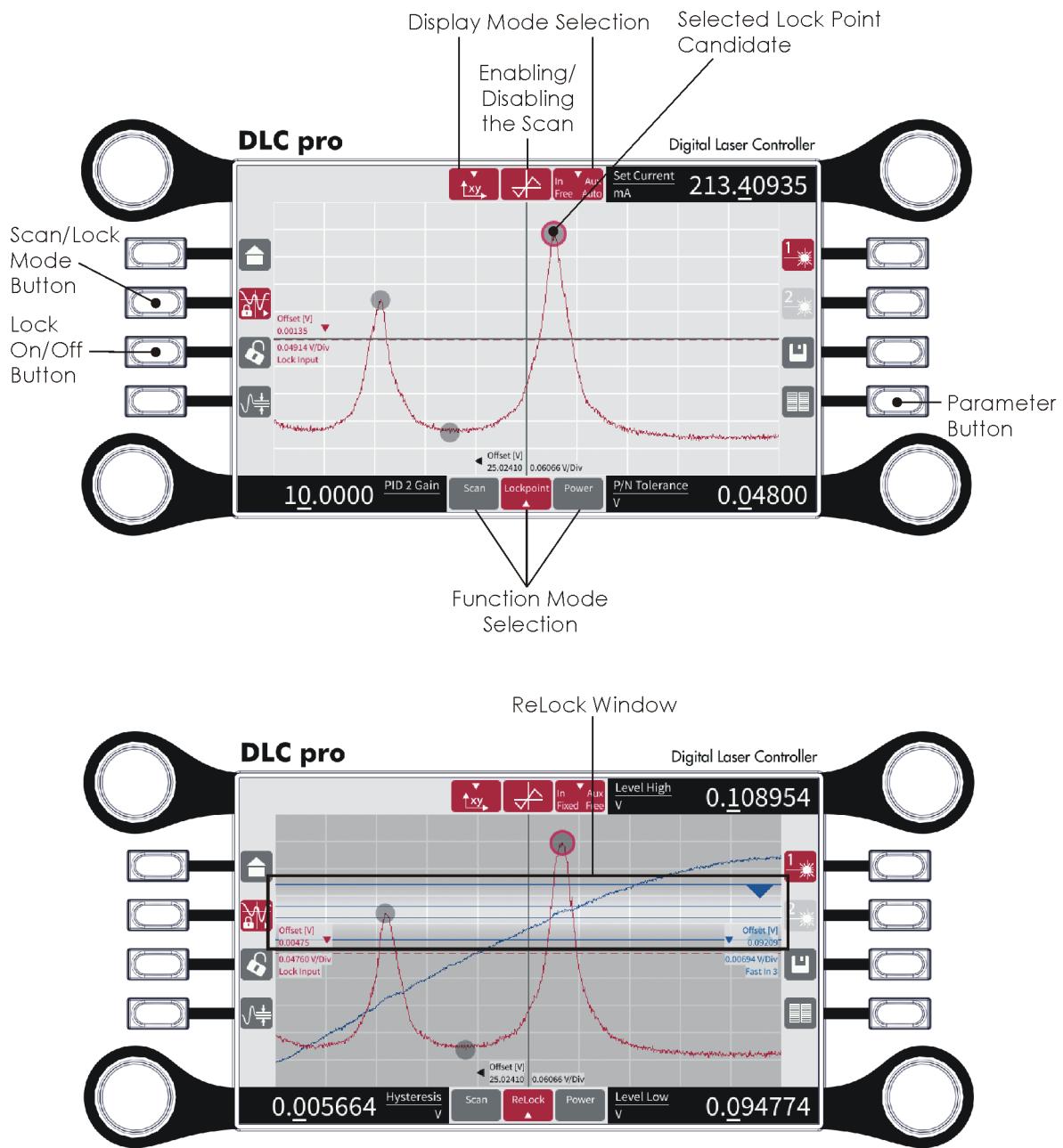


Figure 28 Touchscreen in ReLock function mode; lock point candidates for Top of Fringe lock type shown and ReLock window for out-of-lock detection (example)

- 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.

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 6.9 and 6.12.1).

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 29 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.

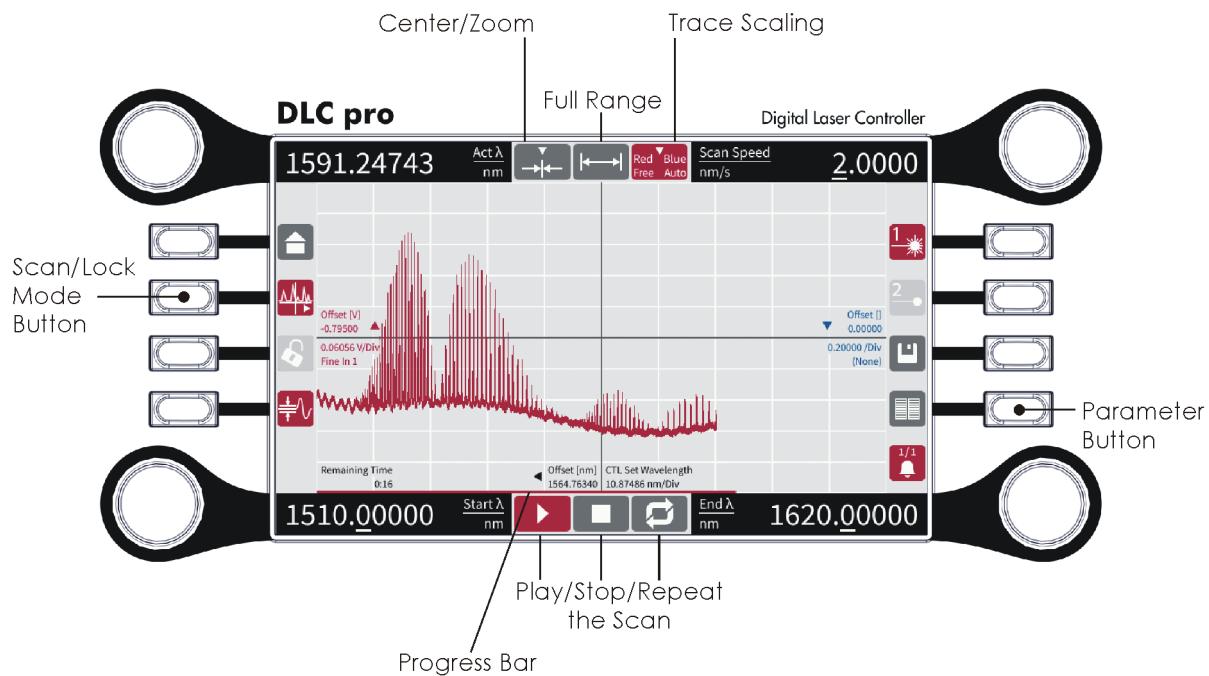


Figure 29 Touchscreen in Wide Scan mode (example DLC CTL)

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 **Top right parameter** in the context parameter menu:
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 29). 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 29).



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 analogue 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 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 μ K.

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**, approx. 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**. Also, when the scan is finished, microsteps are disabled as the motor cannot stop on a microstep. 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 10.8.4)
 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 10.8.4)
 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 5.11);
 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 10.9.1 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 10.9.1 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 10.9.1 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 10.9.2 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 Aln1", 52], ["CC Aln2", 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

- ["Amp. Current", 63], ["AMP Aln", 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 Aln1", 52], ["CC Aln2", 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

- ["Amp. Current", 63], ["AMP Aln", 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)

Top Right Parameter

Select the parameter to show in the top right corner

["Scan Speed"], ["Act value of the parameter to be scanned"], ["Set Current"]

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 30) 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 2nd harmonic generation.



FHG Cavity: The cavity **index 4** at the front panel controls symbolizes the FHG cavity for the 4th 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 30). Please refer to the DL-/TA-SHG/FHG pro manual for details on setting the parameters.

Scan

Scan: Parameters for the SHG/FHG cavity scan.

ReLock

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

PID Slow

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.

NOTE !

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

PDH

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 30).

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).

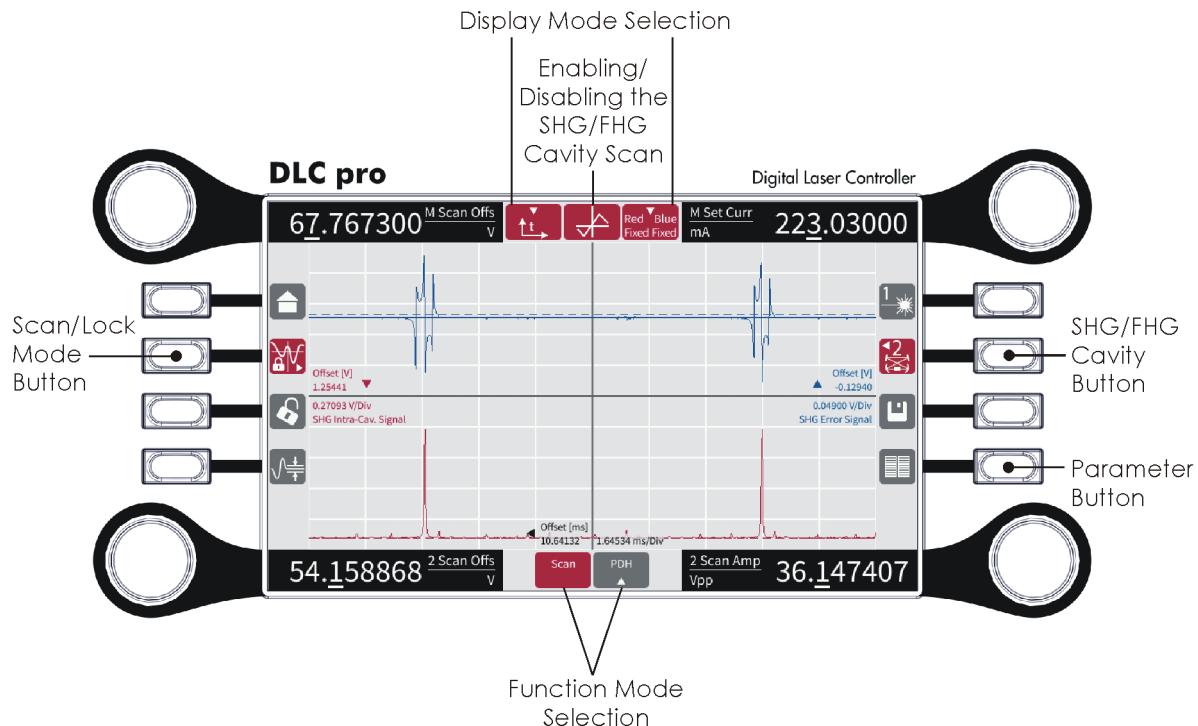


Figure 30 Touchscreen in SHG Cavity Scan function mode (example DLC DL-/TA-FHG pro)

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 30 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.

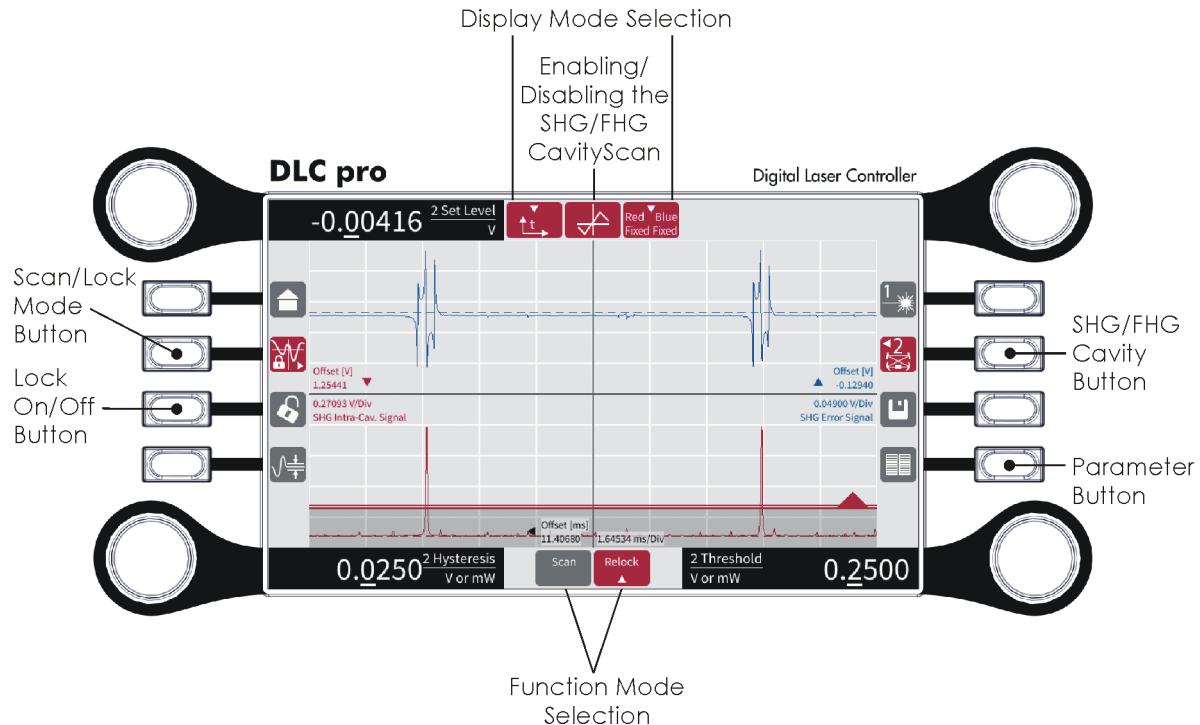


Figure 31 Touchscreen in SHG Cavity ReLock function mode (example DLC DL-/TA-FHG pro)

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 31. 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 2nd harmonic generation. The cavity **index 4** at the front panel controls symbolizes the FHG cavity for the 4th harmonic generation.

5.4.6.1 Scan Rotary Knobs

Parameter settings for the SHG/FHG Cavity Scan function mode.

- **Top-left:** As selected by **Top left parameter** in the context parameter menu:
M Scan Offs [V]: Scan offset for the Master Oscillator scan.
Amp Curr [mA]: Tapered Amplifier set current.
2/4 Set Temp [$^{\circ}$ C]: SHG/FHG crystal set temperature.
- **Bottom-left:** **2/4 Scan Offs** [V]: SHG/FHG cavity scan offset.
- **Top-right:** As selected by **Top right parameter** in the context parameter menu:
M Set Curr [mA]: Master Oscillator set current,
2/4 Act Temp [$^{\circ}$ C]: Display of the SHG/FHG crystal temperature.
- **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 μ s]: 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**.

- **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

Enter 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

Enter 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 AmplitudeSelect 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 [V_{pp}]

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 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**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)

Top Left Parameter

Select the top left parameter in Scan Function mode

["None"], ["Master Scan Offset"], ["SHG Crystal Set Temperature"]

Only DLC TA-SHG/FHG pro ["Amplifier Set Current"]**Top Right Parameter**

Select the top right parameter in Scan Function mode

["None"], ["Master Set Current"], ["SHG Crystal Act Temperature"]

5.5 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 lock point 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 5.7 and 5.8) by tapping the lock point 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 lock point concept but locks the SHG/FHG PC voltage to a cavity resonance close to the center of the SHG/FHG PC voltage range.

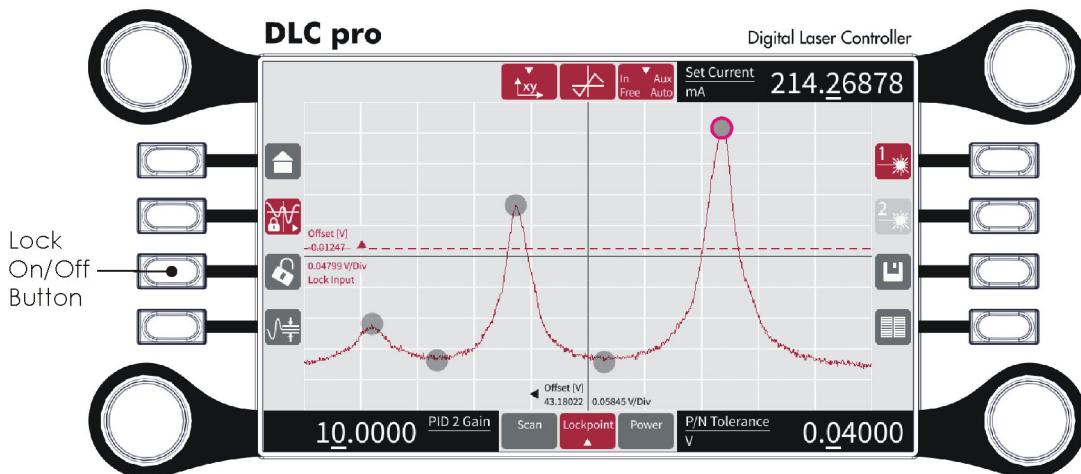


Figure 32 Touchscreen in Scan/Lock mode, laser unlocked (example)

5.5.1 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.

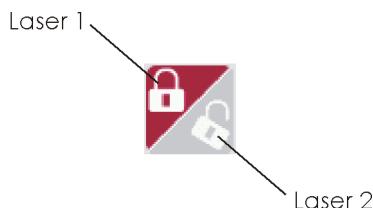


Figure 33 Lock On/Off button with Dual-Laser-Operation and Lock option installed

Lock the selected laser (**Laser 1/Laser 2** buttons, see section 5.7 and 5.8) by tapping the lock point 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.

5.6 Stabilization On/Off

NOTE ! Please refer to sections 5.2.8 and 5.3.6 for detailed information on the power stabilization.

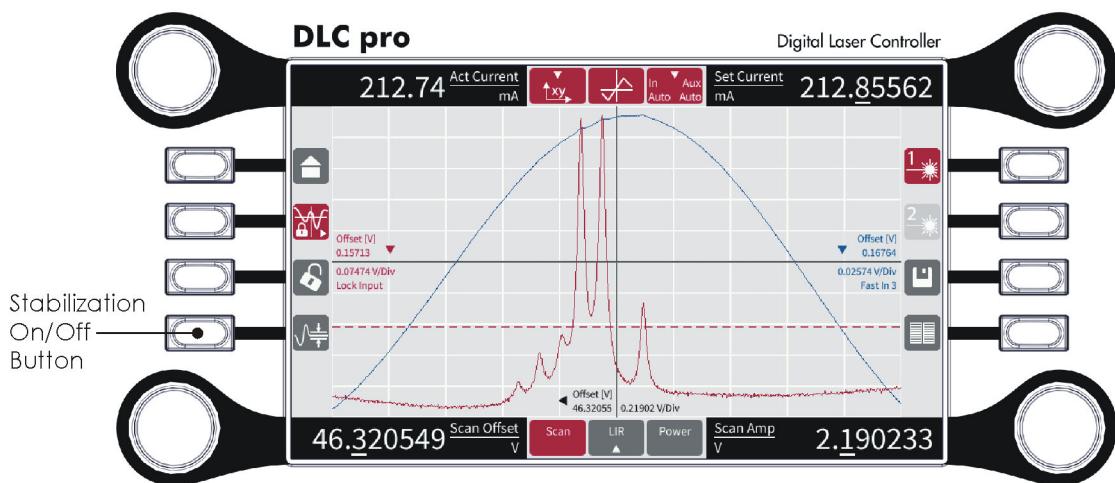


Figure 34 Stabilization On/Off button

Lock the power of the selected laser (**Laser 1/Laser 2**, see section 5.7 and 5.8) 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.

5.6.1 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.

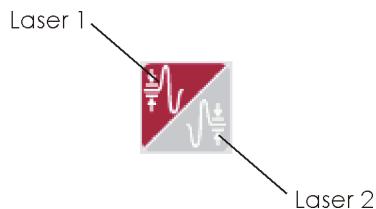


Figure 35 Stabilization On/Off symbol at a DLC pro for Dual-Laser-Operation

Lock the power of the selected laser (**Laser 1/Laser 2** push buttons, see section 5.7 and 5.8) 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.

5.7 Laser 1

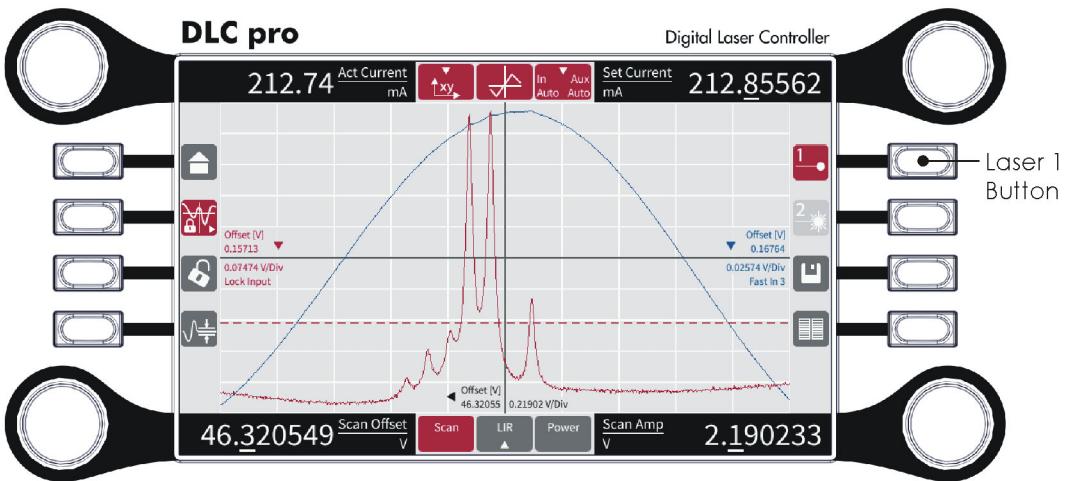


Figure 36 Touchscreen in Scan/Lock mode, Laser 1 selected (example)

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 37 (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**.



Figure 37 Laser 1 selected (left) and enabled for laser emission (right)



Figure 38 Laser 1 not selected and not enabled (left)
Laser 1 not selected **but enabled for laser emission** (right)

5.8 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 10.5 and 10.6. The license key must be activated via the TOPAS DLC pro PC-GUI (please refer to section 10.18). If purchased along with the DLC pro, the licence and the hardware is already installed.

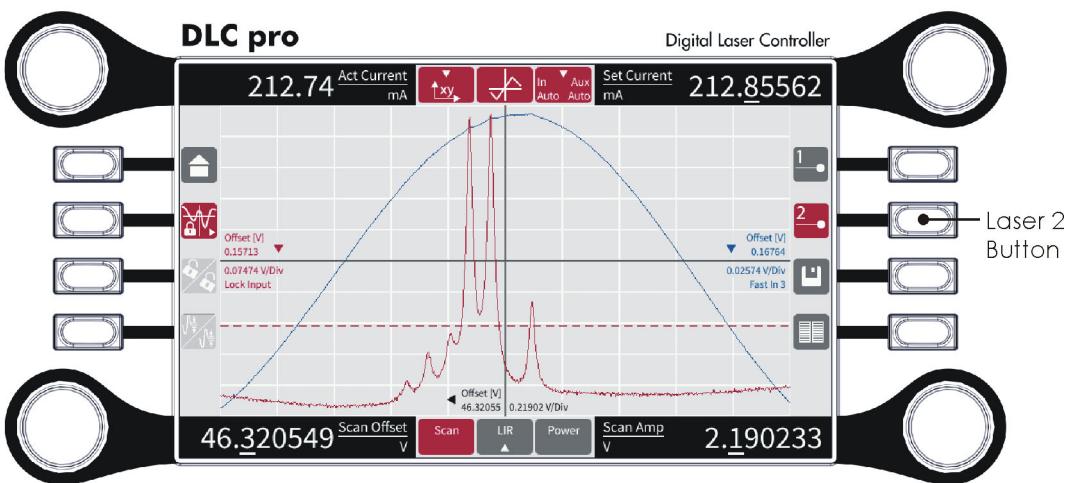


Figure 39 Touchscreen in Scan/Lock mode, Laser 2 selected (example)

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.

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 40 (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 40 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 41 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)

5.9 SHG/FHG Cavity

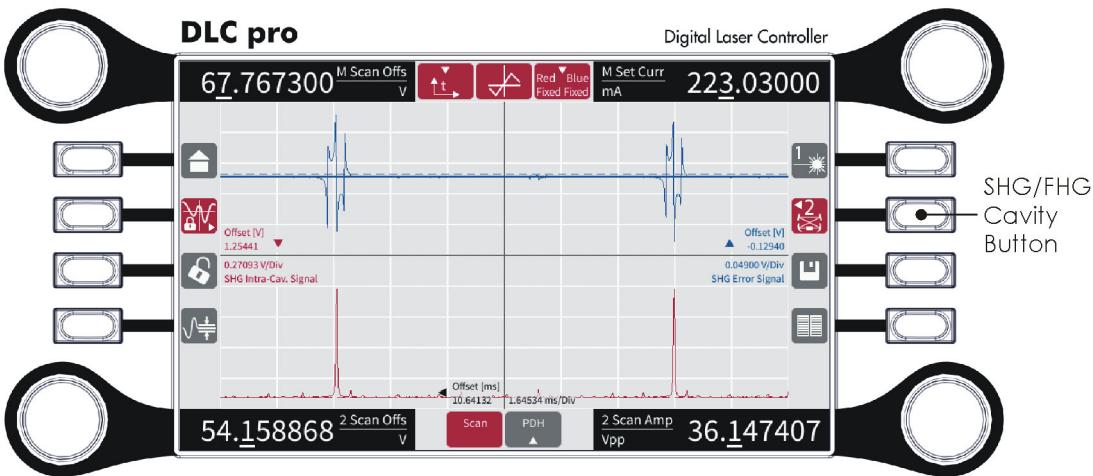


Figure 42 Touchscreen in SHG Cavity Scan/Lock mode, SHG Cavity selected (example DLC DL-TA-FHG pro)

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 2nd harmonic generation.

FHG Cavity

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

5.10 Load/Save

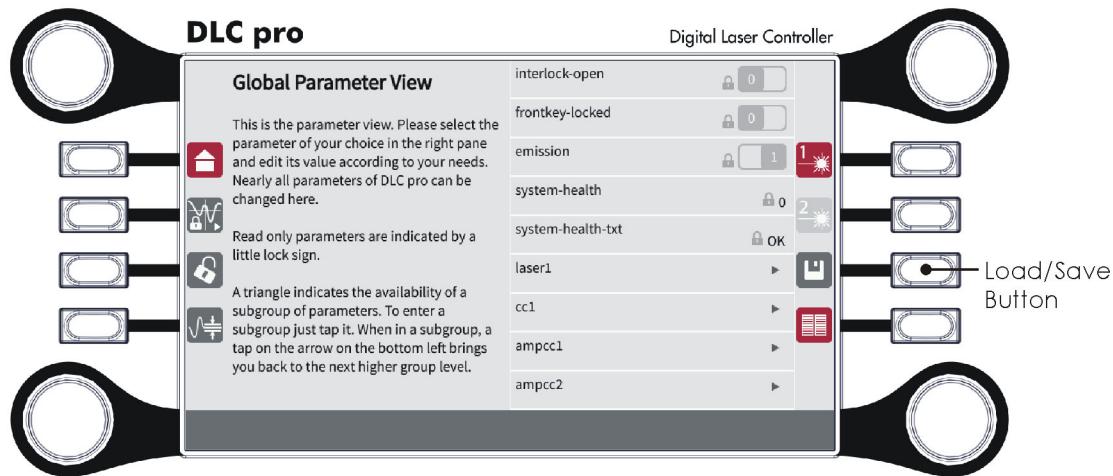


Figure 43 Load/Save button

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 5.10.1).
- 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 5.11) 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 44) 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 10.11 for details.

5.10.1 Configuration Manager

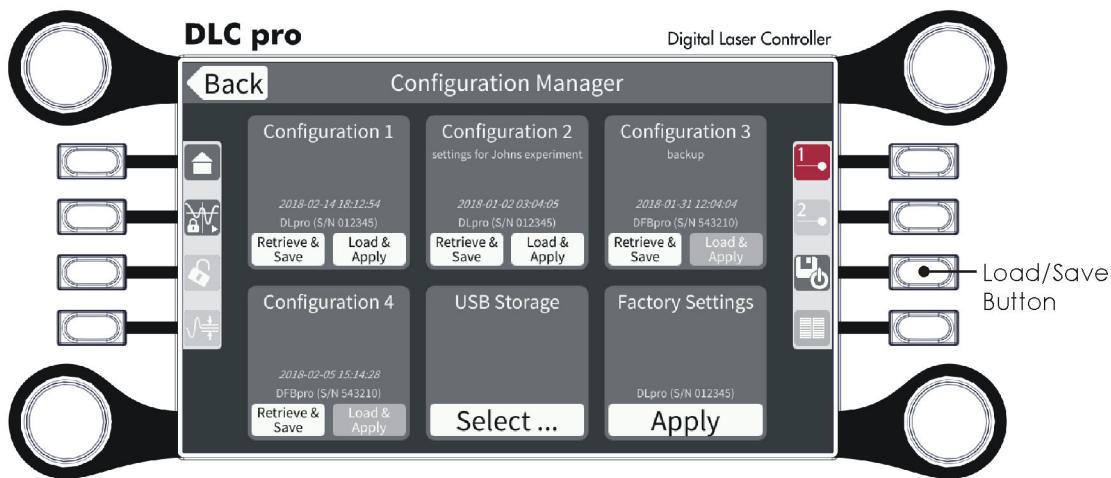


Figure 44 Configuration Manager

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 Manager 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.

The Configuration Manager screen shows six sections:

- Four device parameter configurations which are stored on the DLC pro (**Configuration 1 .. 4**).
- A section (USB Storage, see Figure 45) for selecting configurations from a USB flash drive connected to the USB connector on the DLC pro front panel.
- A section for loading the factory settings.

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 6.9), 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.

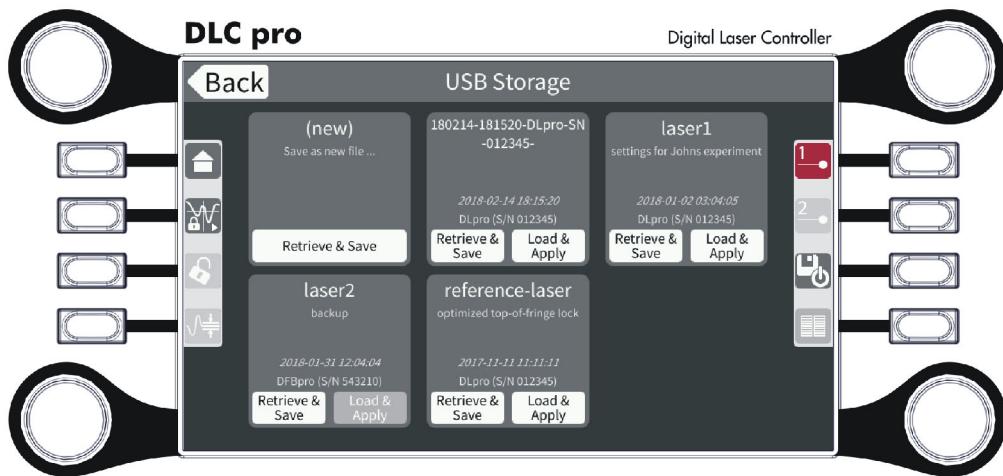


Figure 45 Configuration Manager, USB Storage window

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 6.9), 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.

5.11 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.

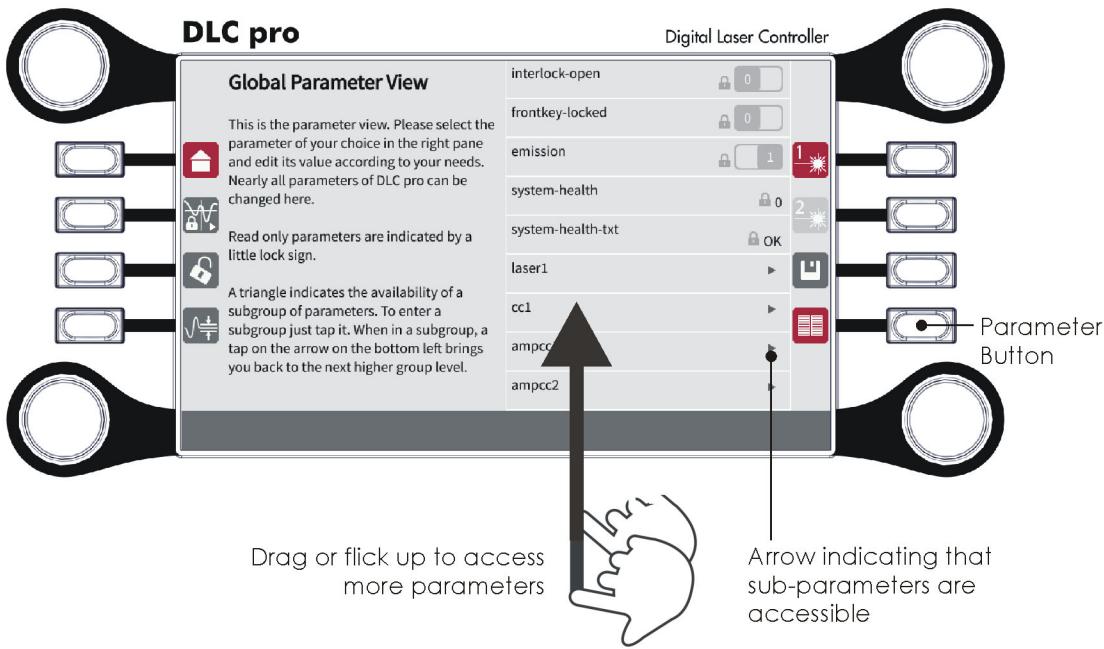
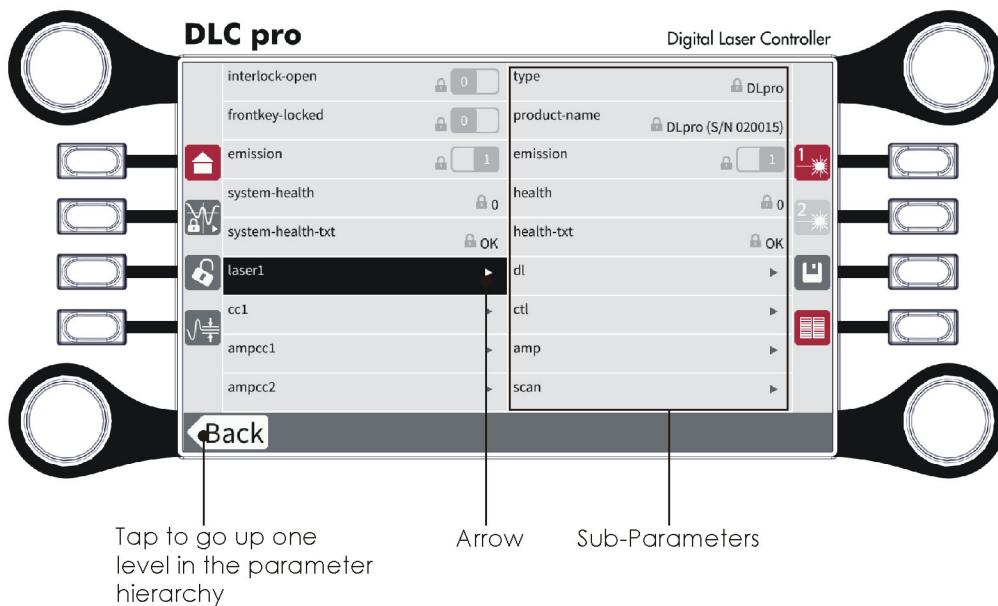


Figure 46 Touchscreen showing the parameter menu (example)

Press the **Parameter** button or tap the corresponding symbol to open the parameter menu on the touchscreen to check and/or change the desired settings.

- The full parameter menu is displayed on the Home screen. A context parameter menu 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 47). 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.

**Figure 47** 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 7, 8, 8.1 or 10 operating system
- Min. 1-GHz-Processor
- Min. 1 GB RAM
- Min. 100 MB memory available on hard-disk
- Recommended screen resolution: 1920x1200
- Depending on the Windows setup, it might be necessary to log in with administrator rights

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.

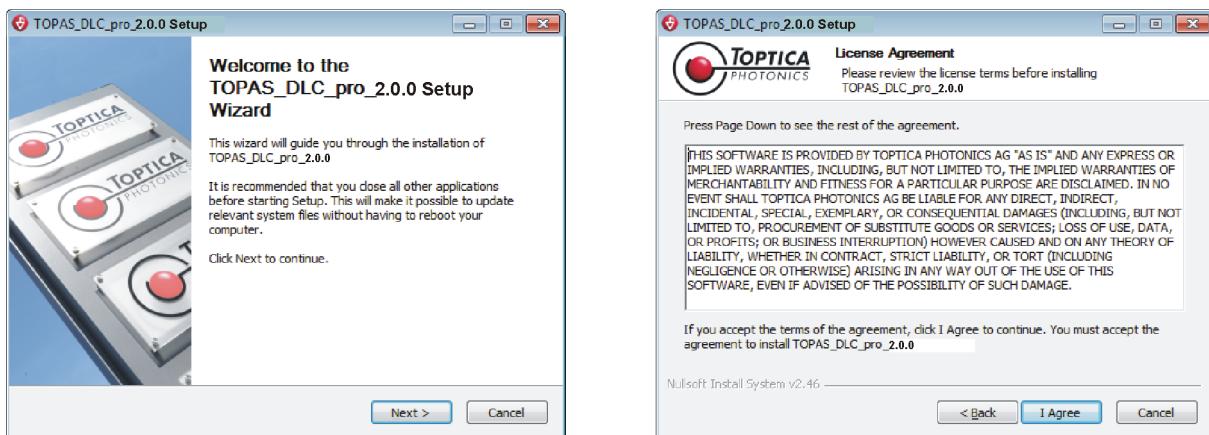


Figure 48 Installation and license agreement screen

Start the installation and confirm the license agreement by clicking **I Agree**.

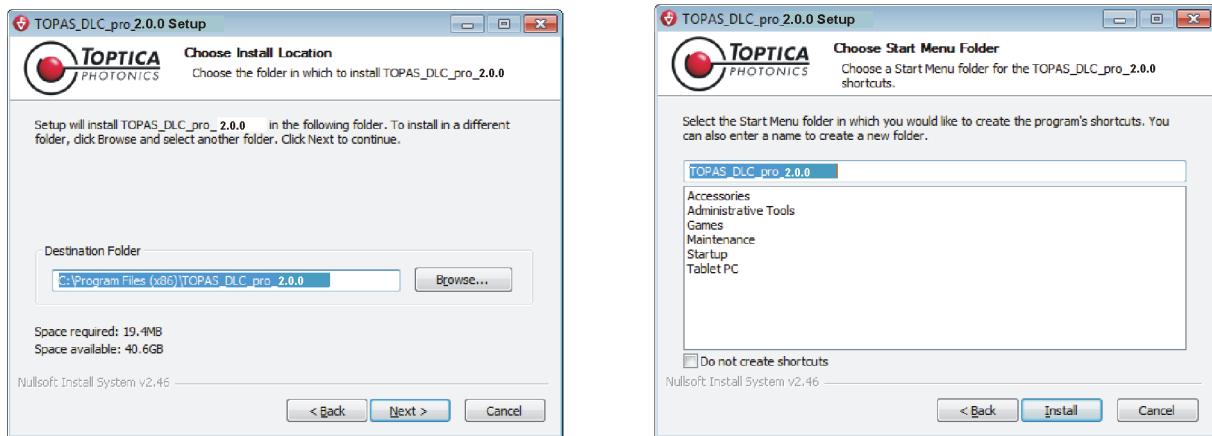


Figure 49 TOPAS DLC pro folder selection screen

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 49 right) you may choose the name of the program folder which is created in the start menu. Click **Install** to continue.

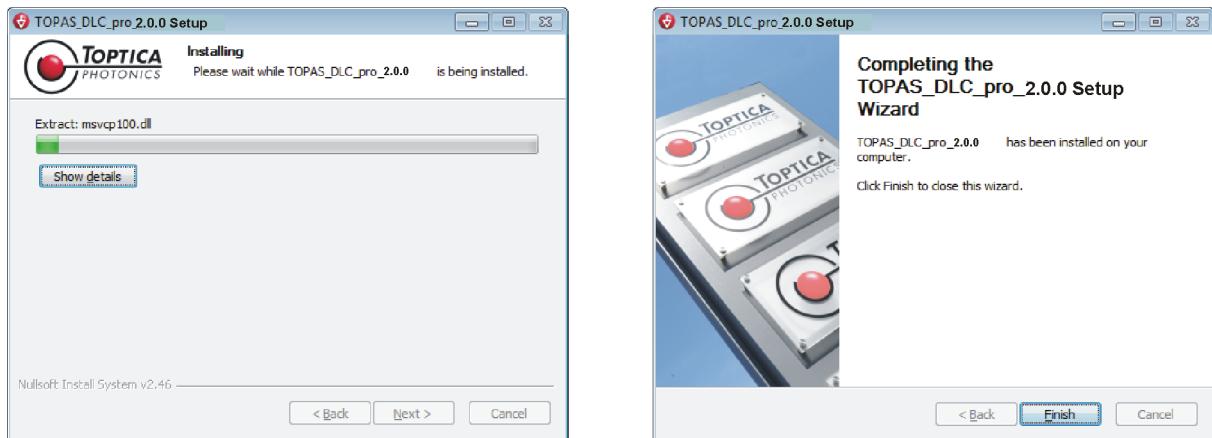


Figure 50 Finishing the installation

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

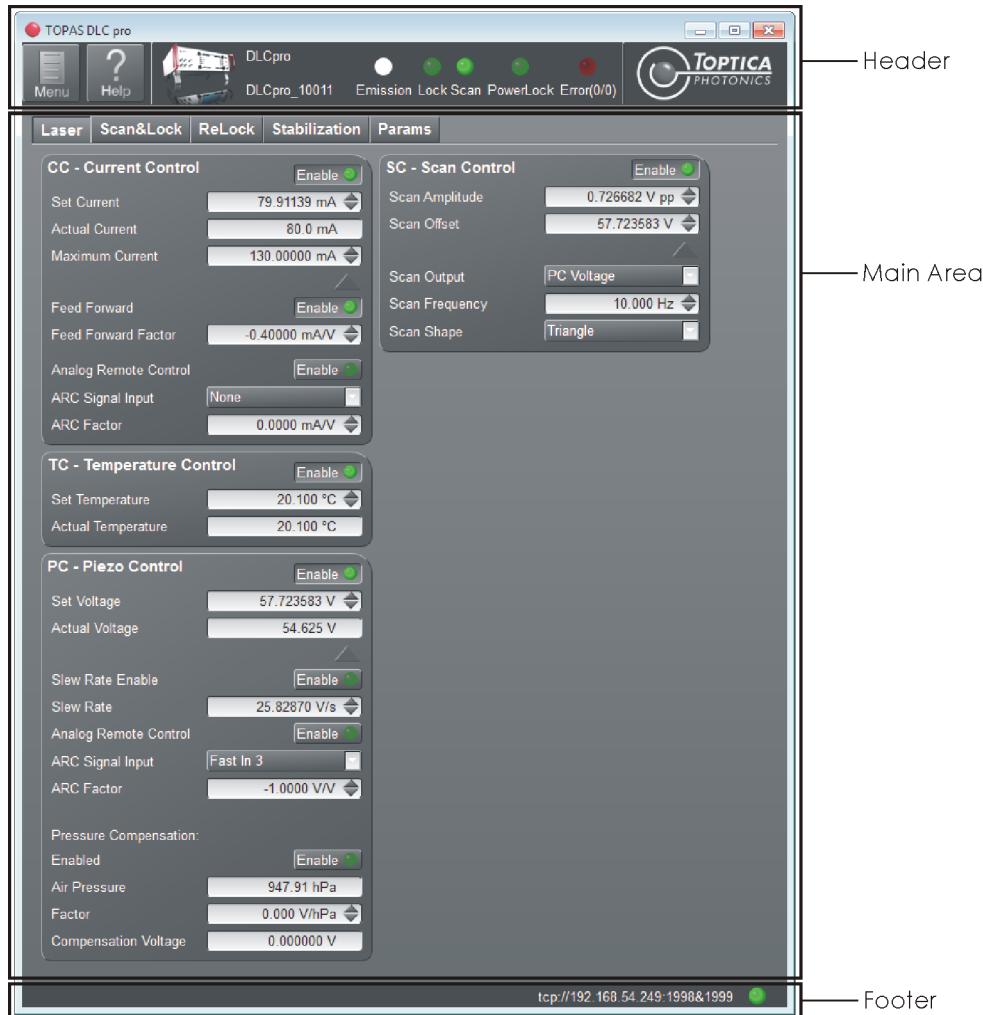


Figure 51 Screen areas

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 10.5 and 10.6. The license key must be activated via the TOPAS DLC pro PC-GUI (please refer to section 10.18). If purchased along with the DLC pro, the licence and the hardware is already installed.

The Digital Laser Controller DLC pro is capable to control two laser heads of the type DL pro or DFB pro. 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 52 General display section at the top

Menu	For information about the Menu, please refer to section 6.9.
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	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: <ul style="list-style-type: none">- 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 55). Clicking on the error indicator opens a window where error messages are displayed. The content of the window can be saved as a .txt file by clicking Export .

6.6 Header at a DLC pro for Dual-Laser-Operation



Figure 53 General display section at the top

Menu	For information about the Menu, please refer to section 6.9.
Help	For information about the Help function, please refer to section 6.9.
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 55). Clicking on the error indicator opens a window where error messages are displayed. The content of the window can be saved as a .txt file by clicking Export .

6.7 Header (DLC DL-/TA-SHG/FHG pro)



Figure 54 General display section at the top (example DLC DL-/TA-FHG pro)

Menu	For information about the Menu, please refer to section 6.10.
Help	For information about the Help function, please refer to section 6.9.
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 55).

Clicking on the error indicator opens a window where error messages are displayed.

The content of the window can be saved as a .txt file by clicking **Export**.

6.8 Footer



Figure 55 Communication display section in the footer

Error Message

When an error occurs, the error message and the error 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.

6.9 Menu

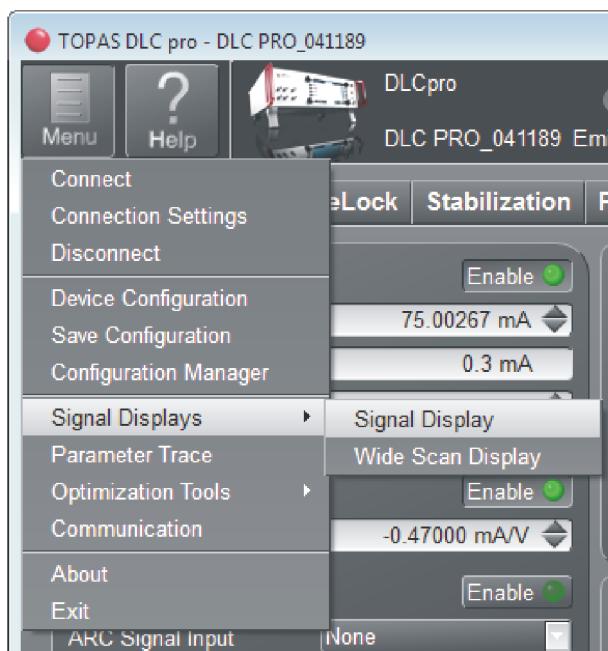


Figure 56 TOPAS DLC pro menu (example)

> Menu > Connect

Establishes a connection to the device selected in the Connection Settings window.

> Menu > Connection Settings

The Connection Settings window (see Figure 57) opens for configuring the connection settings.

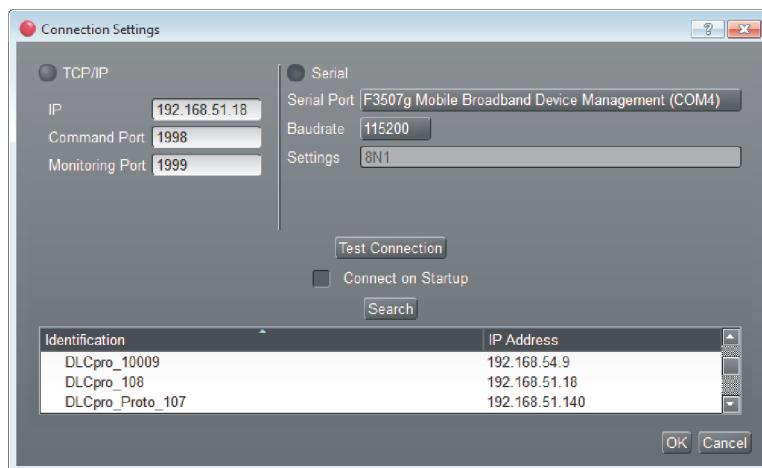


Figure 57 Connection Settings window

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, an error 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

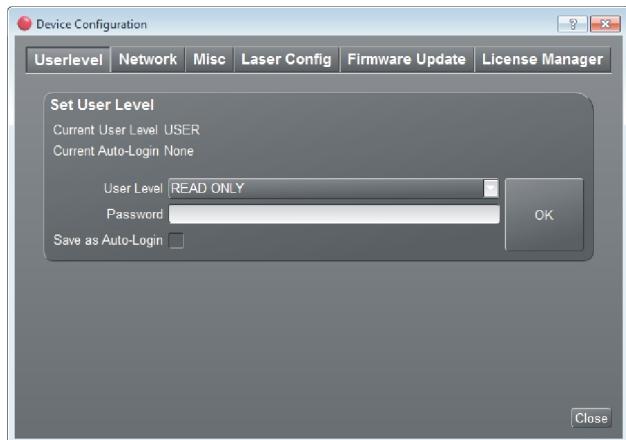


Figure 58 Device Configuration Window User Level Section

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, 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 ! 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

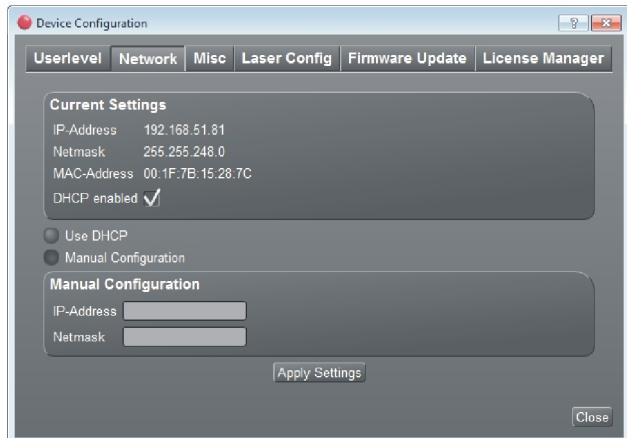
Password Input field for entering the password required for the respective user level.
READ ONLY: No password required.
USER: No password required. Please refer to section 4.8.1 for introducing a password for the USER level.
MAINTENANCE: For password please refer to the Production and Quality Control 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 59** 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").

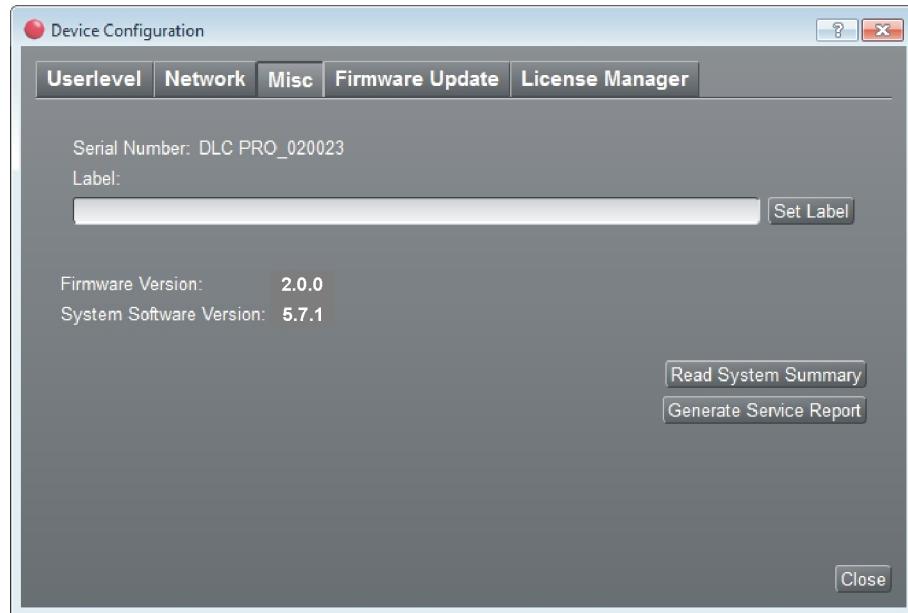
Apply Settings

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 60** Device Configuration Window Misc Section**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.

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 57) !

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.

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.

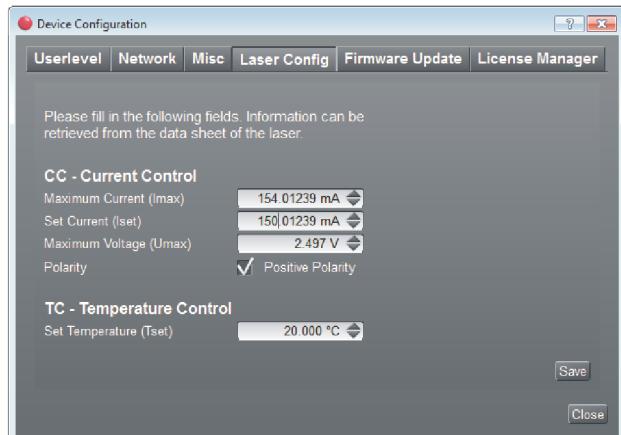


Figure 61 Device Configuration Window Laser Configuration Section (DLC DL pro/DLC DFB pro)

The Laser Configuration Section allows configuration of the laser heads. Depending on whether the laser has an EEPROM or not (please refer to sections 4.5.4 and 4.5.5), 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

Set Current I_{set} Input Field for set current.

Maximum Voltage U_{max} Input Field for maximum voltage.
Only laser heads without EEPROM (please refer to section 4.5.5):
Please set the U_{max} value to the Voltage (DLC pro) specified in section 05 of the laser head Production and Quality Control Data Sheet.

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

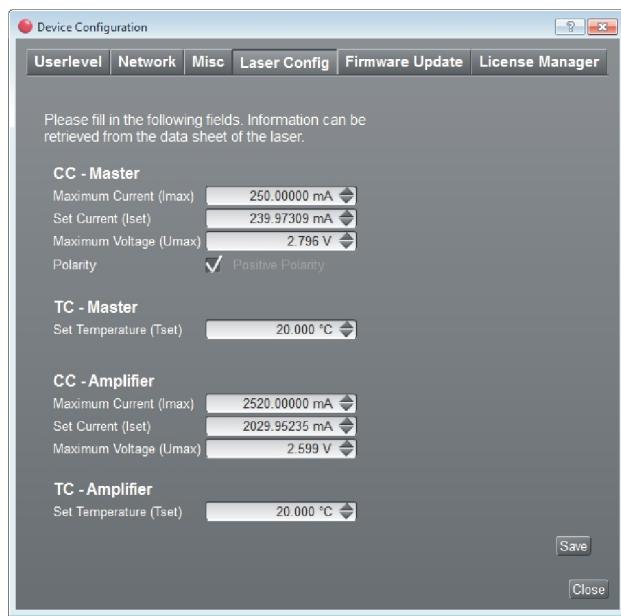


Figure 62 Device Configuration Window Laser Configuration Section (DLC TA pro)

The Laser Configuration Section allows configuration of the laser head. Depending on whether the laser has an EEPROM or not (TA pro with EEPROM from SN 25000 on), 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
Set Current I_{set}	Input Field for set current.
Maximum Voltage U_{max}	Input Field for maximum voltage. Only TA pro laser heads without EEPROM (SN up to 24999): Please set the U_{max} value to the Voltage (DLC pro) specified in section 1.3 of the TA pro Production and Quality Control Data Sheet.
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
Set Current I_{set}	Input Field for set current.
Maximum Voltage U_{max}	Input Field for maximum voltage. Only TA pro laser heads without EEPROM (SN up to 24999): Please set the U_{max} value to the Voltage (DLC pro) specified in section 1.4 of the TA pro Production and Quality Control Data Sheet.
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 10.16.2.

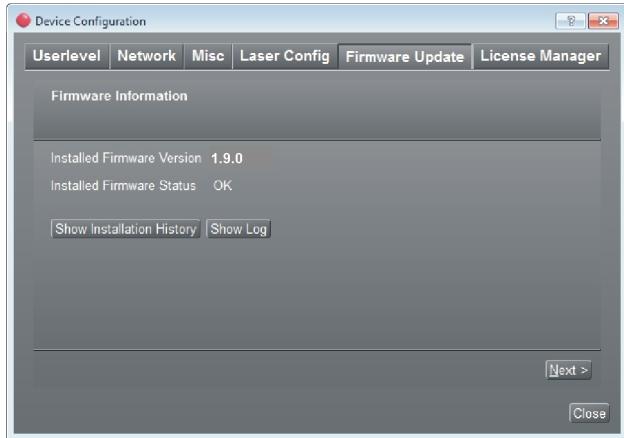


Figure 63 Device Configuration Window Firmware Update Section

- | | |
|----------------------------------|--|
| 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. |

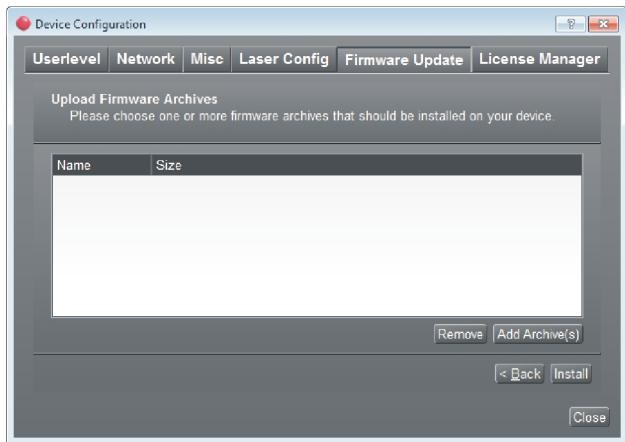


Figure 64 Firmware Update Archives Window

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 10.18.

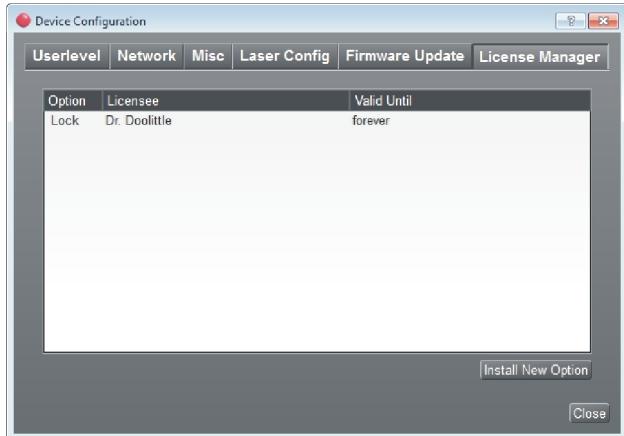


Figure 65 Device Configuration Window License Manager Section

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.

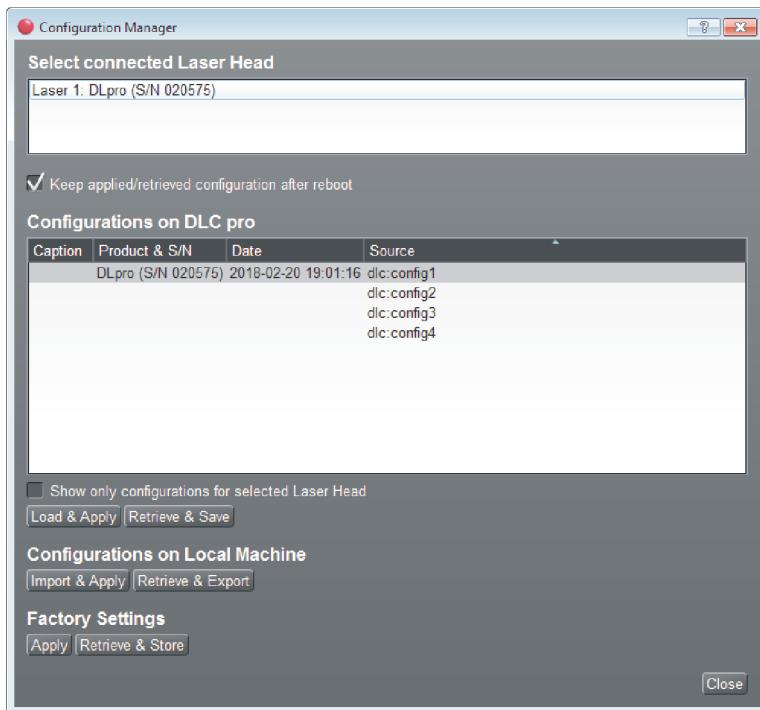


Figure 66 Configuration Manager Window

The Configuration Manager 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.

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 6.9).

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 separate 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 10.18).

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.

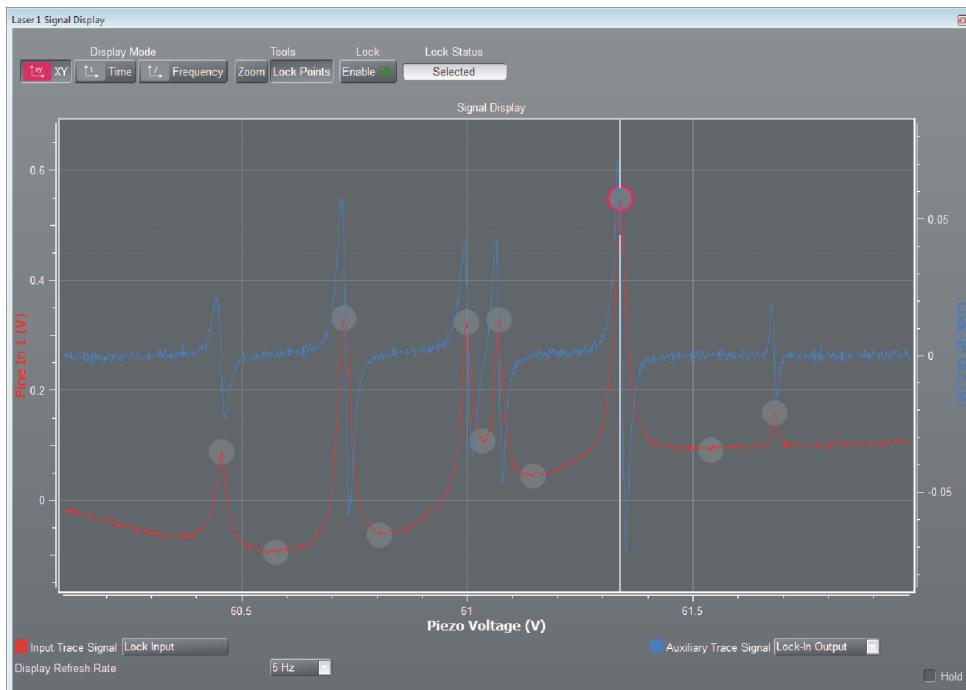


Figure 67 Signal Display showing the Lock Input signal (Input Trace Signal, red) and the Lock-In Output signal (Auxiliary Trace Signal, blue) for Top of Fringe locking and lock point candidates (example)

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 **LockPoints** Tool for showing and selecting lock points, etc. (for details please refer to section 6.13.1). 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 lock point 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 68).

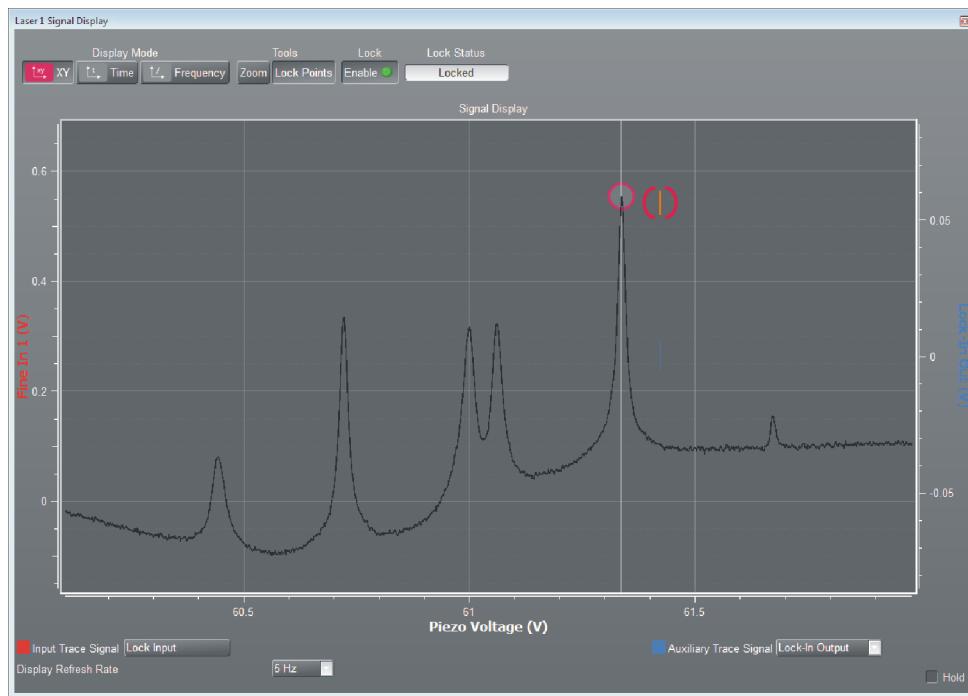


Figure 68 Signal Display when the laser is locked (example)

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.

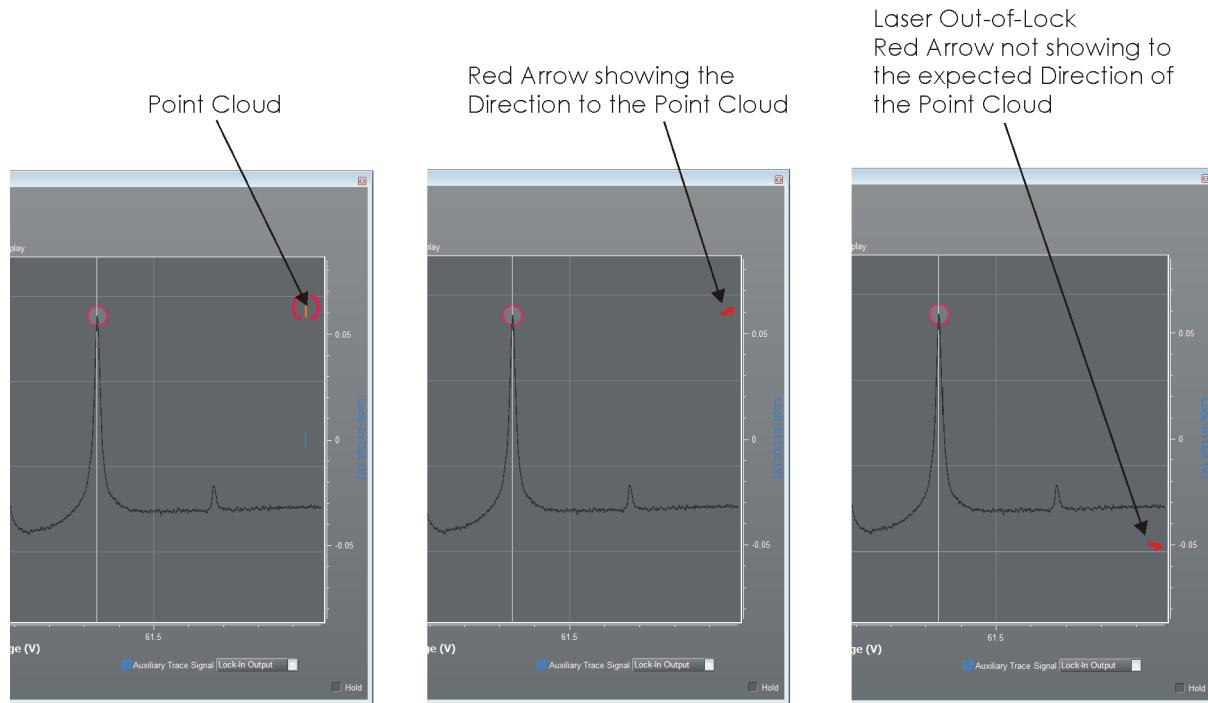


Figure 69 Red arrows showing the direction to the Lock Input signal point cloud

Right clicking in the graph area allows you to configure the graph appearance (color and thickness of traces, etc.). 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 lock points, etc. (please refer to section 6.13.1). 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: Lock point candidates are displayed.

Selected: Lock point candidate is selected.

Locking: Lock is enabled, lock point not reached, yet.

Locked: Laser is locked to the selected lock point.

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 update rate for the Signal Display.

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 70 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 6.12.1), do not use the screen display for analysis, as it shows artifacts.
The full resolution of all recorded data points can be exported 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 6.12.1).
	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 6.12.1).
	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 analogue 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 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 6.12.1) 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 6.19).

It is possible to zoom into the recorded data while the scan is still in progress. Use the **Full Range** button (see section 6.12.1) 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 6.12.1) 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 6.12.1) 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 μ K.

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.

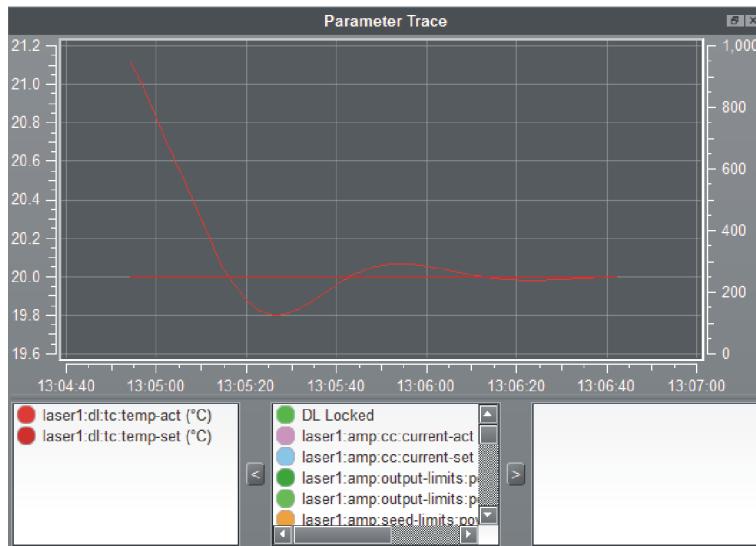


Figure 71 Parameter Trace Window

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 separate 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 10.18).

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 67) and a series of windows which guide you through the steps described in sections 5.3.10, 6.13.3 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.

> **Menu > Communication**

Adds the Communication window to the main area of the screen.

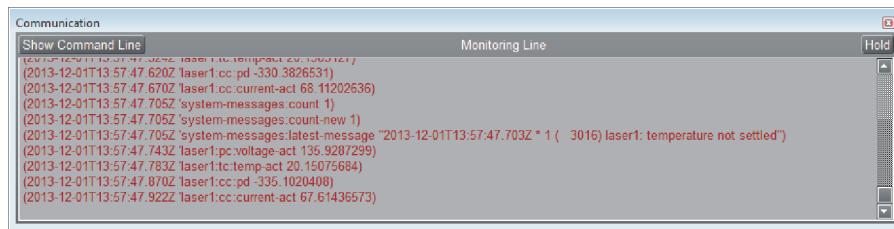


Figure 72 Communication Window

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**.

6.10 Menu (DLC DL-/TA-SHG/FHG pro)

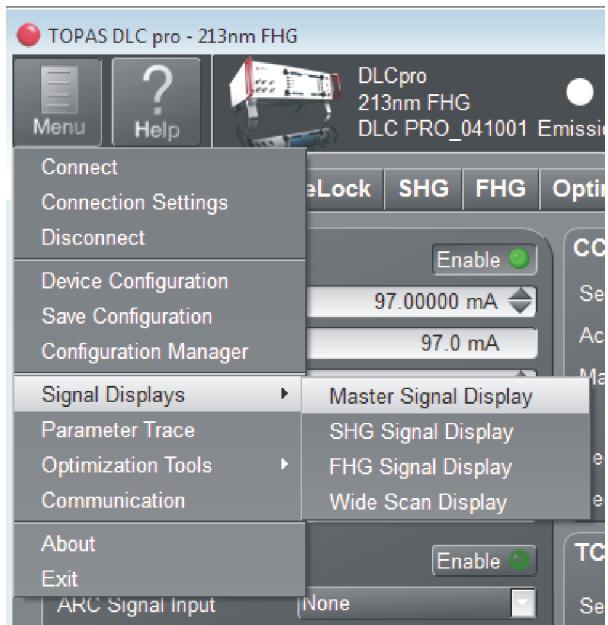


Figure 73 Menu (example DLC DL-/TA-FHG pro)

The standard TOPAS DLC pro menu is described in section 6.9. 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 6.9).

> 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.

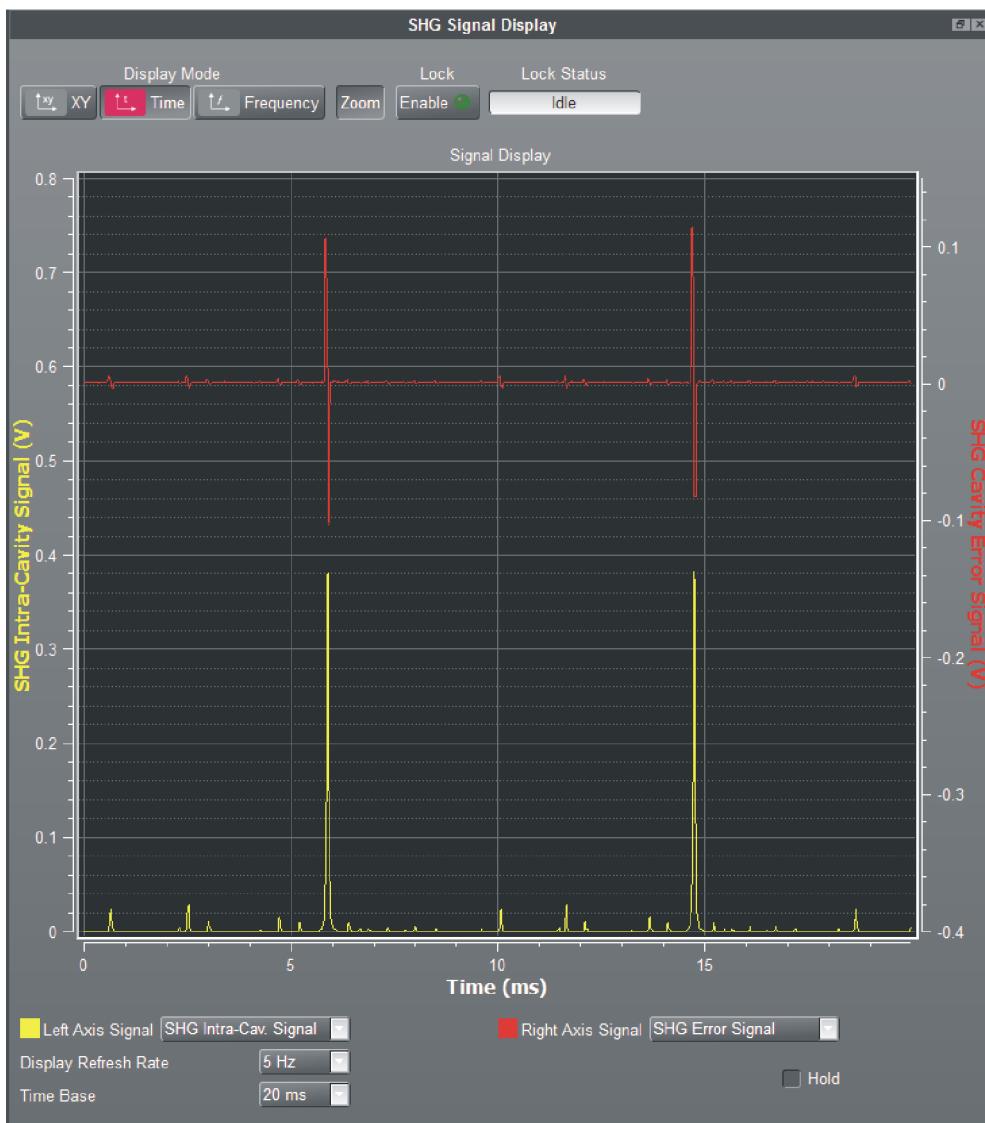


Figure 74 Example: SHG Signal Display (DLC DL-/TA-SHG pro) showing the SHG Intra-Cavity Signal (yellow trace) and the SHG Error Signal (red Trace)

Please refer to the Signal Display description in section 6.9. 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 6.9).

> 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)).

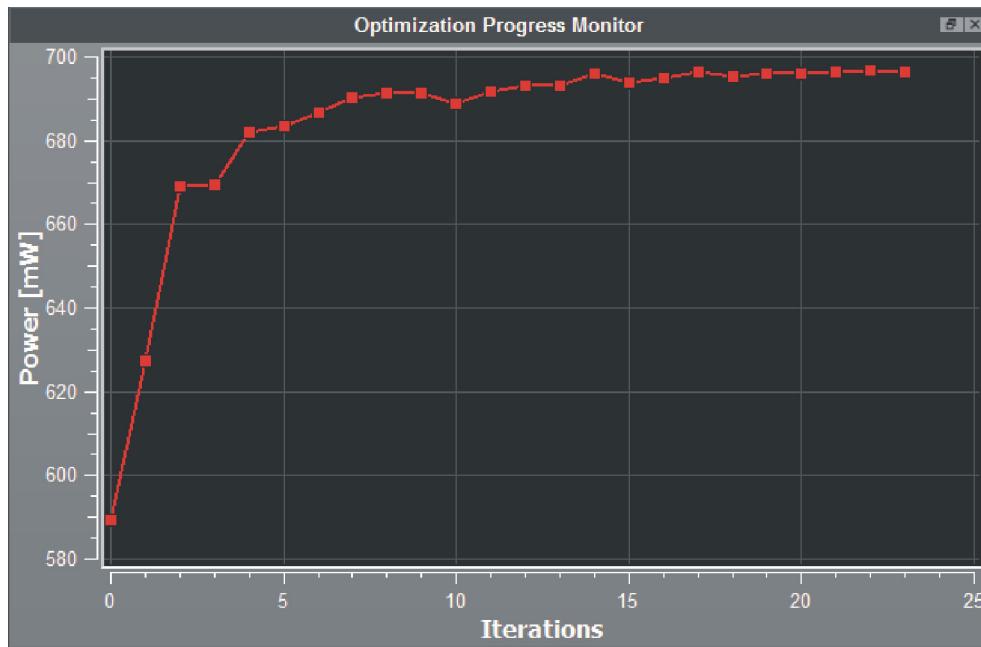


Figure 75 Optimization Progress Monitor window (DLC DL-/TA-SHG/FHG pro with AutoAlign option)

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.

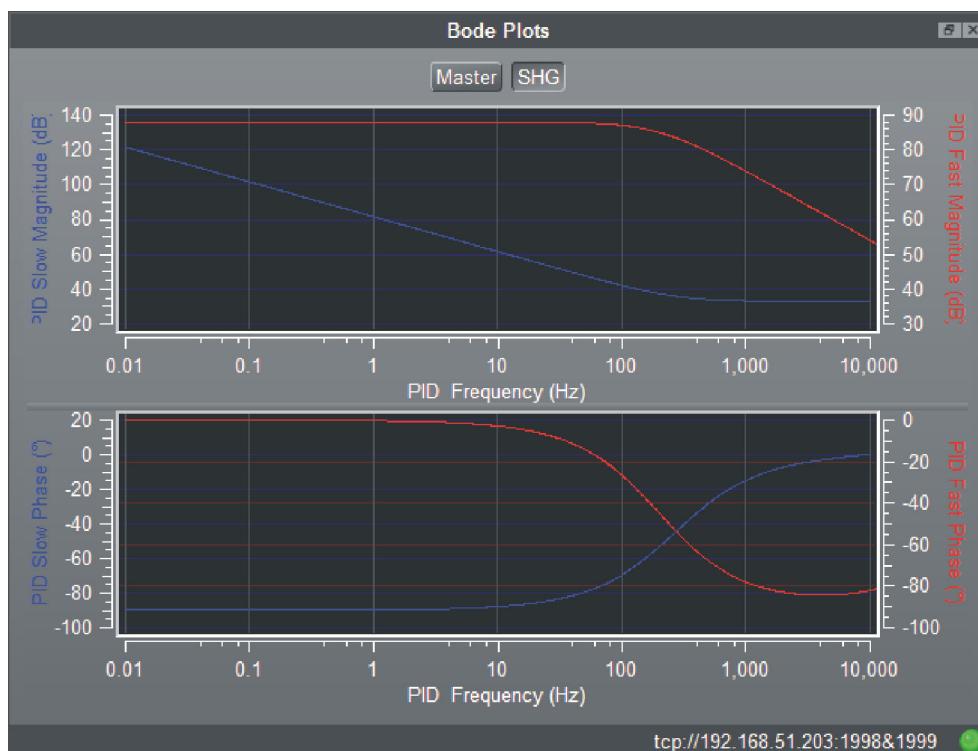


Figure 76 Bode Plots window (example DLC DL-/TA-SHG pro)

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.

6.11 Help

Click to open a pdf version of this DLC pro manual.

6.12 Laser Tab

6.12.1 DLC pro for Laser Head DL pro

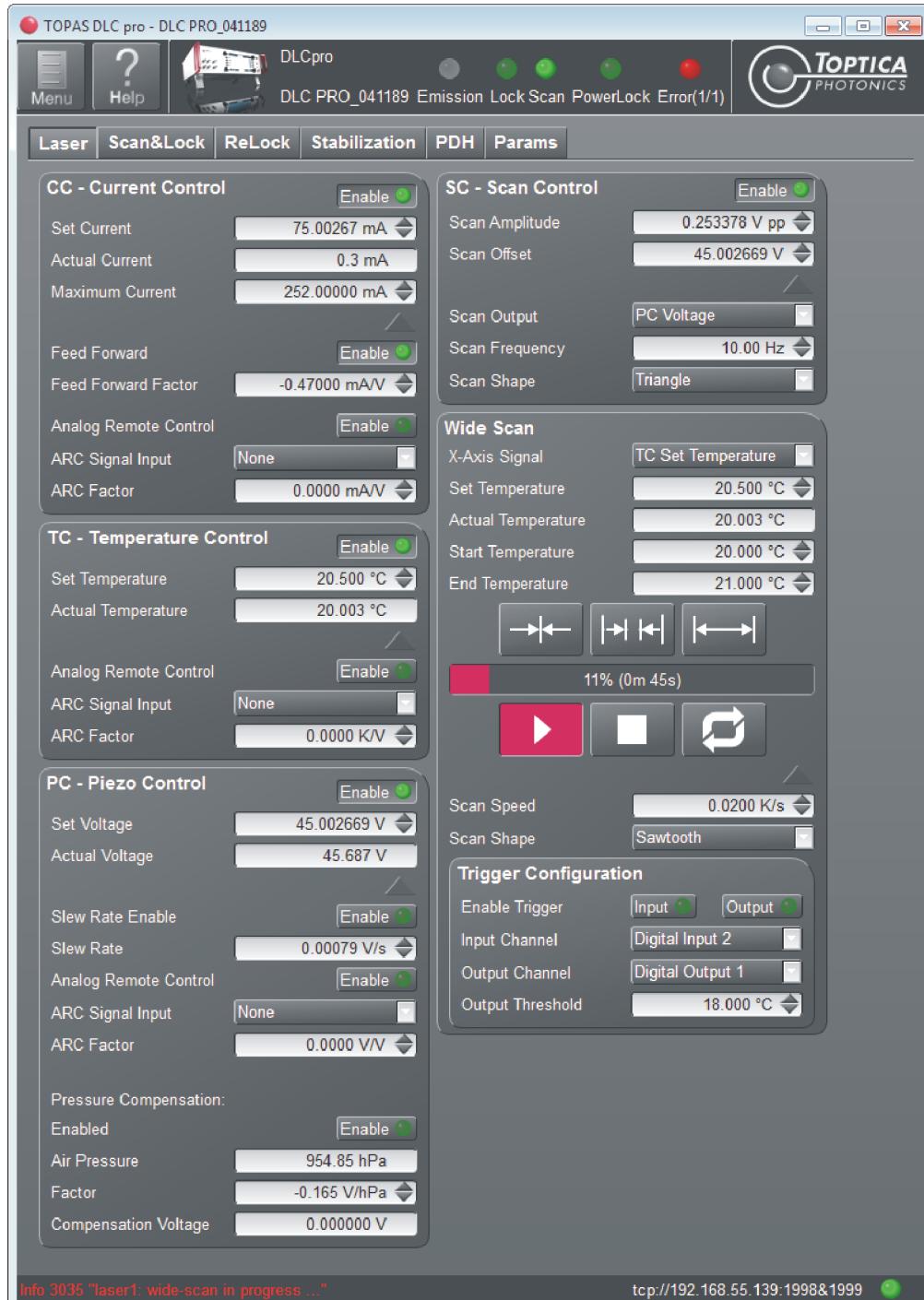


Figure 77 Laser tab (DLC DL pro)

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} .
------------------------	---

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 10.9.1 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 10.9.1 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 10.9.1 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 10.10 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 ! 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 6.9).

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 6.19) 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 10.8.4).
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 10.8.4).

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 6.19):
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 10.8.4) for input trigger.
Output Channel	Select output channel (pin of the Digital I/O connector on the MC+ module, see section 10.8.4) 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.

6.12.1.1 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 6.19) or via software commands (see section 10.12).

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.

6.12.2 DLC pro for DFB pro

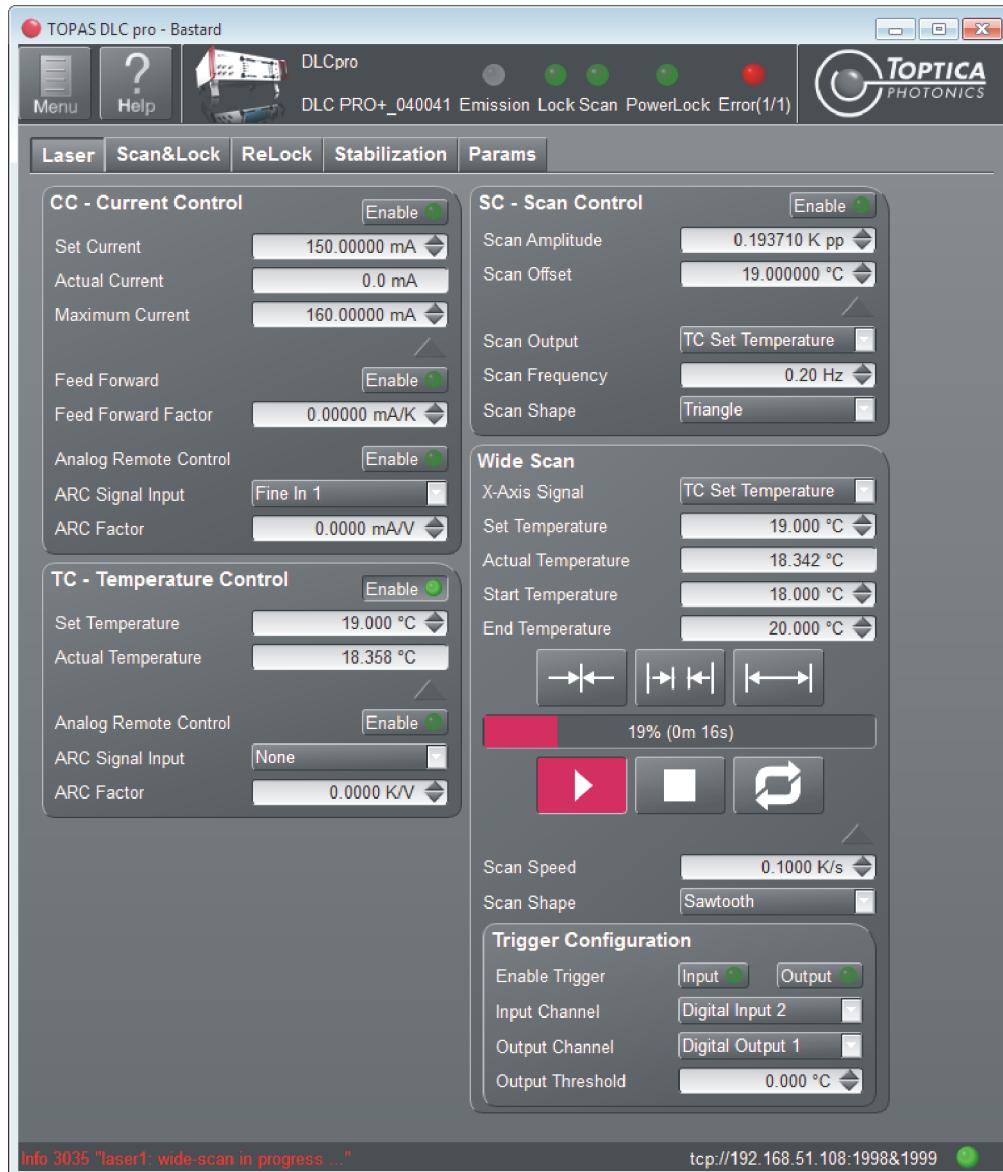


Figure 78 Laser tab (DLC DFB pro)

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 6.12.1 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.

6.12.3 DLC pro for Laser Head TA pro

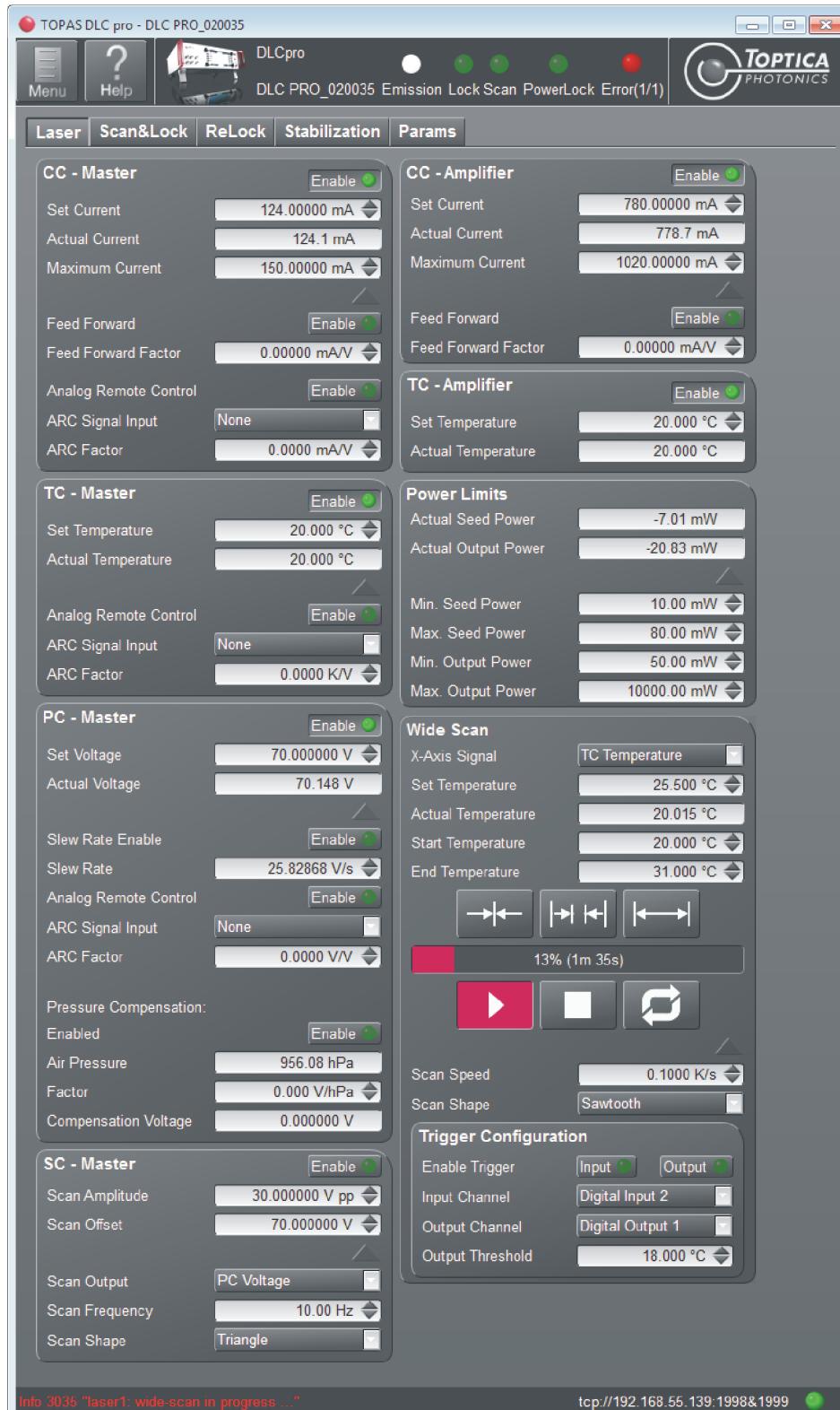


Figure 79 Laser tab (DLC TA pro)

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 6.12.1 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} .

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 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.

6.12.4 DLC pro for Laser Head CTL

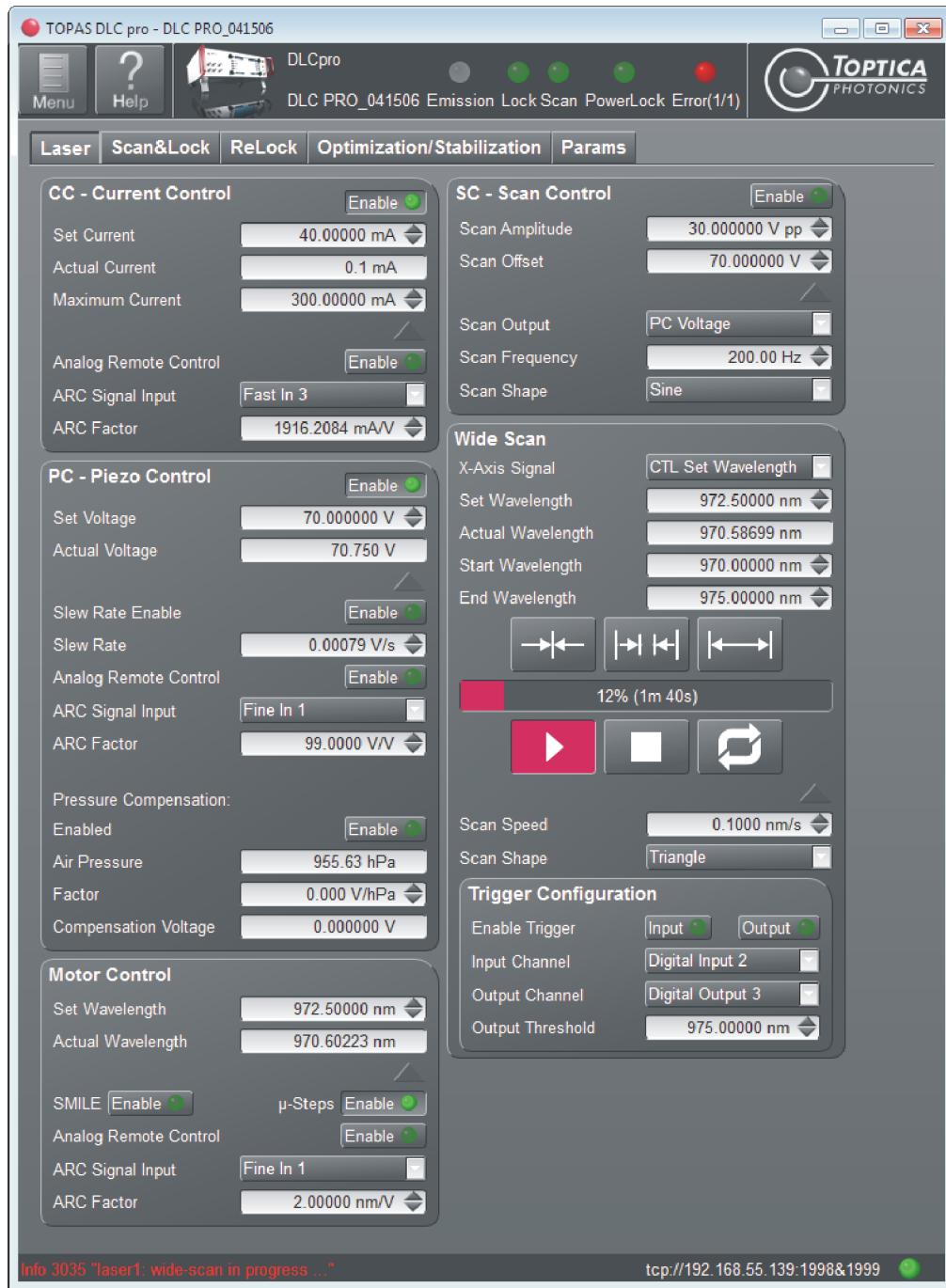


Figure 80 Laser tab (DLC CTL)

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 6.12.1 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 (approx. 1 pm) while scanning. By default, these microsteps are enabled, but are automatically disabled for fast scans and if the scan is paused.
Analog Remote Control Enable	Activates/deactivates the Motor Analog Remote Control. Please refer to section 10.9.2 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].

6.12.5 DLC pro for Laser Head DL-/TA-SHG/FHG pro

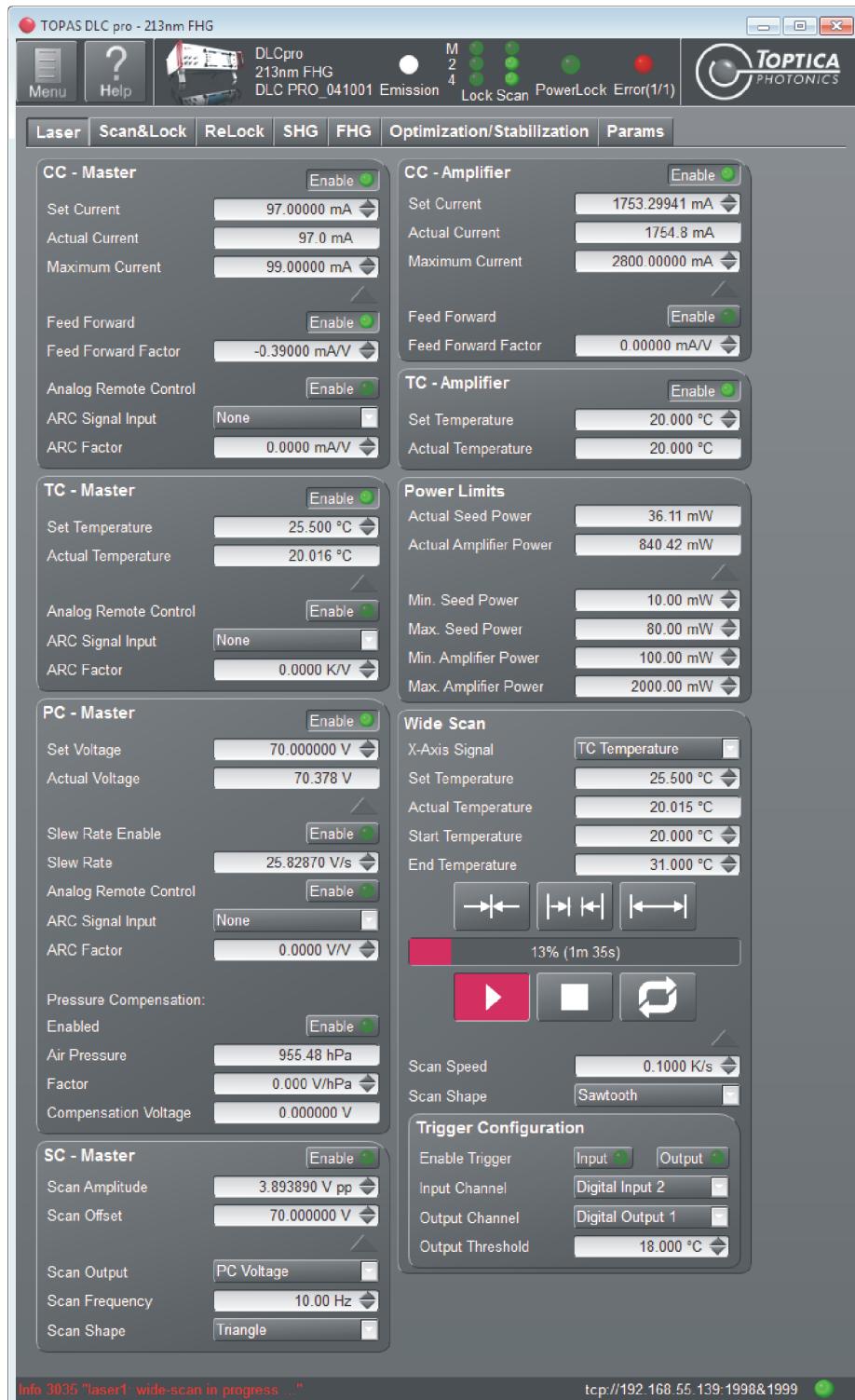


Figure 81 Laser tab (DLC TA-SHG/FHG pro, example DLC TA-FHG pro)

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 6.12.3 for description of the Master Oscillator and Tapered Amplifier operator controls, and to section 6.12.1 for description of the Wide Scan operator controls.

6.13 Scan & Lock Tab

NOTE ! To show and use the Scan & Lock tab, a separate 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 10.18). If purchased along with the DLC pro, the licence is already installed. Otherwise a 30-day trial licence is provided on the USB flash drive in the Options Folder.

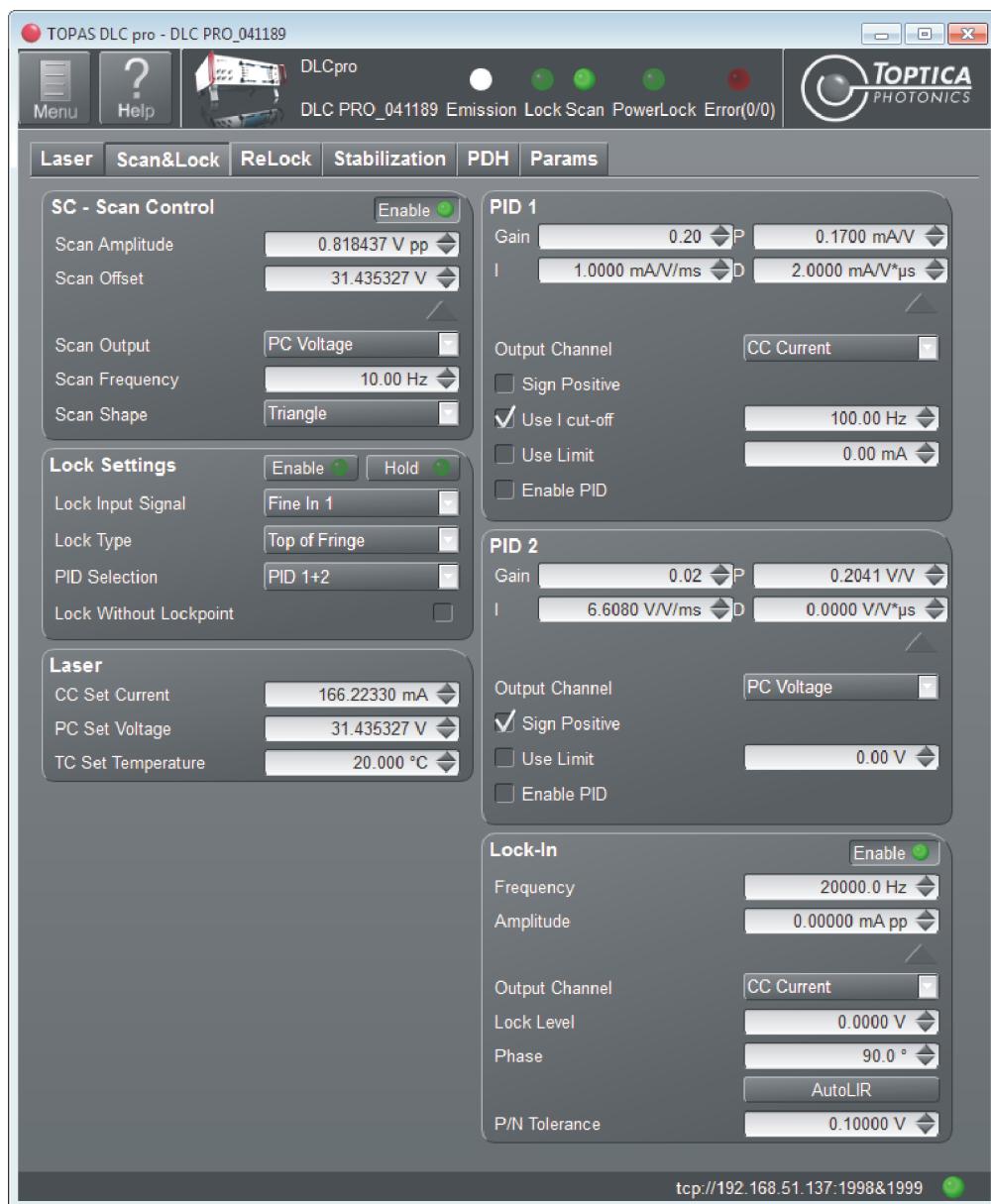


Figure 82 Scan & Lock tab (example DLC DL pro)

SC - Scan Control	For a full description, please refer to SC Scan Control in section 6.12.1.
Lock Settings	
Enable	Locks/unlocks the laser to the selected lock point 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. Choose 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). To use Top of Fringe PDH , the Lock Input Signal must be set to PDH In 1 or PDH In 2 .
Lock Without Lockpoint	Check box to select the Lock mode without lock point 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
Set Level	Set lock level voltage for Side of Fringe lock point 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.

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]

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 lock points 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.

6.13.1 Using the LockPoints Tool of the Signal Display for Locking

NOTE ! For showing the Lock-relevant functions of the **Signal Display**, a separate 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 10.18).

The LockPoints Tool in the Signal Display is used for showing and selecting lock points. The procedures for Side of Fringe and Top of Fringe locking with the PC-GUI is described in sections 6.13.2 and 6.13.3.

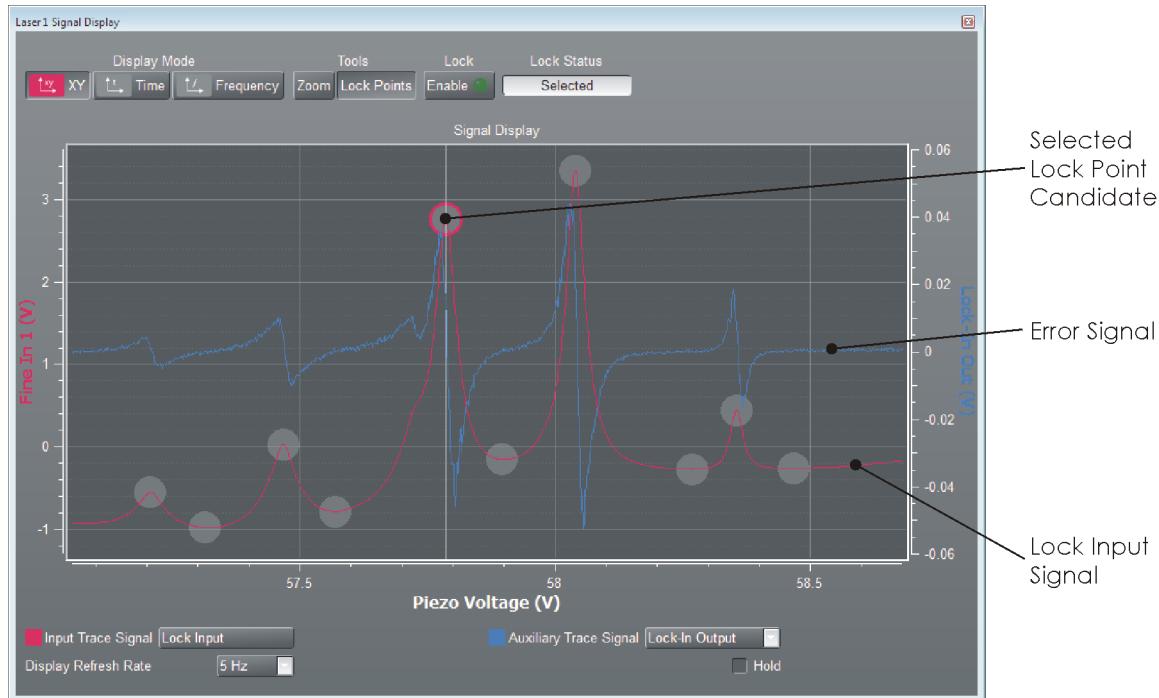


Figure 83 Lock Points tool of the Signal Display

For detailed information on the Signal Display, please refer to section 6.9.

- 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 lock point candidates, click **Lock Points**.
- To lock the laser, select a lock point 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 lock point 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 6.9).
- To freeze the screen display, check the **Hold** checkbox.

6.13.2 Side of Fringe Locking with TOPAS DLC pro PC-GUI

NOTE ! For showing the Lock-relevant functions of the **Signal Display**, a separate 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 10.18).

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 10.18).
- 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.

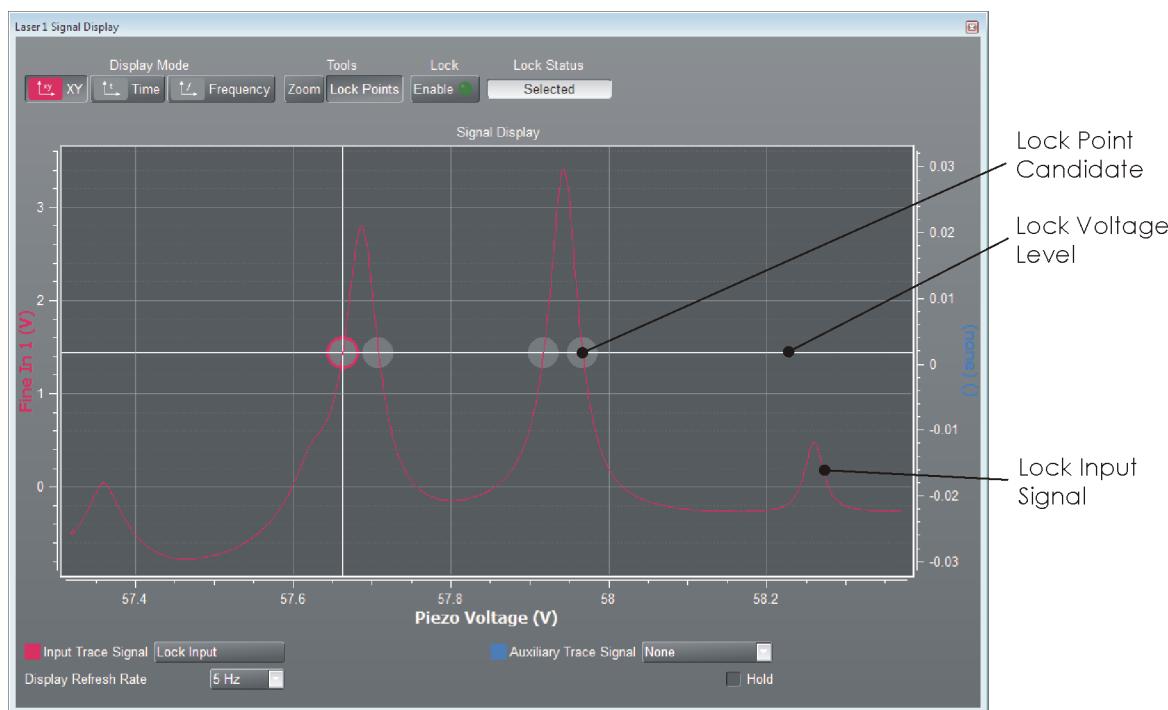


Figure 84 Signal Display showing the Lock Input signal (red) and lock point candidates for Side of Fringe locking.

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 lock point: **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 lock point in the spectrum is clearly visible on the Signal Display.
7. Click **Lock Points** on the Signal Display to display the lock point 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. Lock point candidates are displayed where the Lock Input signal crosses the lock voltage level line.

9. **Locking with lock point candidates:** Select the lock point by clicking the desired **lock point candidate**. For a clearer display, unwanted lock point candidates can be deselected in the Params tab (**Laser 1 > dl > lock > candidate filter > positive-edge/negative-edge**).

Locking without lock point 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 lock point candidates: The laser scans to the selected lock point. When the scan reaches the lock 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 6.9).

Locking without lock point 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 6.9).

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 6.13 for information on PID controller setting options.

6.13.3 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 separate 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 10.18).

Only Top of Fringe (Lock-In): The Lock Wizard in the TOPAS DLC pro PC-GUI (**Menu > Optimization Tools > Lock Wizard**, see section 6.9) 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 6.18).
For an application example of a Top of Fringe PDH lock with high-finesse cavity, please refer to section 7.2.

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 10.18).
- **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.

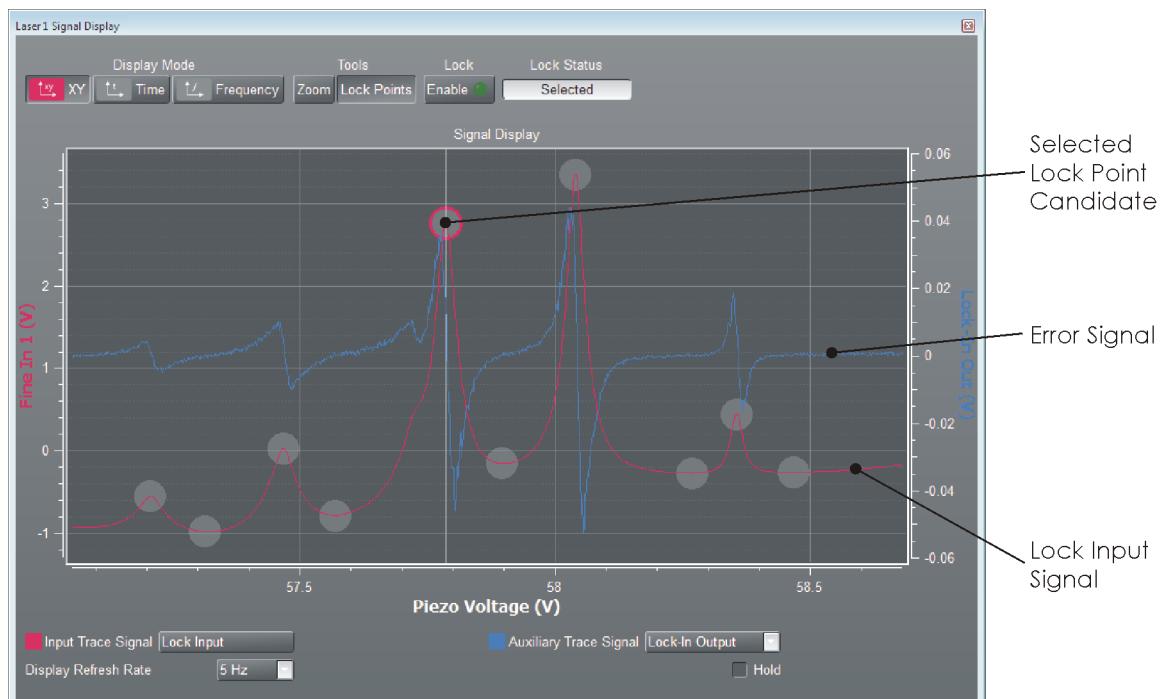


Figure 85 Signal Display showing lock point candidates for Top of Fringe locking

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 lock point: **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 lock point in the spectrum is clearly visible on the Signal Display.
7. Click **Lock Points** on the Signal Display to display the lock point 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:
- Lock point is in signal valley: rising flank of the Error signal (default color: blue).
- Lock point 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 lock point candidates:** Select a lock point by clicking the desired **lock point candidate**. For a clearer display, unwanted lock point candidates can be deselected in the Params tab (**Laser 1 > dl > lock > candidate filter > top/bottom**).

NOTE !

If the lock points at the extrema are not properly detected automatically, this behavior can be improved by setting the 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 lock point 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 lock point candidates: The laser scans to the selected lock point. When the scan reaches the lock 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 6.9).

Locking without lock point 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 6.9).

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 6.13 for information on PID controller setting options.

6.14 ReLock Tab

NOTE ! To show and use the ReLock tab, a separate 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 10.18).

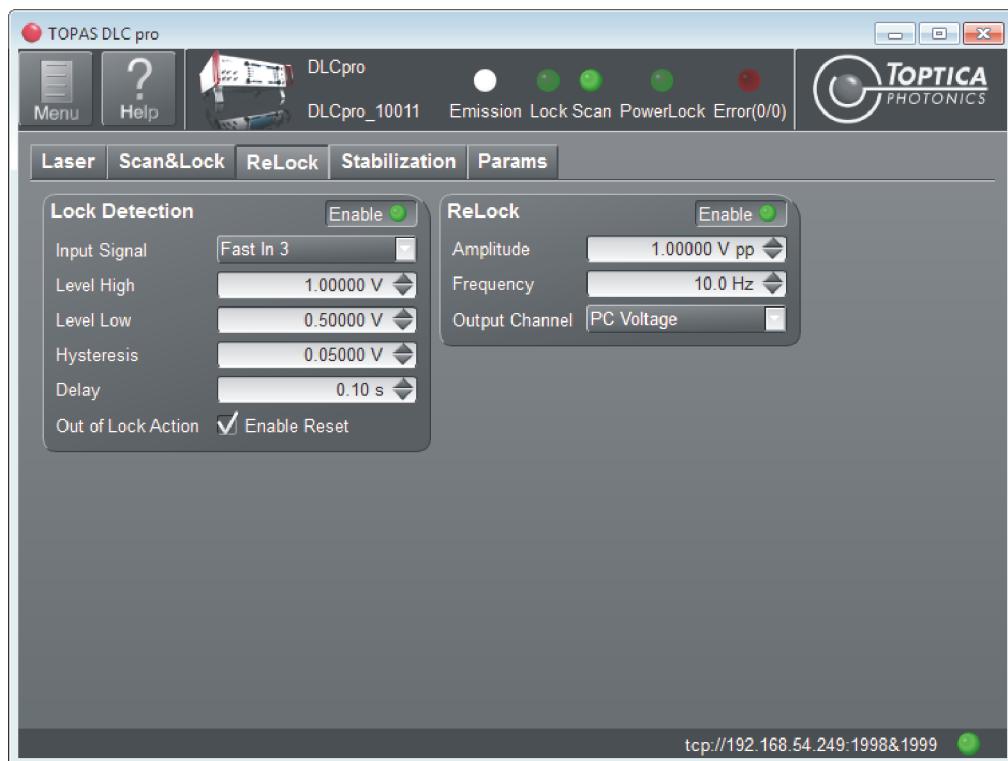


Figure 86 ReLock tab

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.

6.14.1 ReLock Configuration with TOPAS DLC pro PC-GUI

Prerequisites:

- The laser is ready to be locked (please refer to sections 6.13.2, 6.13.3).
- 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**.

6.15 SHG Tab (DLC DL-/TA-SHG pro)

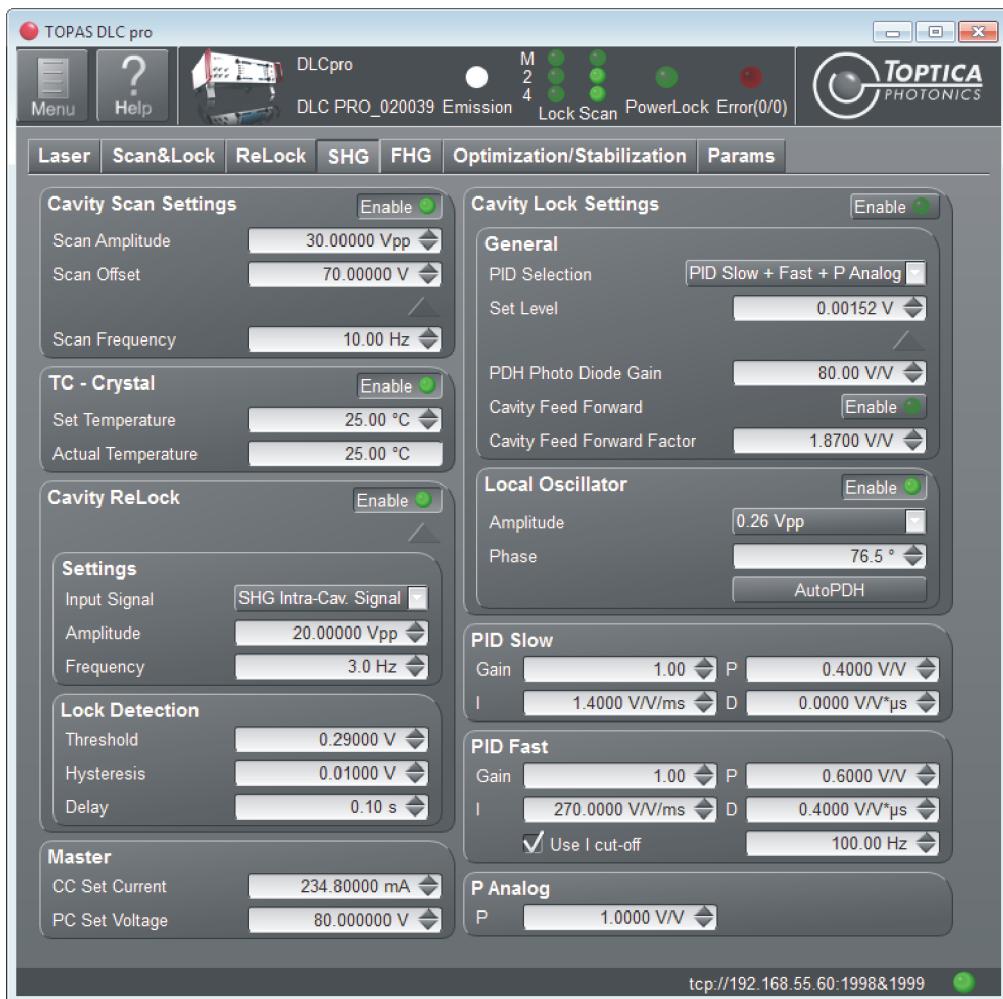


Figure 87 SHG tab (DLC DL-/TA-SHG pro)

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.

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.
P	Proportional gain of the analog feedback path to the Master Oscillator in [V/V].

6.16 FHG Tab (DLC DL-/TA-FHG pro)

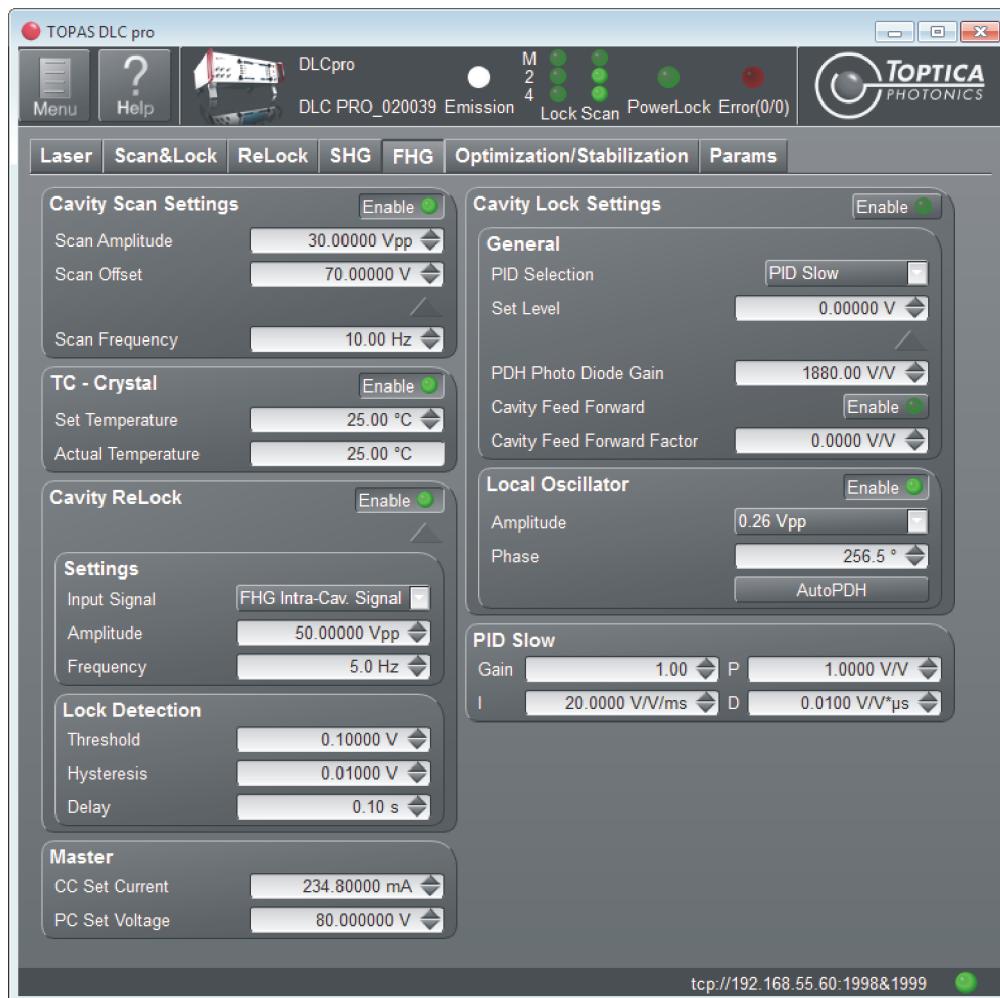


Figure 88 FHG tab (DLC DL-/TA-FHG pro)

The FHG tab for control of the FHG Stage is equivalent to the SHG tab which is described in section 6.15. Please note that P Analog is not available.

6.17 Optimization/Stabilization Tab

NOTE ! For details of the power stabilization, please refer to section 5.3.6.

6.17.1 DLC pro for Laser Head DL pro

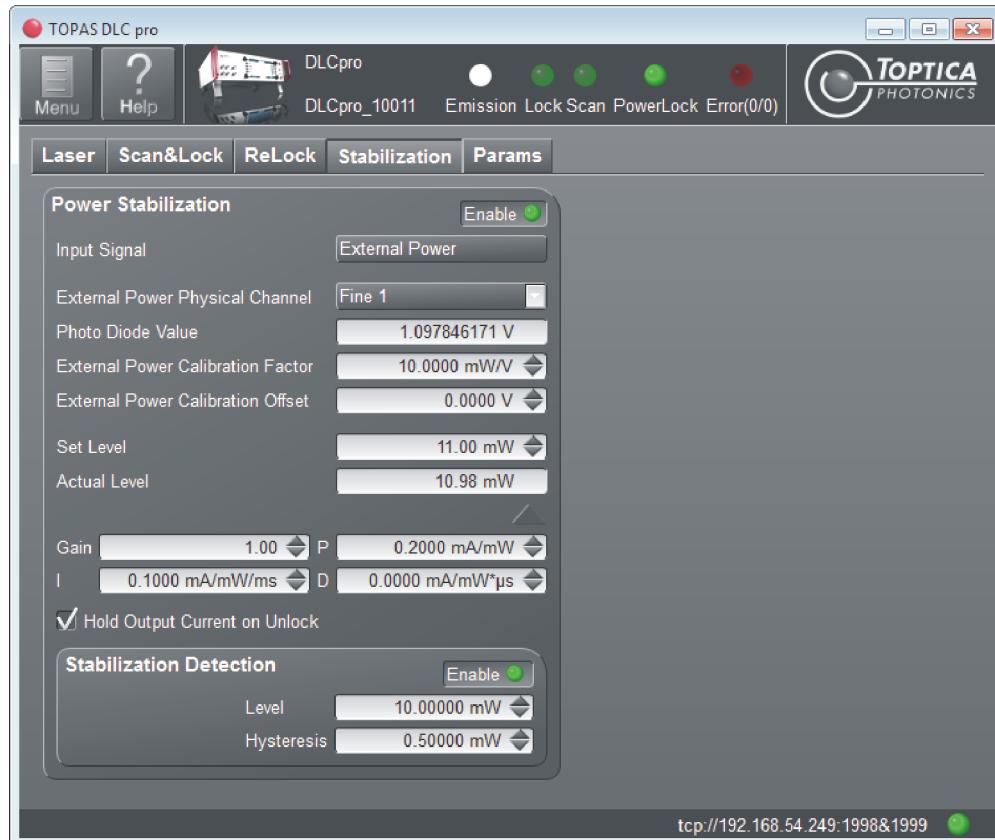


Figure 89 Stabilization tab (DLC DL pro)

The Stabilization tab comprises the operator controls for the DL pro power stabilization. Please refer to section 6.17.4 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.

6.17.2 DLC pro for Laser Head TA pro

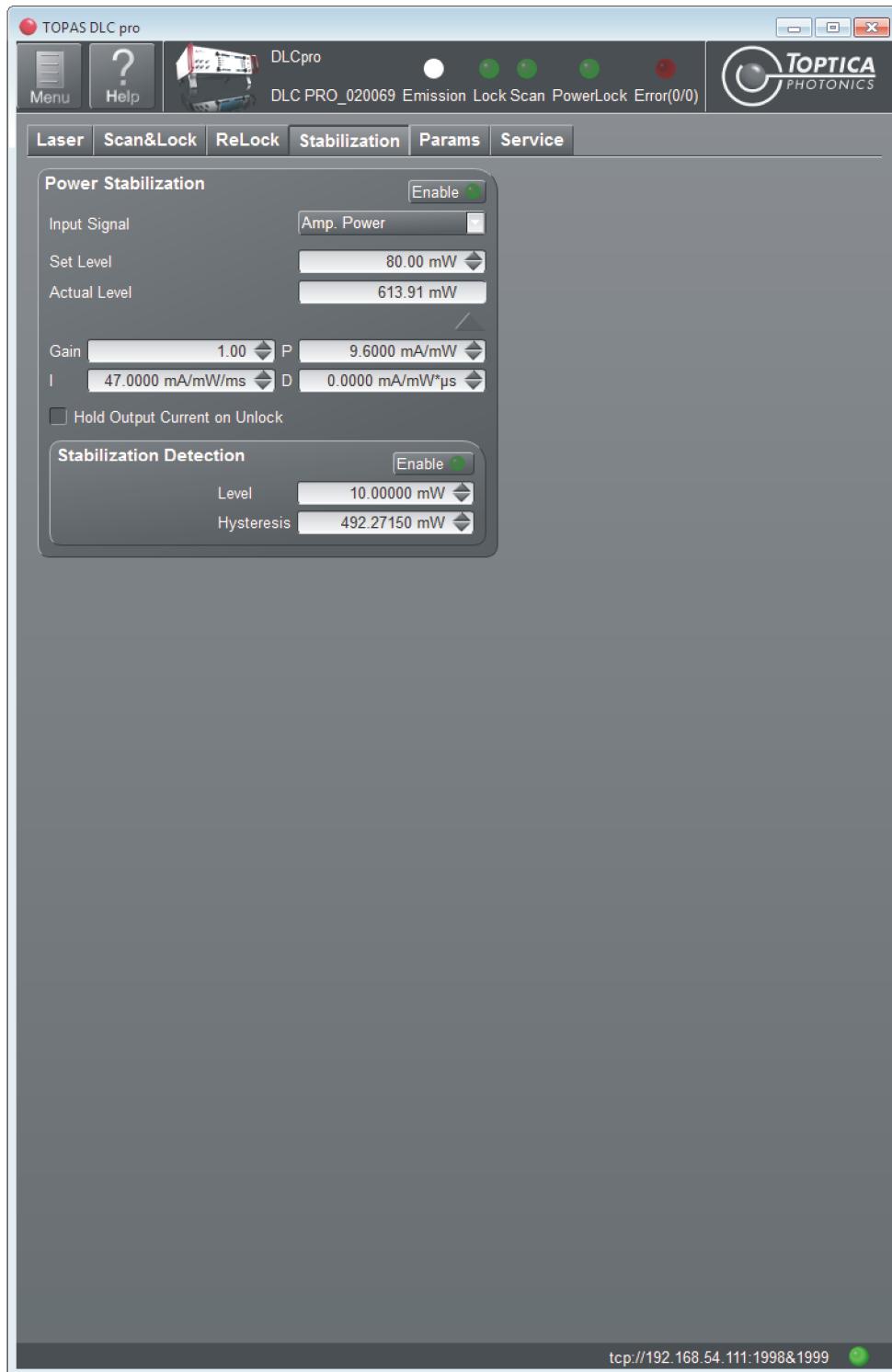


Figure 90 Stabilization tab (DLC TA pro)

The Stabilization tab comprises the operator controls for the TA pro power stabilization. Please refer to section 6.17.4 for a description of the operator controls.

6.17.3 DLC pro for Laser Head CTL

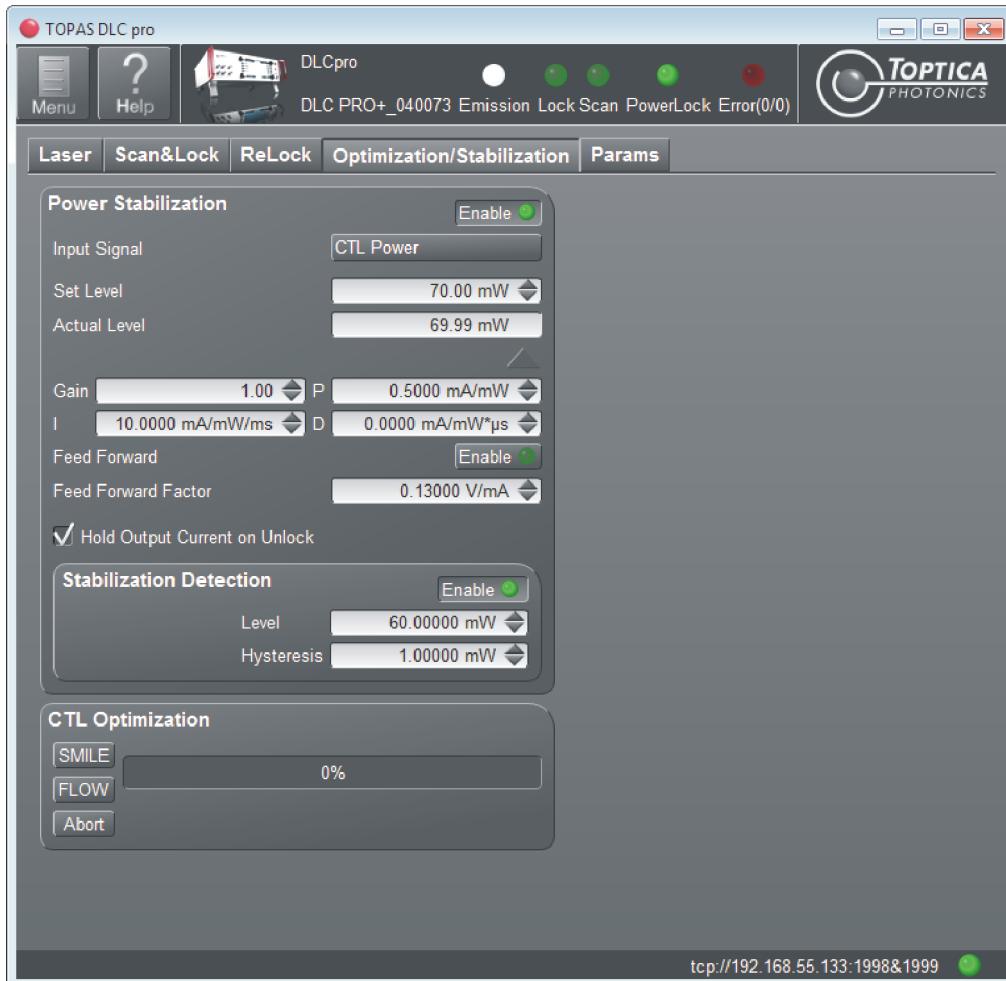


Figure 91 Optimization tab (DLC CTL)

The Optimization/Stabilization tab comprises the operator controls for the CTL power stabilization and the optimization routines. Please refer to section 6.17.4 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.

6.17.4 DLC pro for Laser Head DL-/TA-SHG/FHG pro

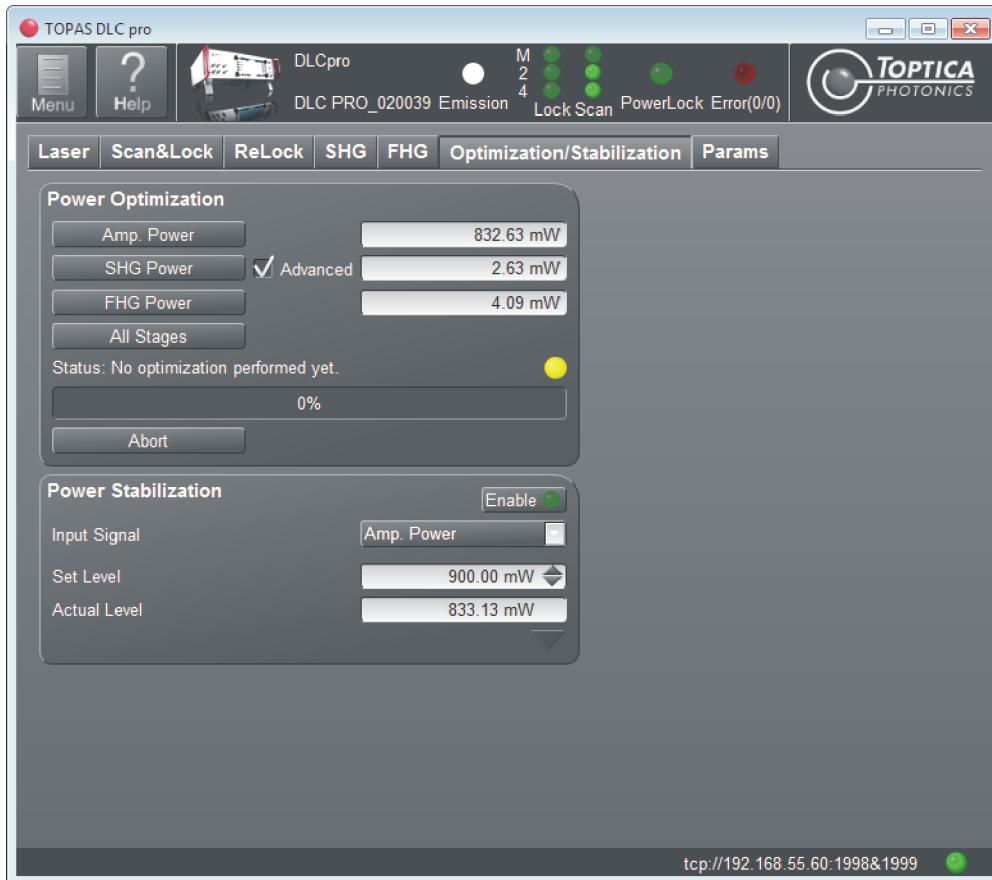


Figure 92 Optimization/Stabilization tab (example DLC DL-/TA-FHG pro)

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 6.17.1 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 μ s].

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.

6.18 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 10.4 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 6.13.3), a separate 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 93 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.

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 1

Settings for channel 2 of the PDH module.

Please refer to the descriptions of **Channel 1** for information.

6.19 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.

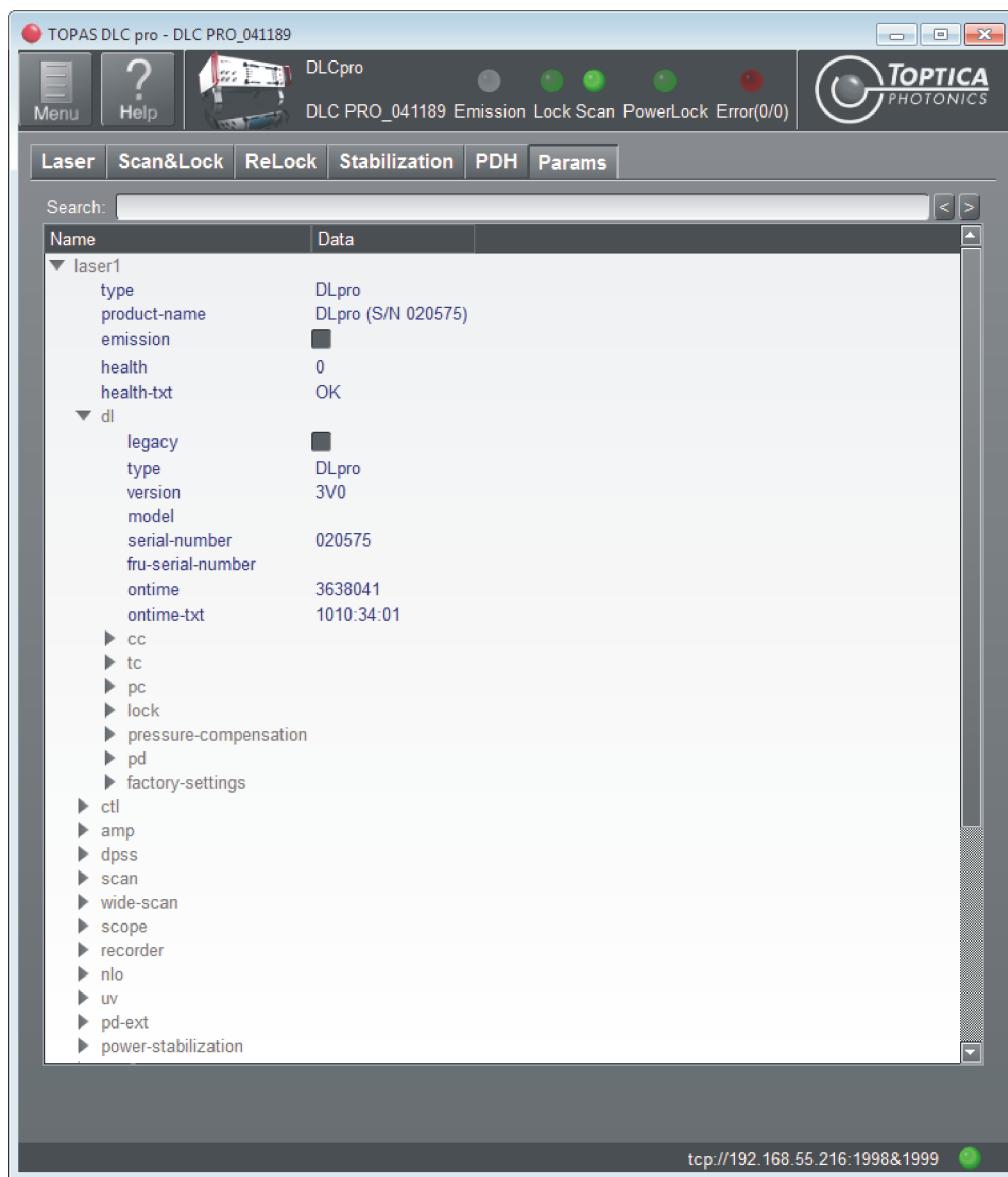


Figure 94 Params tab (example)

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 separate 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 10.18). If purchased along with the DLC pro, the licence is already installed. Otherwise a 30-day trial licence is provided on the USB flash drive in the Options Folder.

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 95. 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 lock points. 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.

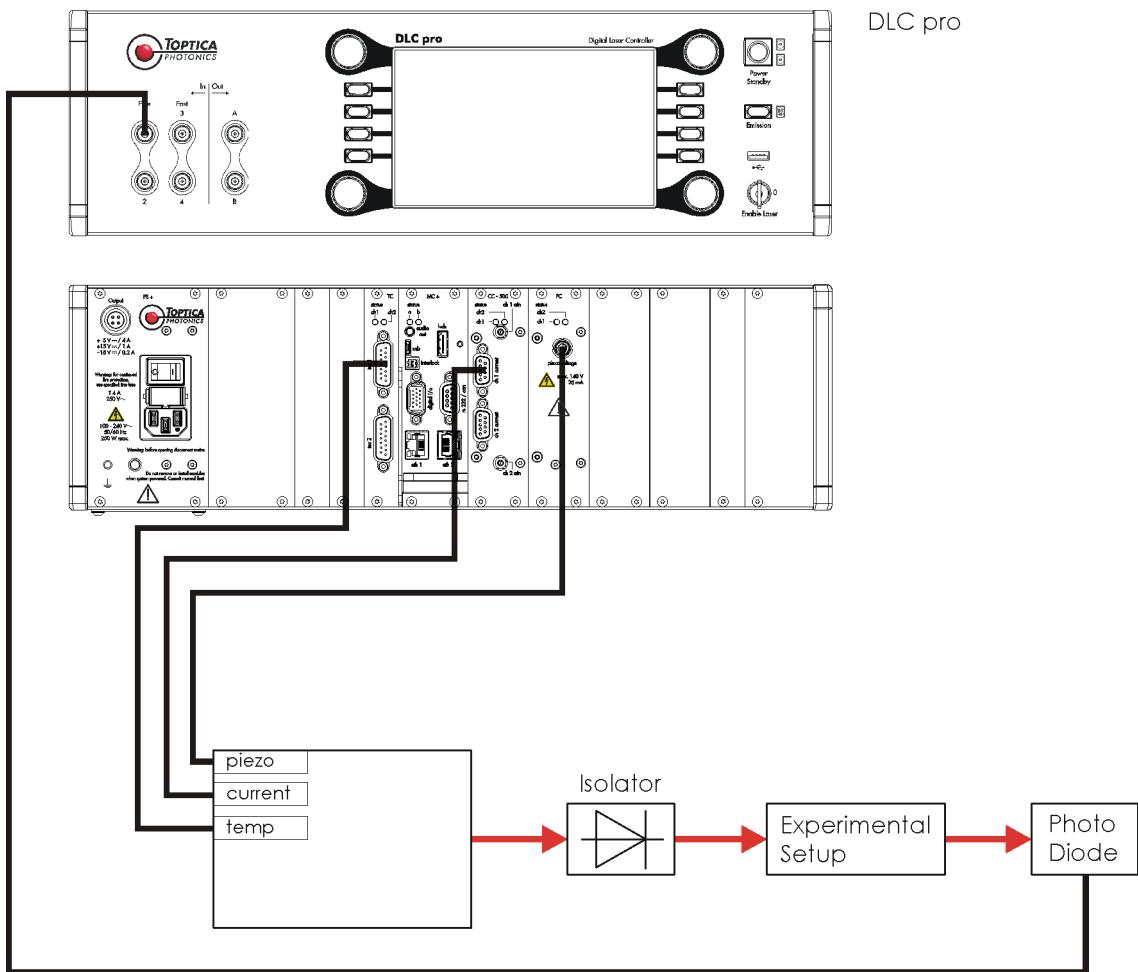


Figure 95 Typical setup for a frequency lock of a TOPTICA diode laser head via the DLC pro

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:

DLC 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.

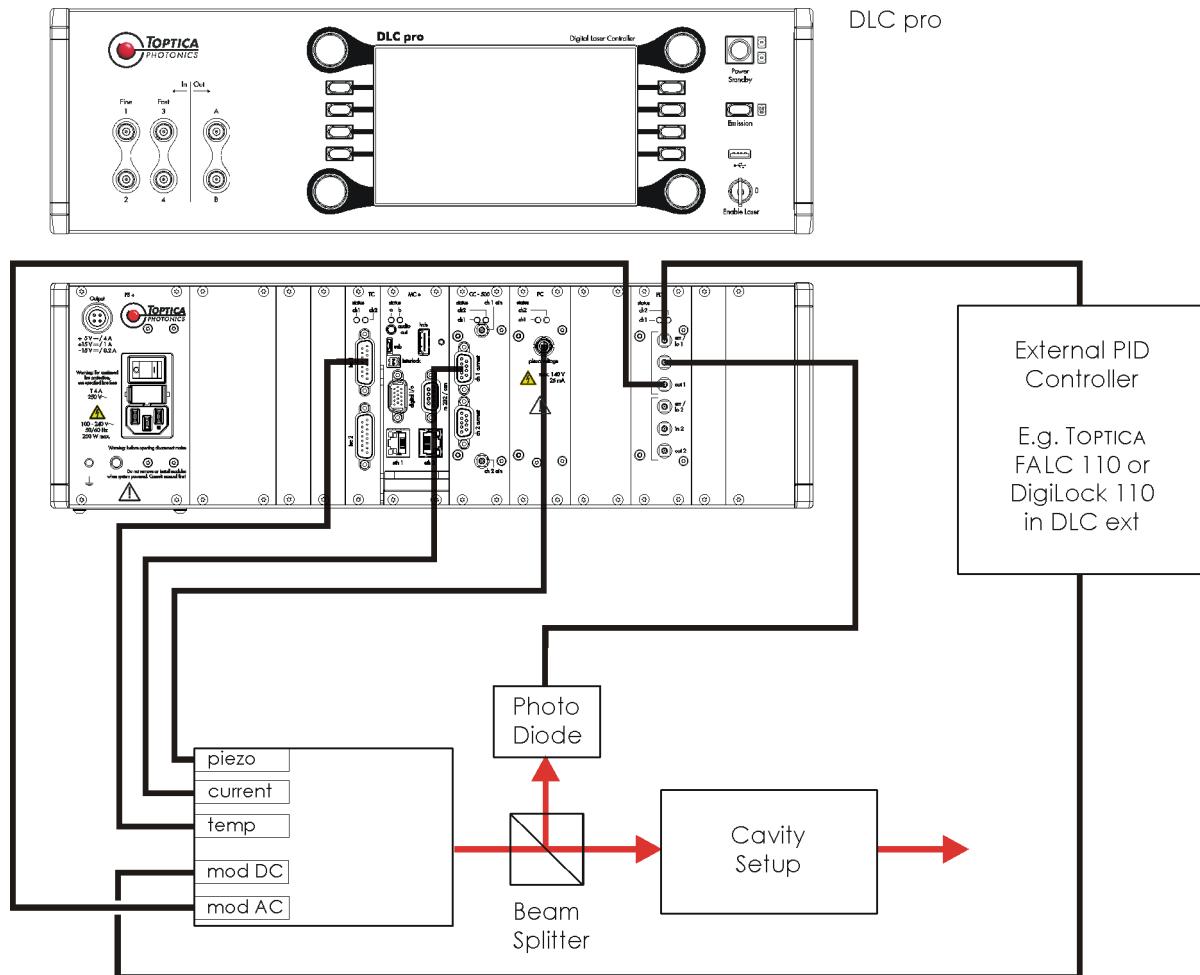


Figure 96 Experimental setup for Top of Fringe Lock with cavity, PDH module in the DLC pro and an external PID controller to increase the bandwidth of the control loop, e.g. when the laser linewidth should be narrowed, or to increase the lock stability.

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**.

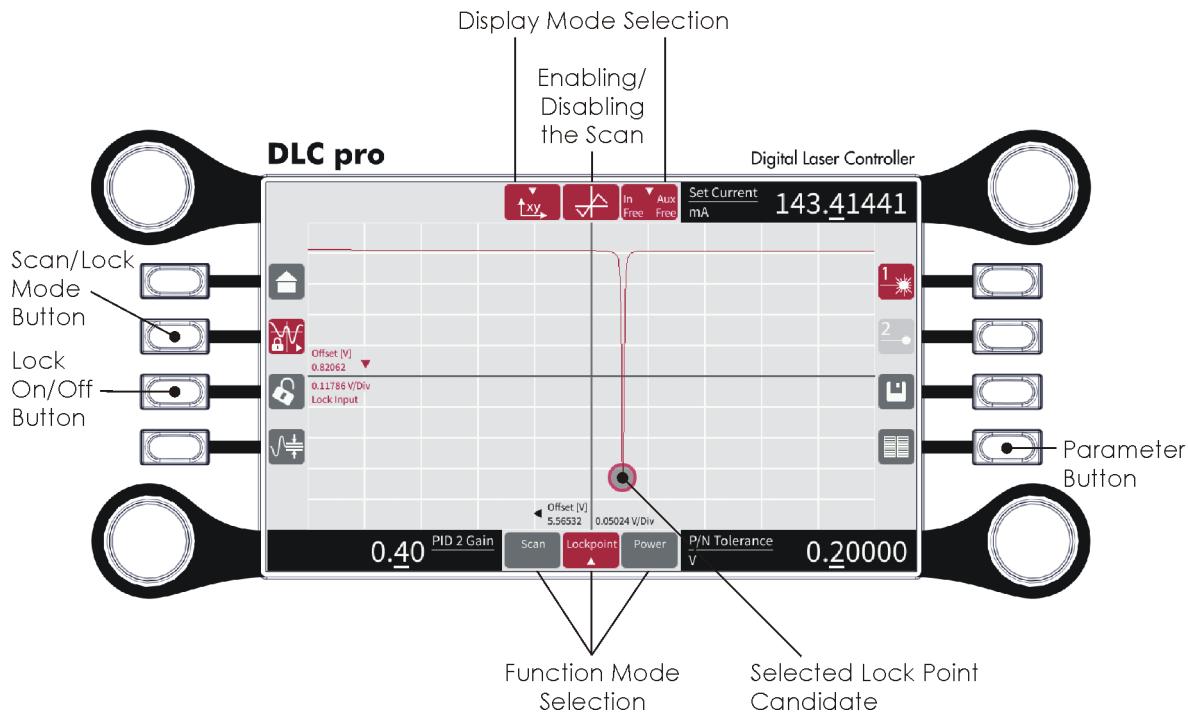


Figure 97 Lockpoint function mode: Lock point candidates for Top of Fringe PDH Lock type (example)

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 lock point in the spectrum is clearly visible on the display.

NOTE ! If the lock points 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 98. 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.

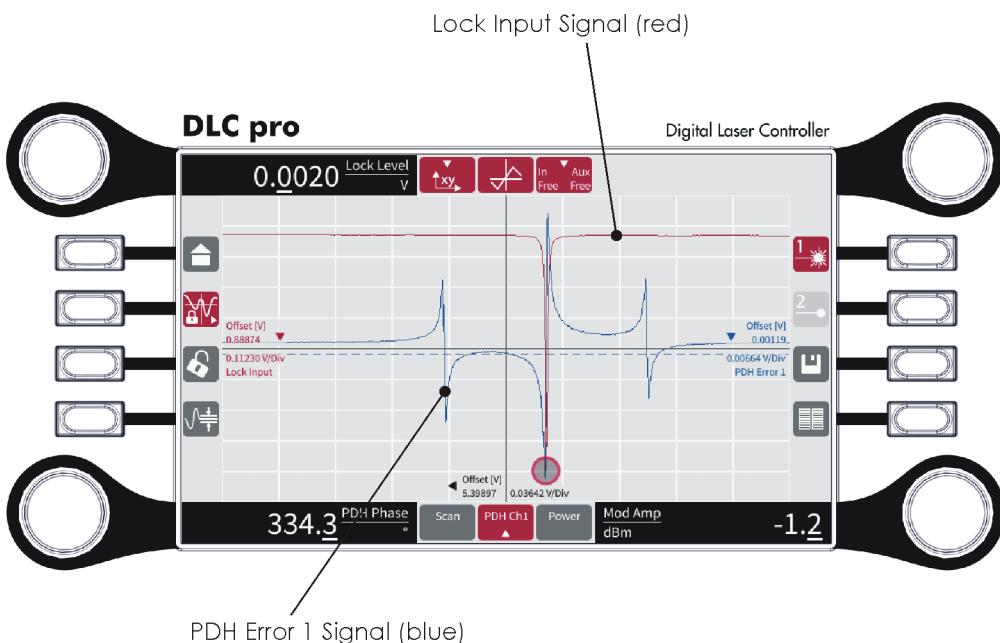


Figure 98 Display of the cavity spectrum (Lock Input Signal, red) with the corresponding PDH Error 1 signal (blue).

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 lock point 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 lock point. Enter this value as **Lock Level** (top right rotary knob).

9. Switch to **Lockpoint** function mode.

Locking with lock point candidates: Select the lock point by tapping on the **Lock Point Candidate** (see Figure 106). For a clearer display, unwanted lock point candidates can be deselected in the context parameter menu (**Lock Settings > Peak/Trough Lock Candidates**).

Locking without lock point 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 5.5).

Locking with lock point candidates: The laser scans to the selected lock point. When the scan reaches the lock point, the scan stops, and the PID controller(s) switch on.

Locking without lock point 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 lock point, 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 5.5). 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

Some experiments require an extended control bandwidth in order to achieve high suppression of noise components. The setup in Figure 99 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 99, no DLC pro Lock option license is required.

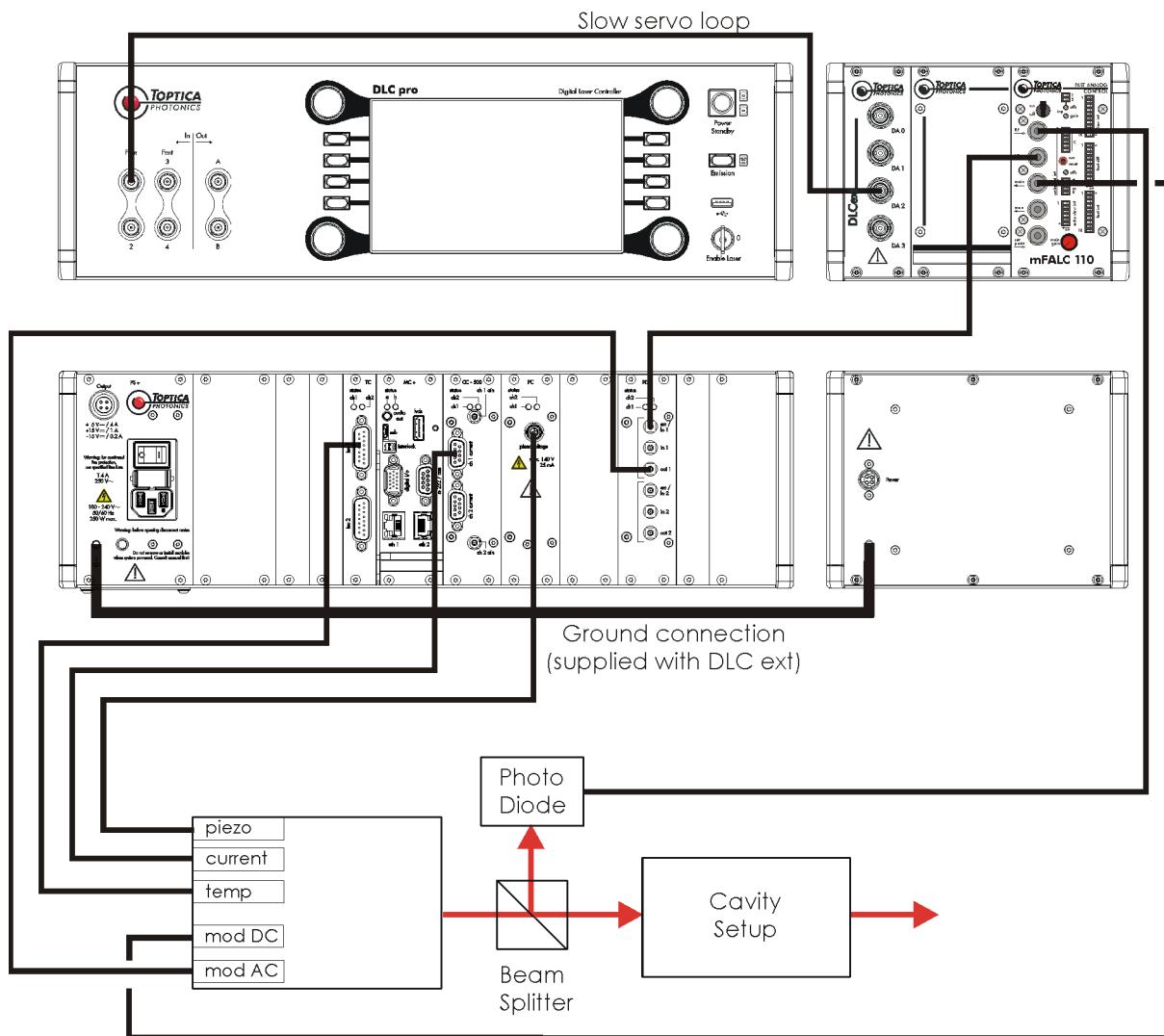


Figure 99 Experimental setup for Top of Fringe Lock with cavity, PDH module in the DLC pro and an external PID controller with integrated mixer (mFALC 110 in a DLC ext rack)

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 100 shows the experimental setup.

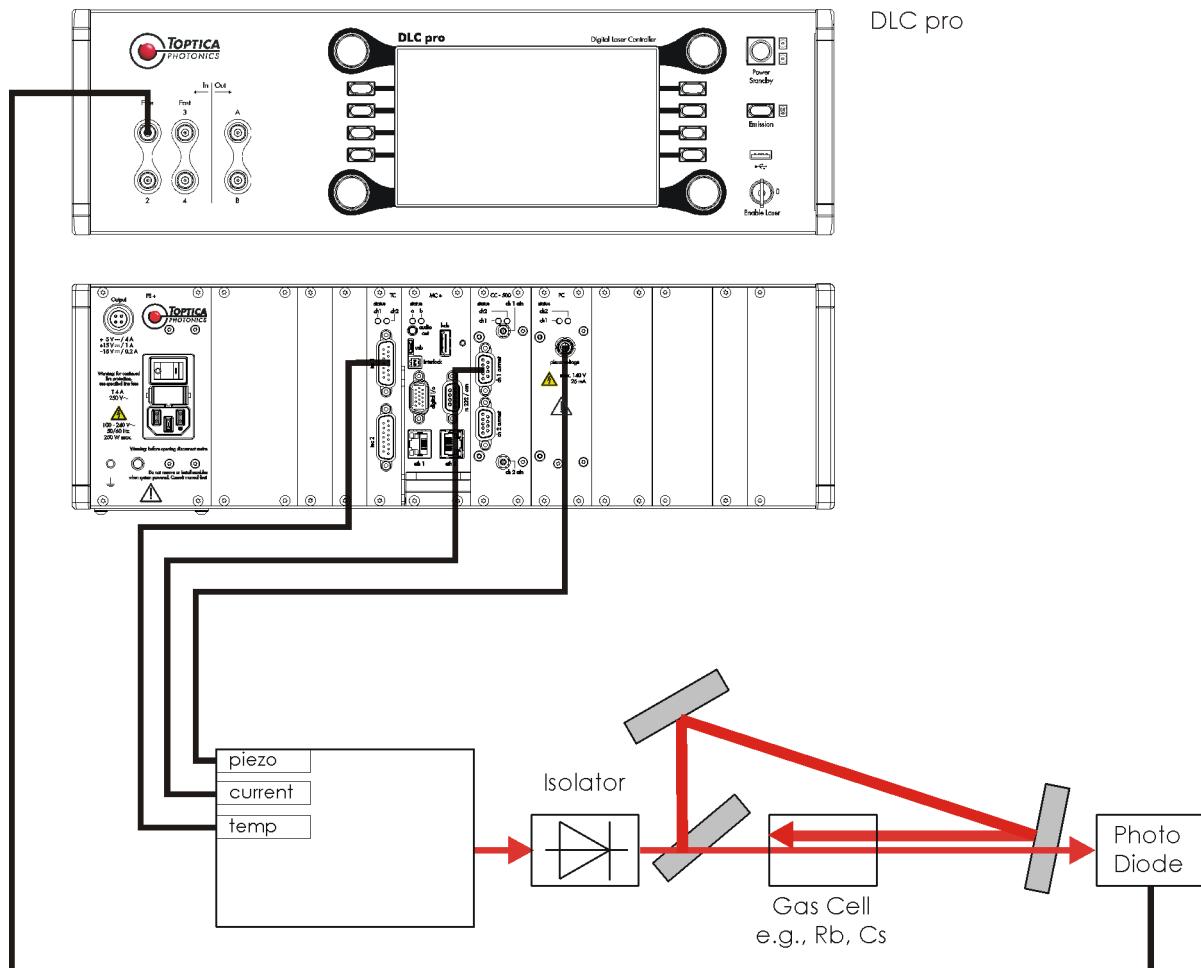


Figure 100 Experimental setup for Doppler-free saturation spectroscopy

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 6.13.

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 101.

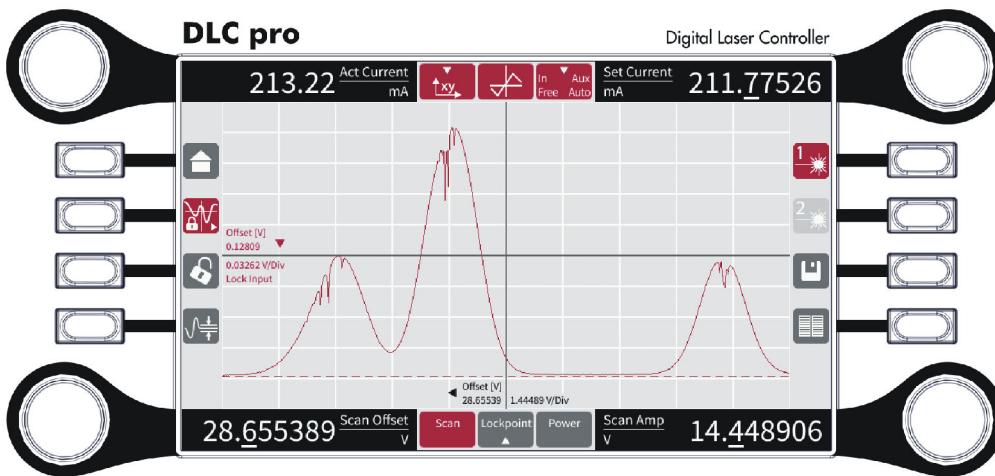


Figure 101 Absorption signal of a Doppler-free Rb spectroscopy

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 6.13.2. 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**.

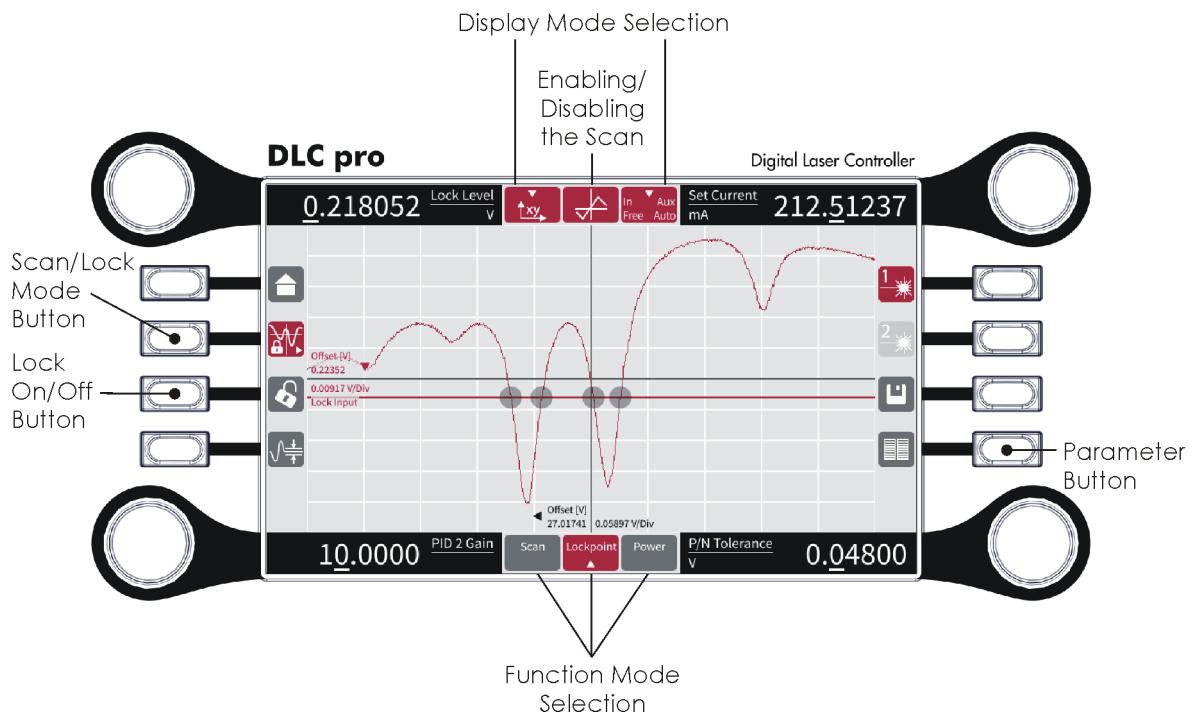


Figure 102 Lockpoint function mode; lock voltage level and lock point candidates for Side of Fringe locking (example)

4. Select both PID controller(s) for stabilizing to the lock point (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 lock point in the spectrum is clearly visible on the display.

NOTE ! The selected lock voltage level is displayed as a red line. Lock point 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 103), and the desired lock point is shown.

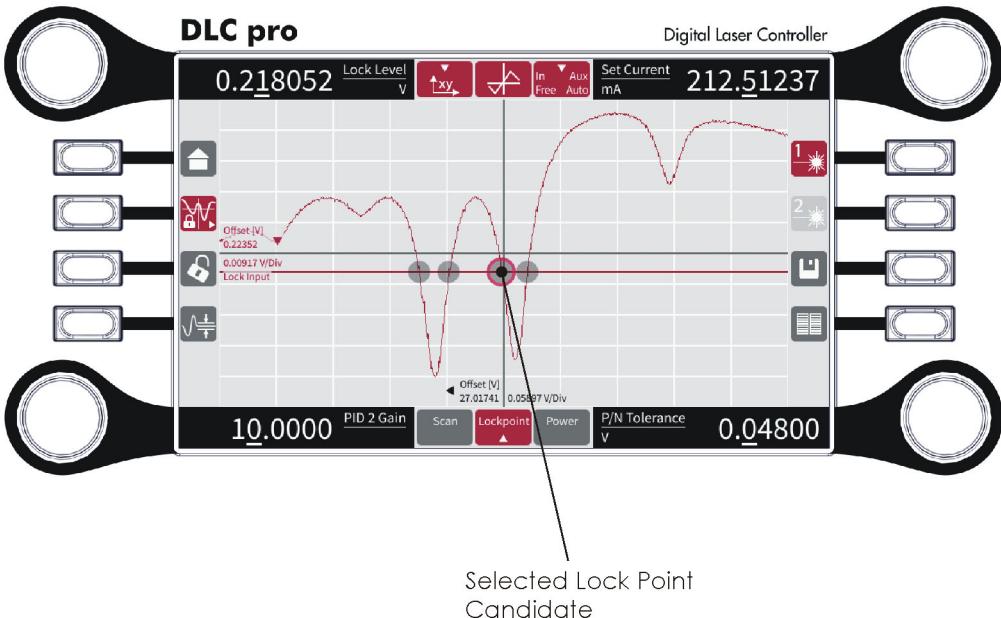


Figure 103 Rb transitions at 780 nm. Lock point selected

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 lock point, 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. Lock point 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 lock point candidates:** Select the lock point by tapping on the **Lock Point Candidate**. For a clearer display, unwanted lock point candidates can be deselected in the context parameter menu (**Lock Settings > Positive-Edge/Negative-Edge Lock Candidates**).
Locking without lock point 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 5.5).

Locking with lock point candidates: The laser scans to the selected lock point. When the scan reaches the lock point, the scan stops, and the PID controller(s) switch on.

Locking without lock point 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.

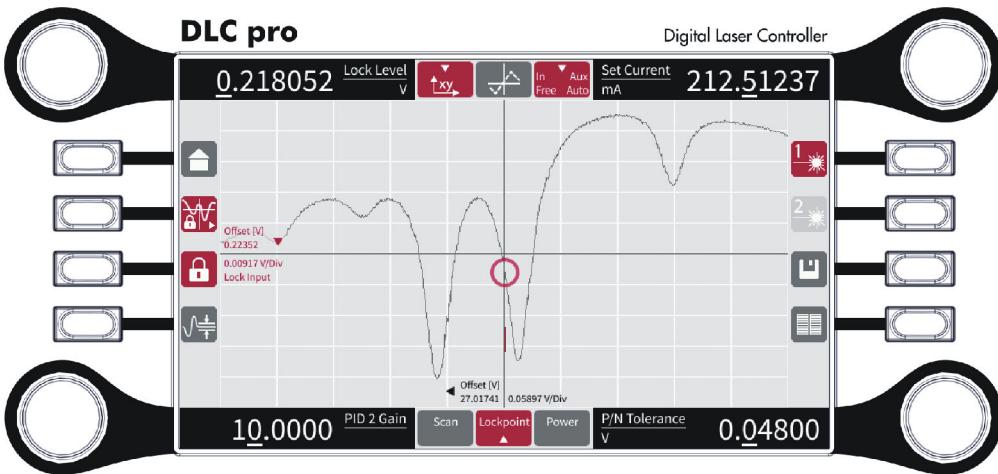


Figure 104 Side of Fringe lock display after the lock is engaged

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 5.5). 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 105 and section 5.3.2). Figure 105 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.

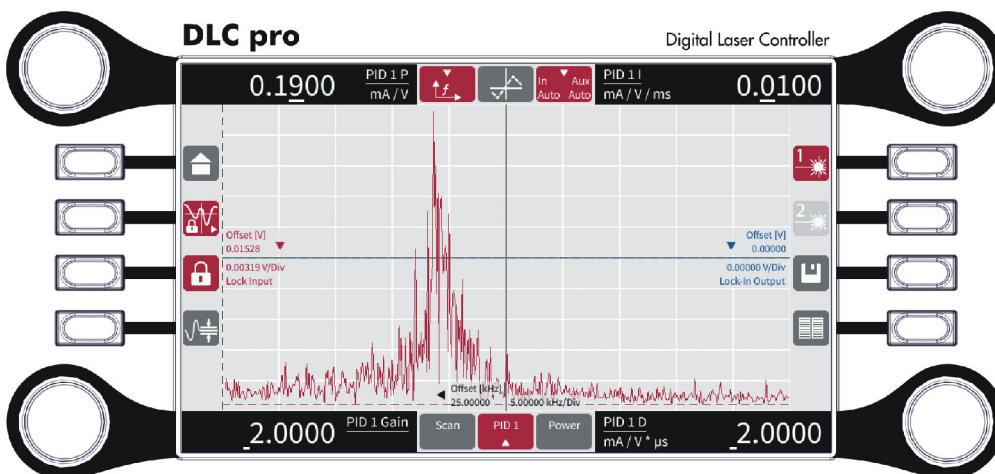


Figure 105 Frequency display of a photo diode signal.

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 6.13.3. 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 6.9) is an interactive tool which helps to set up a Top of Fringe lock.

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**.

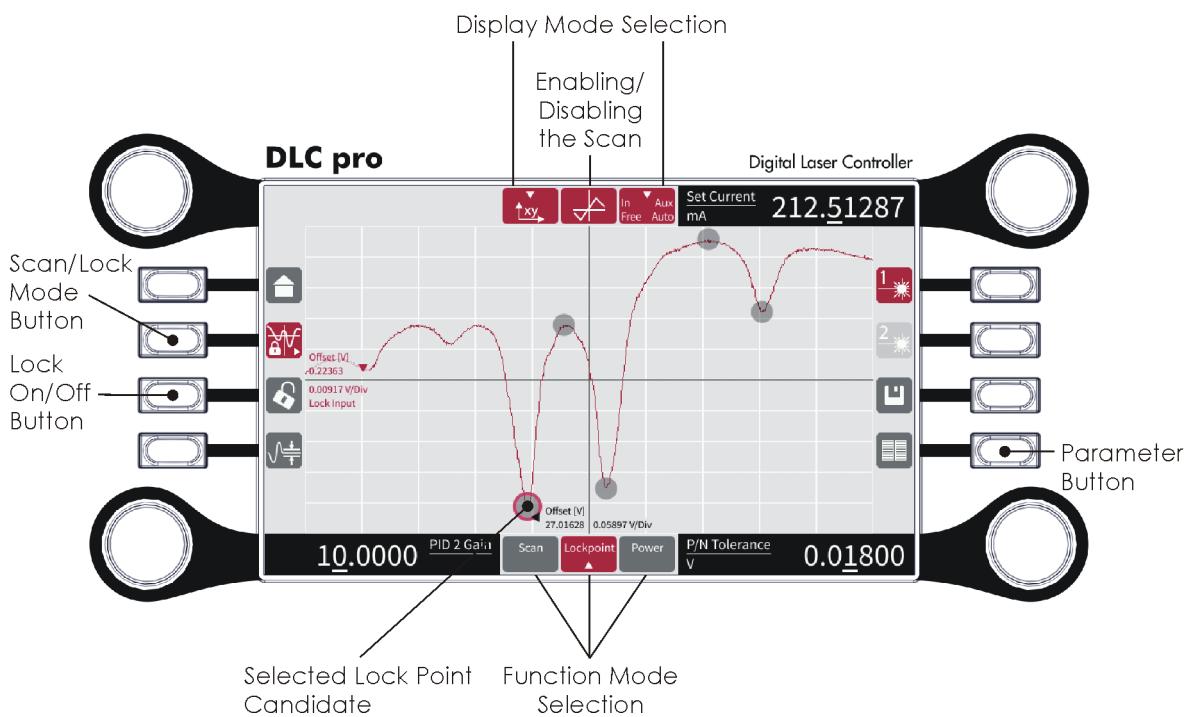


Figure 106 Lockpoint function mode: Lock point candidates for Top of Fringe Lock type (example)

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 lock point in the spectrum is clearly visible on the display.

NOTE ! If the lock points 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 [$^{\circ}$] (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.

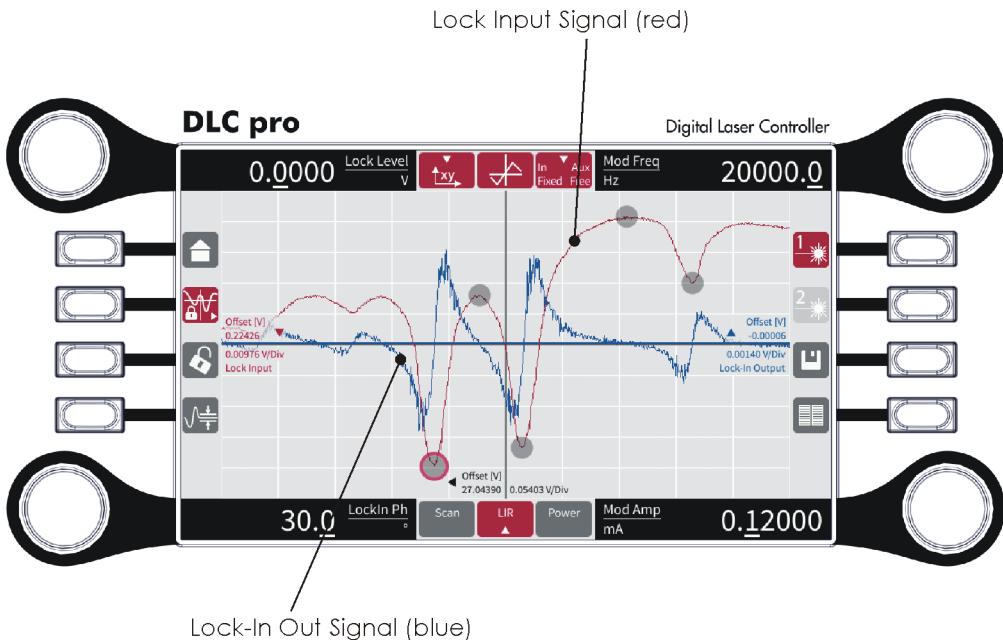


Figure 107 Display of the Doppler-free Rb spectrum (red) with the corresponding Lock-In Output signal (blue).

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 lock point candidates: Select the lock point by tapping on the **Lock Point Candidate** (see Figure 106). For a clearer display, unwanted lock point candidates can be deselected in the context parameter menu (**Lock Settings > Peak/Trough Lock Candidates**).

Locking without lock point 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 5.5).

Locking with lock point candidates: The laser scans to the selected lock point. When the scan reaches the lock point, the scan stops, and the PID controller(s) switch on.

Locking without lock point 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 lock point, 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 5.5). 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.

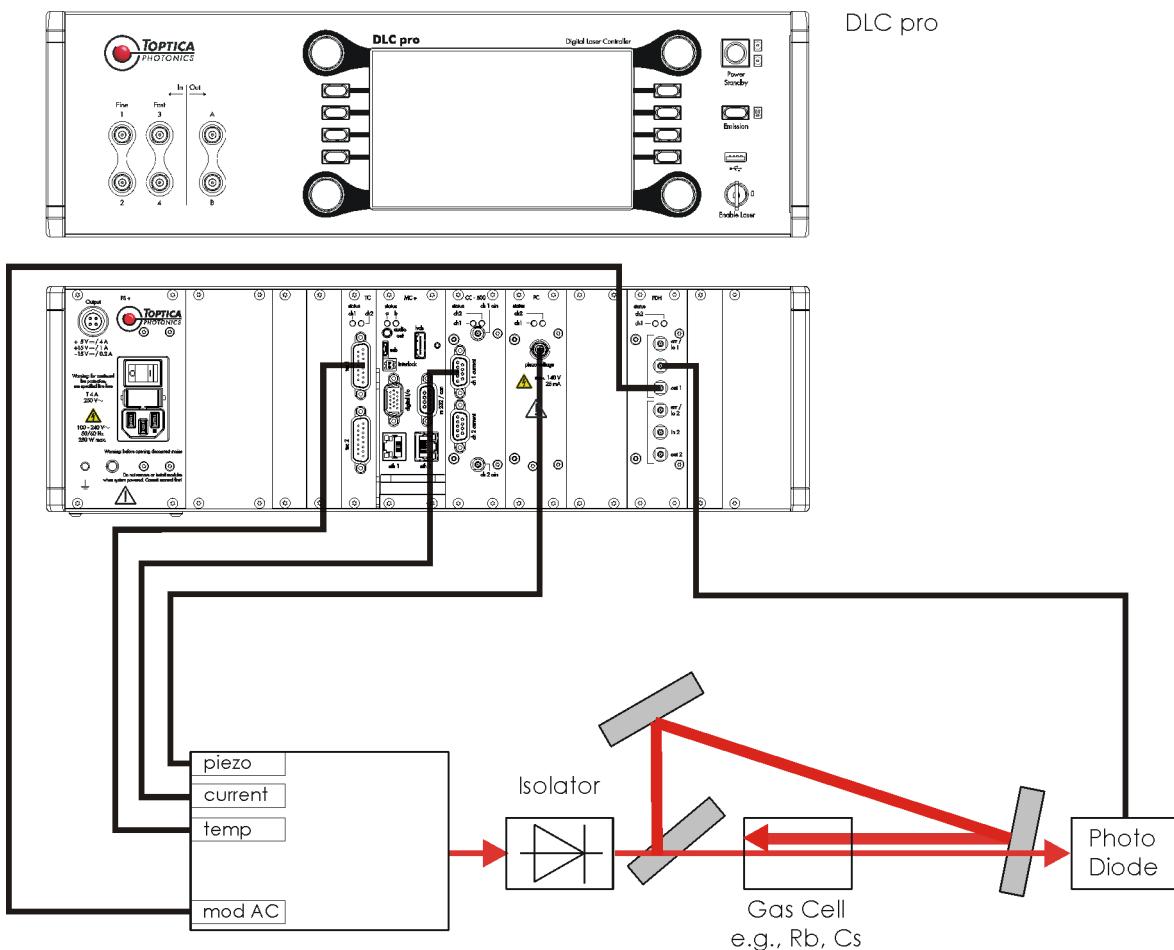


Figure 108 Experimental setup for Doppler-free saturation spectroscopy using the PDH module

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 108 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 separate 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 10.18). If purchased along with the DLC pro, the licence is already installed. Otherwise a 30-day trial 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 109) 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.

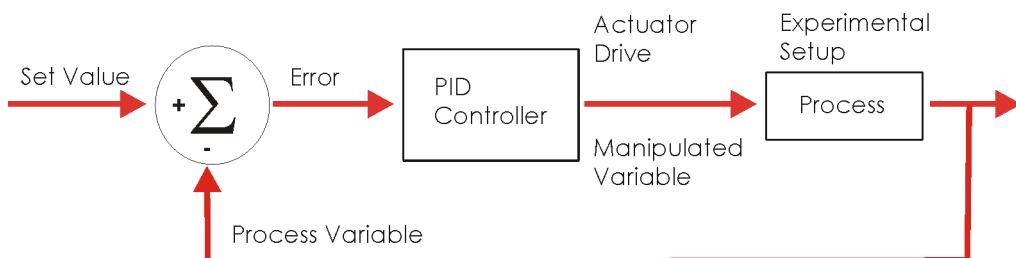


Figure 109 PID controller feedback loop

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 (touchscreen, 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 locks¹. 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 lock point 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 v_{osc} starts: $P = 0.6 \times P_{osc}$; $I = 2 P_{osc} / v_{osc}$; $D = (P_{osc} \times v_{osc}) / 8$

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 lock point), or use a wavemeter 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 lock point 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 110 and Figure 111.

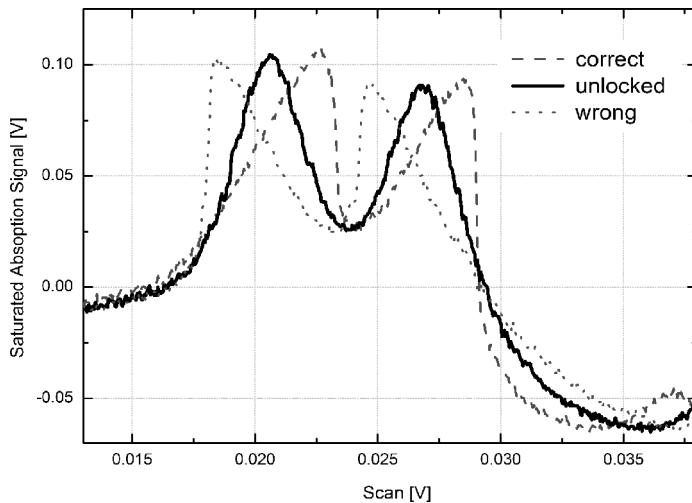


Figure 110 Polarity of the PID controller for Side of Fringe lock.

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.

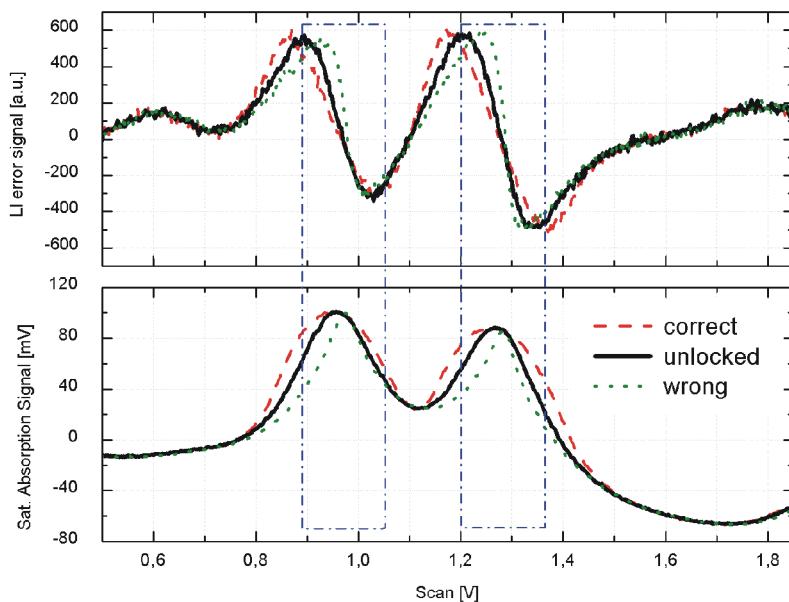


Figure 111 Polarity of the PID controller using frequency modulation

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.

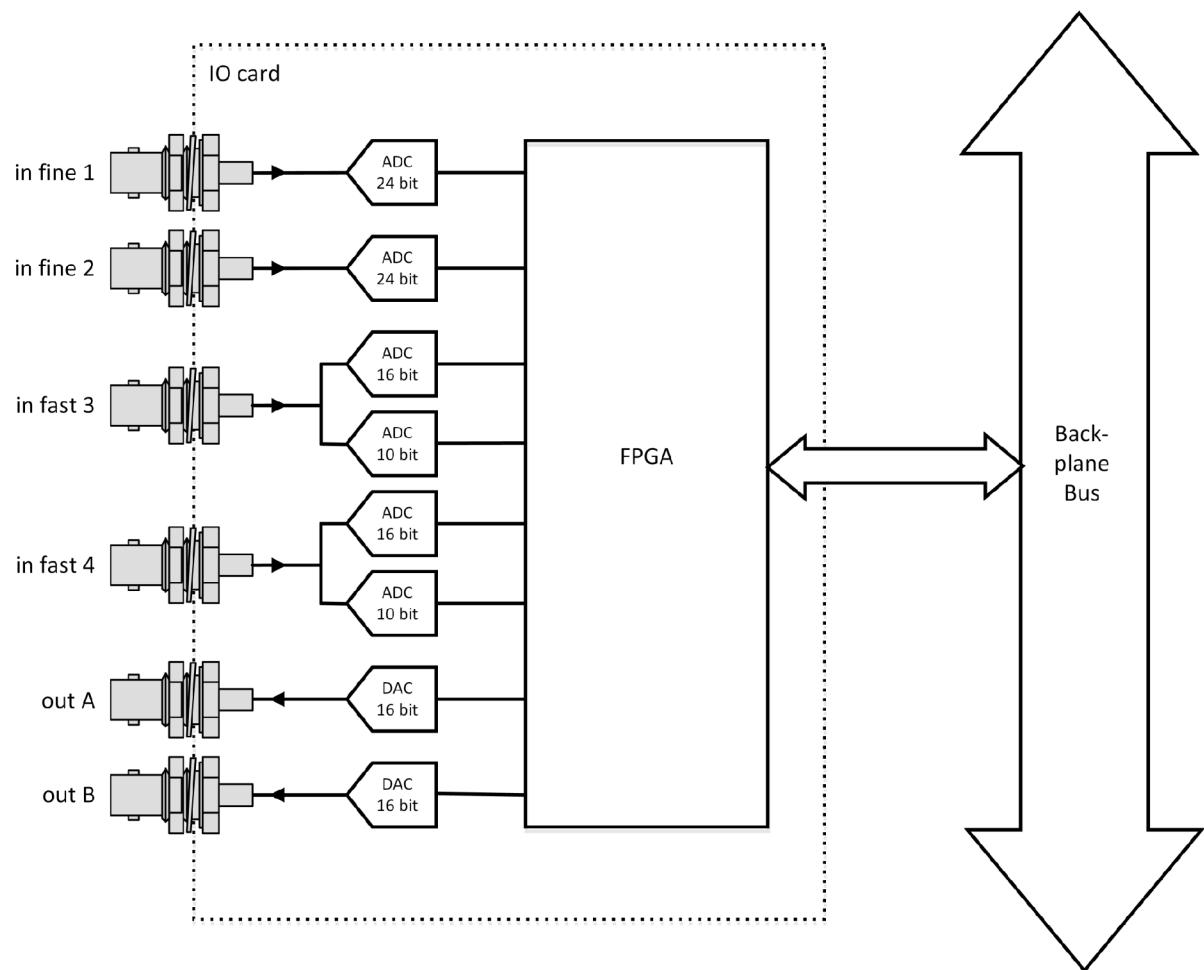


Figure 112 I/O Board schematic overview

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 10.6 for information.

9.2.1 PS+ Module

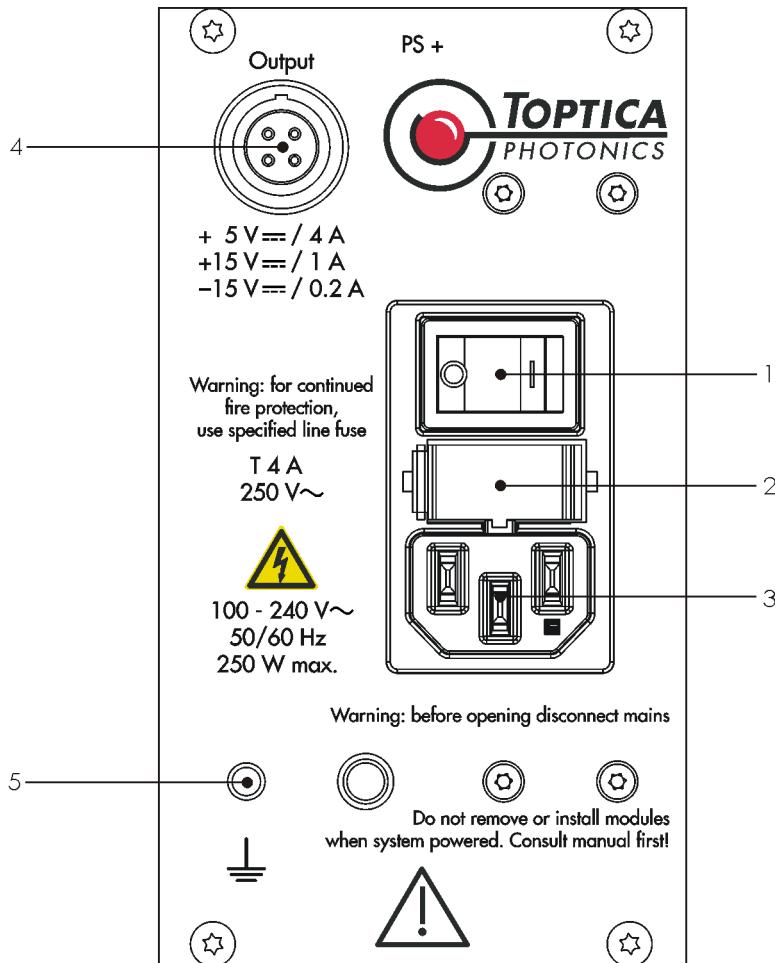


Figure 113 Panel of the PS+ module

1 ON/OFF Switch

2 Fuse Cartridge

3 Mains Connector

4 Output Connector

5 Ground Pin

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 10.8.6. 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

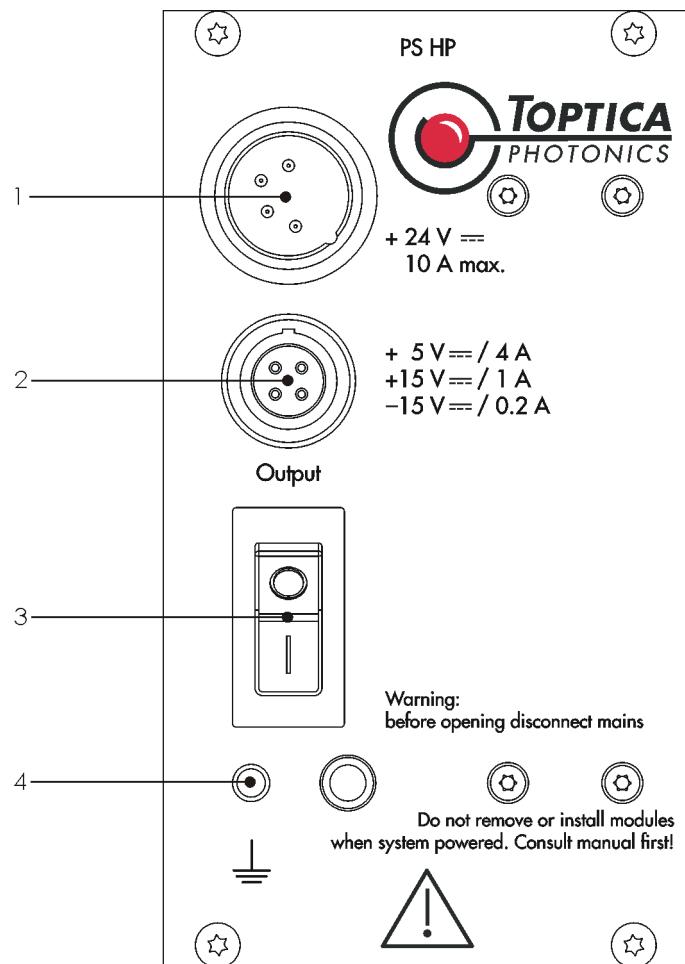


Figure 114 Panel of the PS HP module

- | | | | |
|----------|-------------------------------------|----------|---------------|
| 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 <ul style="list-style-type: none">• 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 10.8.6. 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 115 for connecting a DLC pro with PS HP module to mains via the supplied external power adaptor and mains cable.

DANGER ! Before **connecting/disconnecting the mains cable or the power adaptor connector**,
CAUTION ! always switch off the DLC pro at the ON/OFF switch of the PS HP module.

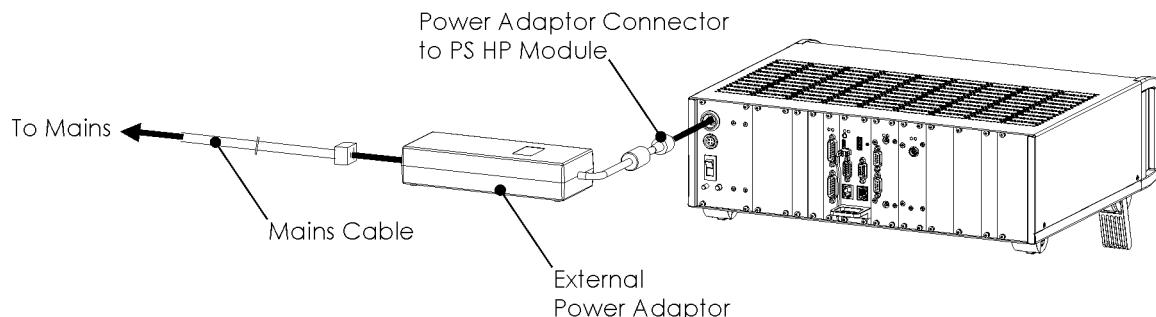


Figure 115 Mains connection of DLC pro with PS HP module. The external power adaptor is delivered by TOPTICA

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.

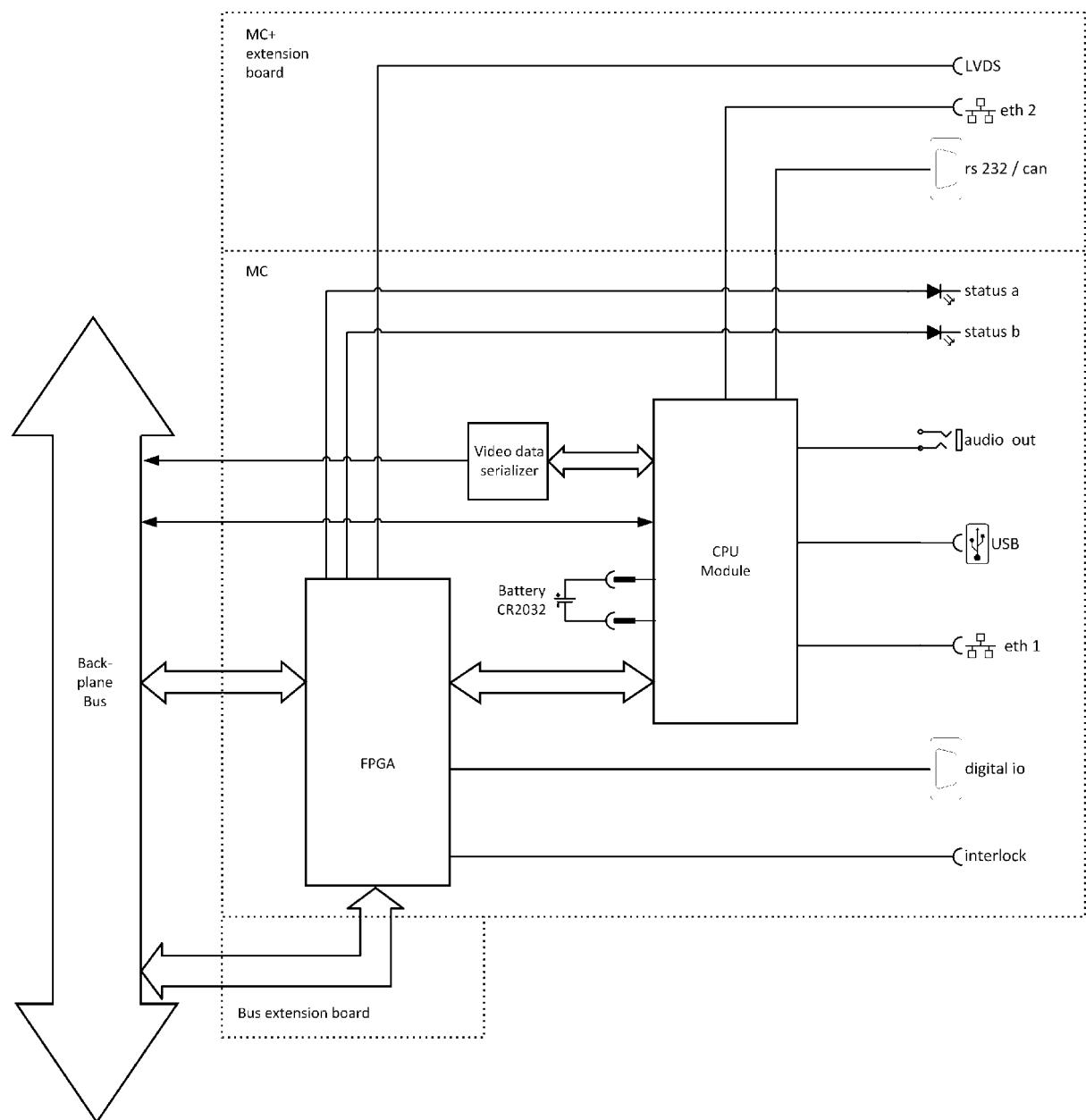


Figure 116 Block diagram of the MC+ module

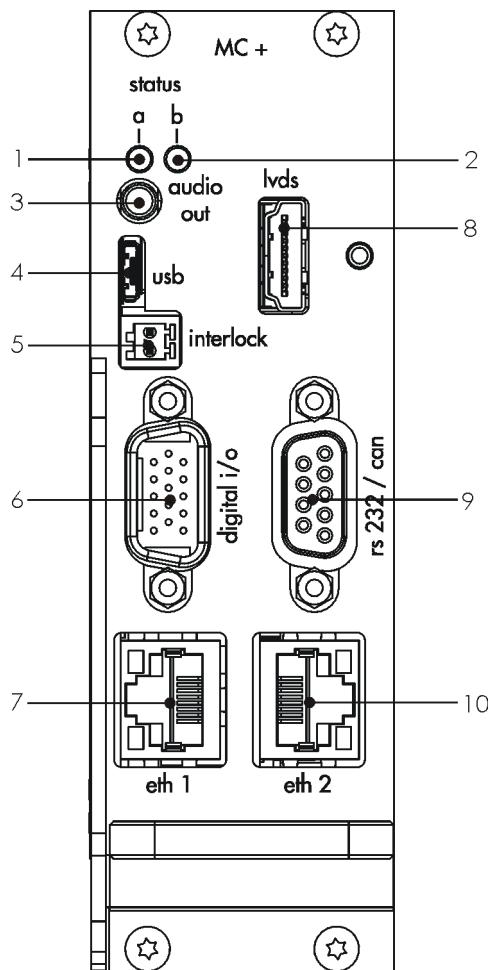


Figure 117 Panel of the MC+ module

- | | | |
|-----------------|--------------------------------|-------------------------|
| 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 <ul style="list-style-type: none">• 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 10.19. NOTE ! A micro USB 2.0 cable with connector type B must be used.
5 External Interlock Connector <ul style="list-style-type: none">• 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 2.2.1.
6 Digital I/O Connector <ul style="list-style-type: none">• 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.

6 Digital I/O Connector <ul style="list-style-type: none"> D-Sub 15 HD male connector <p>(continued)</p>	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 6.12.1). mode 3 Software control. Use parameter io > digital-out1 > value-set to control the voltage of this pin.
	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 1 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 6.12.1). 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 10.8.4.

7 Ethernet 1 Connector	Ethernet connector for remote control of the DLC pro via TCP/IP.
8 LVDS Connector	<p>Connector for high-speed digital communication with supported TOPTICA laser heads.</p> <p>CAUTION ! Connection to other devices may damage the DLC pro laser driver electronics.</p> <p>NOTE ! The LVDS Connector is not present at MC modules.</p>
9 RS 232/Can Connector • D-Sub 9 connector	<p>Currently not supported.</p> <p>NOTE ! The RS232/Can Connector is not present at MC modules.</p>
10 Ethernet 2 Connector	<p>Ethernet connector RJ45.</p> <p>DLC DL-/TA-SHG/FHG pro: Connection between DLC pro and DL-/TA-SHG/FHG pro laser head.</p> <p>NOTE ! The Ethernet 2 Connector is not present at MC modules.</p>

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.

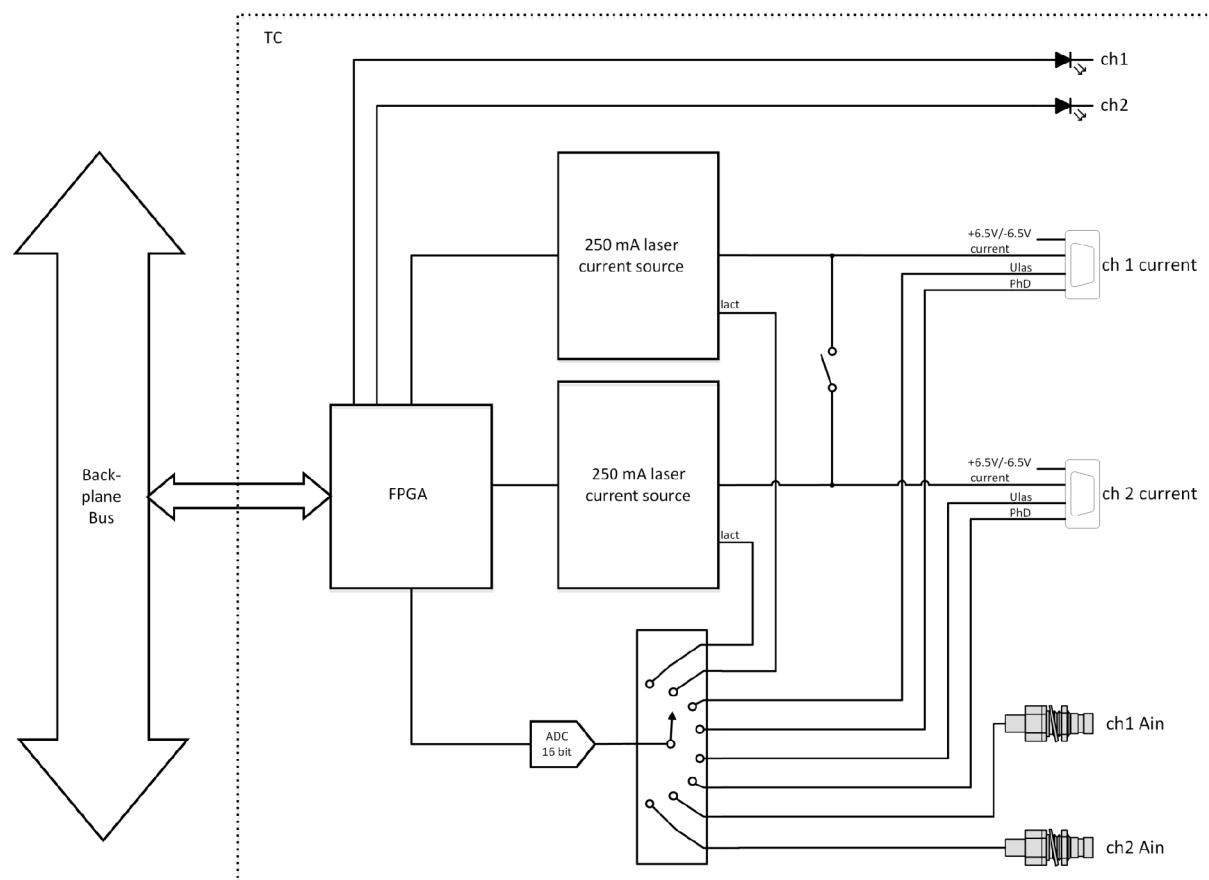


Figure 118 Block diagram of the CC-500 module

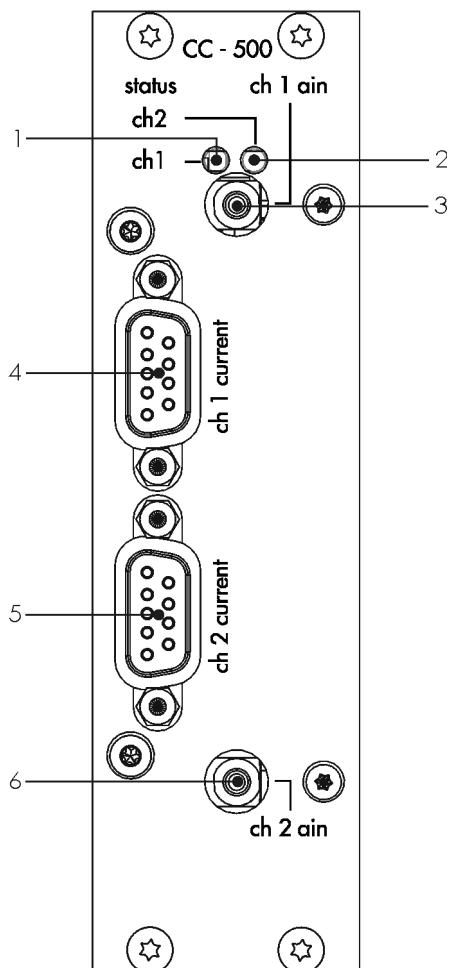


Figure 119 Panel of the CC-500 module

- | | |
|--------------------------------|--------------------------------|
| 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 <ul style="list-style-type: none">• SMB connector	Multi-purpose measurement input, - 4 V .. + 4 V, input resistance 1 MΩ.
4 Channel 1 Current Connector <ul style="list-style-type: none">• D-Sub 9 connector	Connector for channel 1 current. For pin assignment of the D-Sub 9 connector, please refer to section 10.8.1. 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 <ul style="list-style-type: none">• D-Sub 9 connector	Connector for channel 2 current. For pin assignment of the D-Sub 9 connector, please refer to section 10.8.1. 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 <ul style="list-style-type: none">• SMB connector	Multi-purpose measurement input, - 4 V .. + 4 V, input resistance 1 MΩ. DLC TA pro: Used for monitoring the seed power (please refer to the TA pro laser head manual).

9.2.4.1 Changing the CC-500 Current Output

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 10.5 to remove and install the plug-in module.

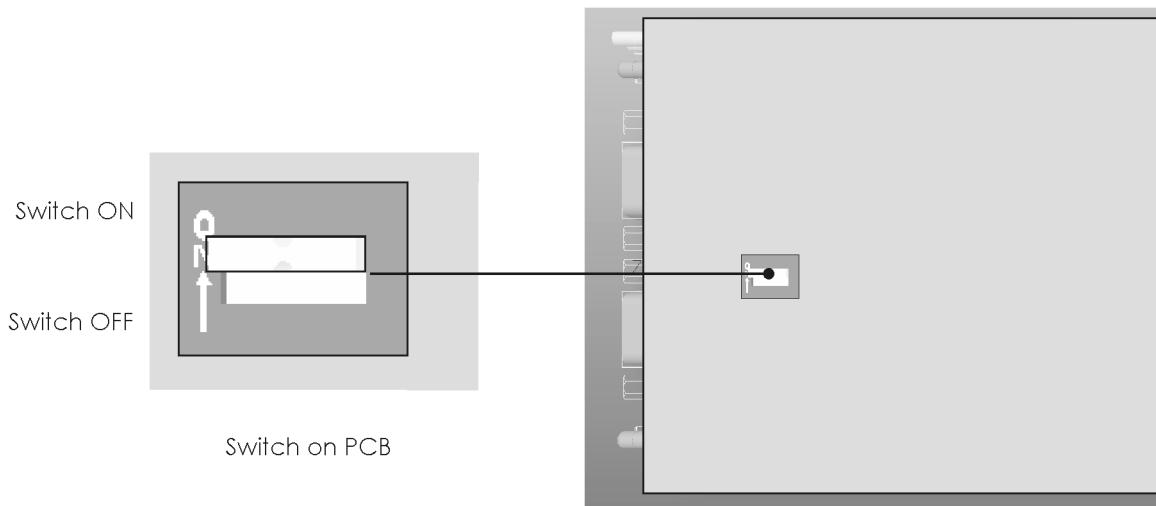


Figure 120 Switch on the CC-500 pcb to change the current output

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 10.6.

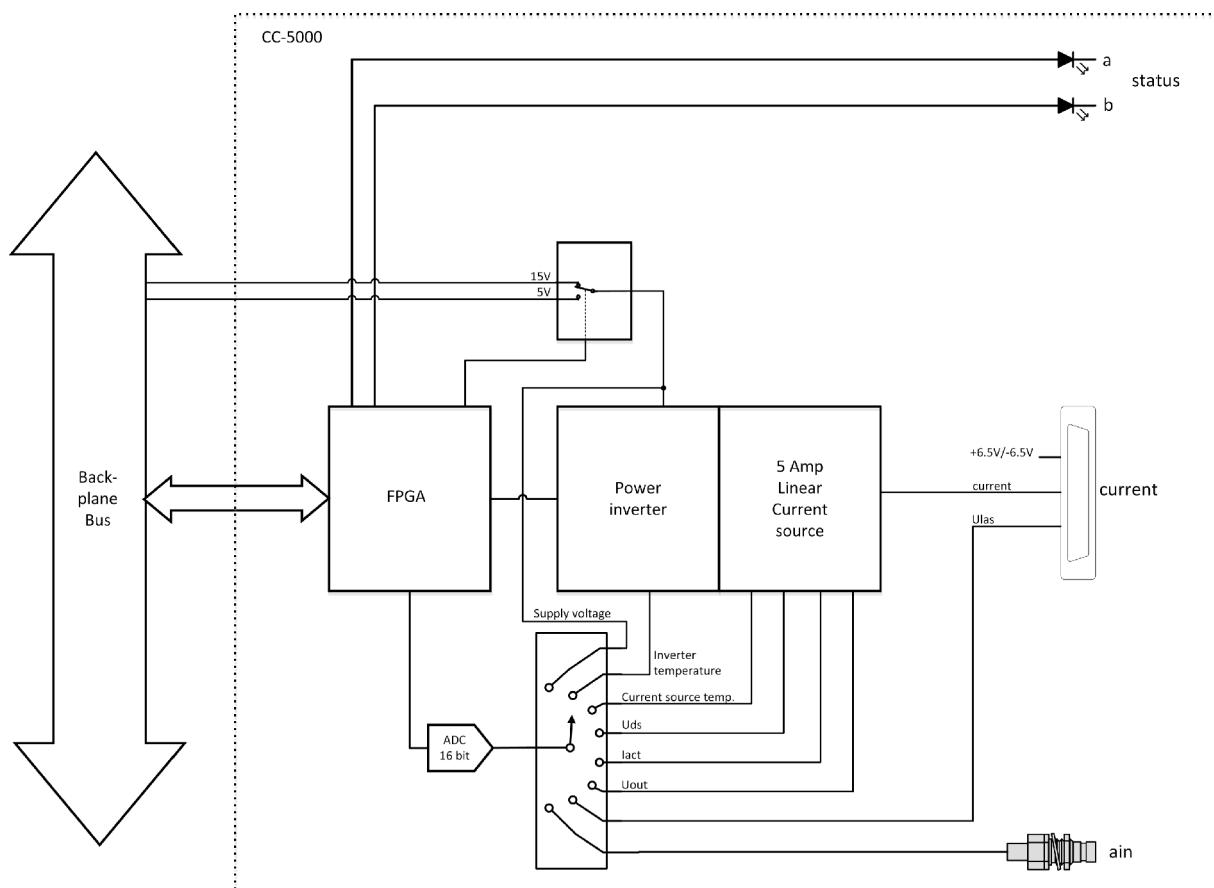


Figure 121 Block diagram of the CC-5000 module

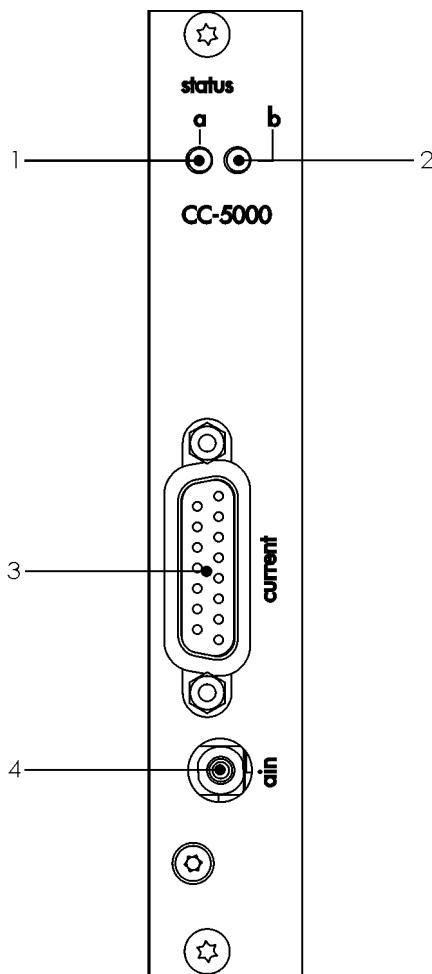


Figure 122 Panel of the CC-5000 module

- | | | | |
|----------|--------------|----------|--------------------|
| 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 10.8.2.
4 Ain	• SMB connector Multi-purpose measurement input, - 4 V .. + 4 V, input resistance 1 MΩ. DLC TA pro: Used for monitoring the amplified output power (please refer to the TA pro 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 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.

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.

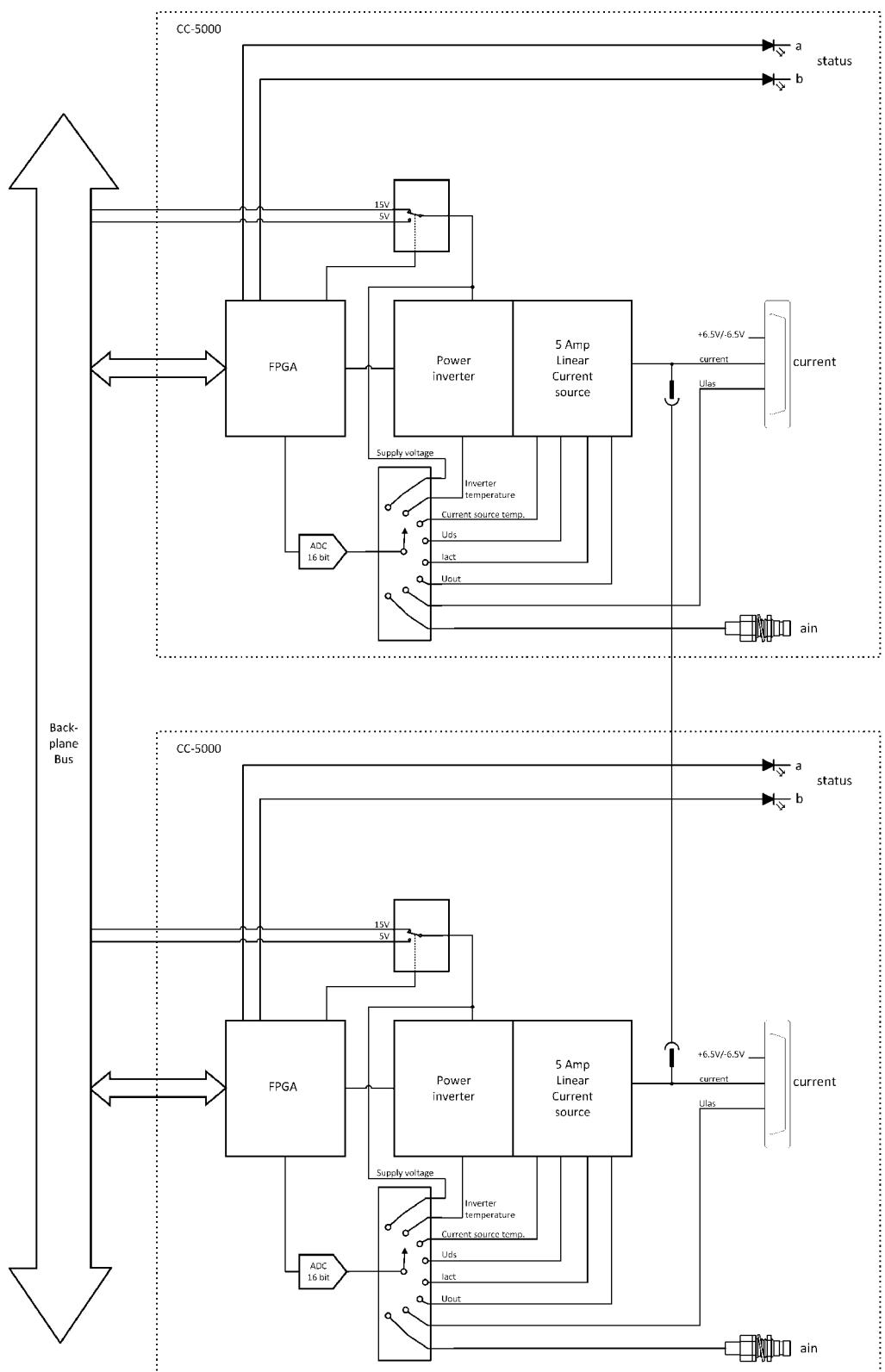


Figure 123 Block diagram of the combination of two CC-5000 modules

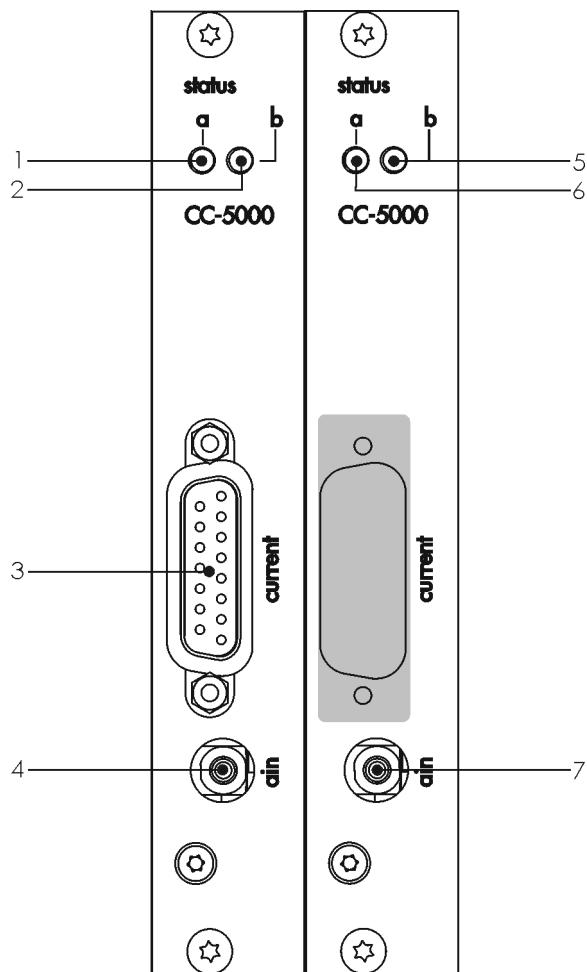


Figure 124 Panel of the combination of two CC-5000 modules

- | | | |
|-------------------------------|-----------------------------------|------------------------------------|
| 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 10.8.2.
4 Ain (left CC-5000) • SMB connector	Multi-purpose measurement input, - 4 V .. + 4 V, input resistance 1 MΩ. DLC TA pro: Used for monitoring the amplified output power (please refer to the TA pro 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 touch-screen, PC-GUI or software commands.

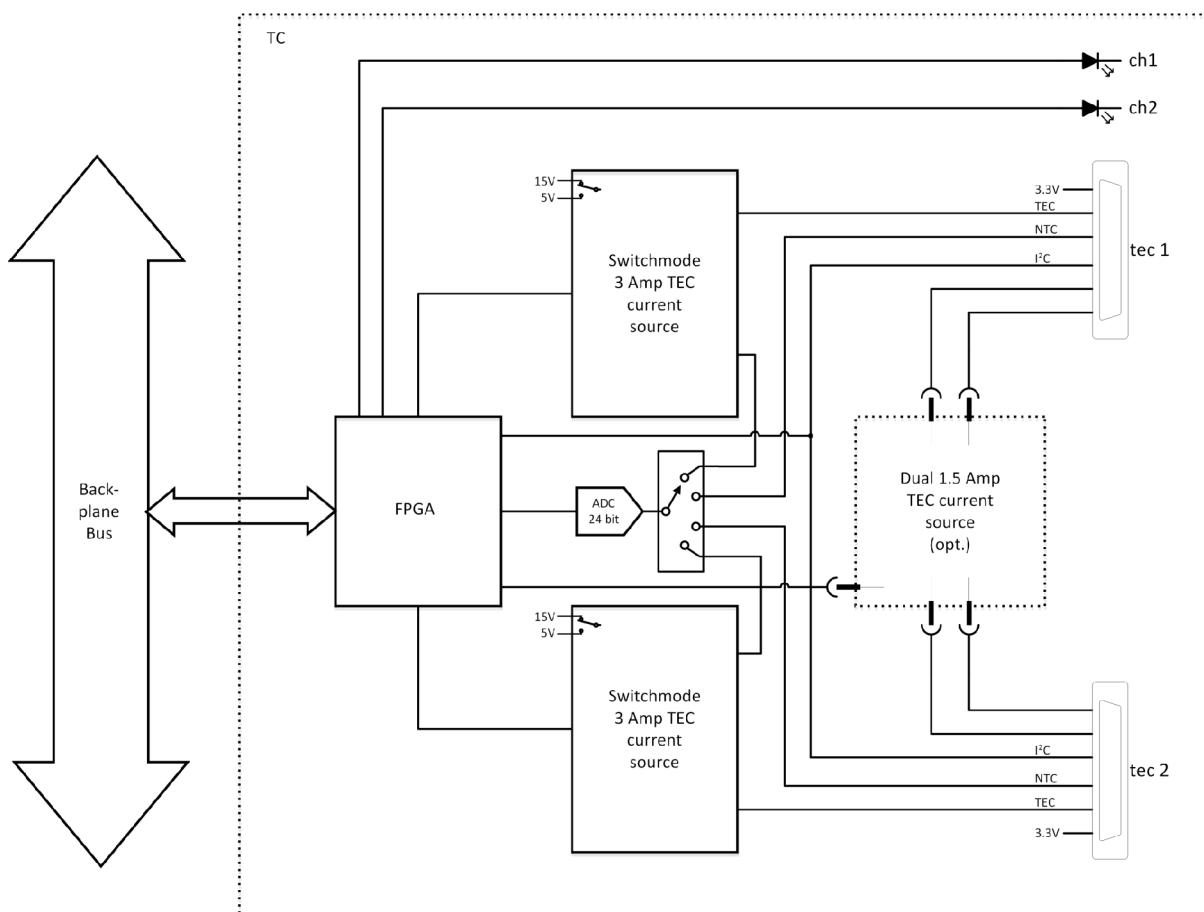
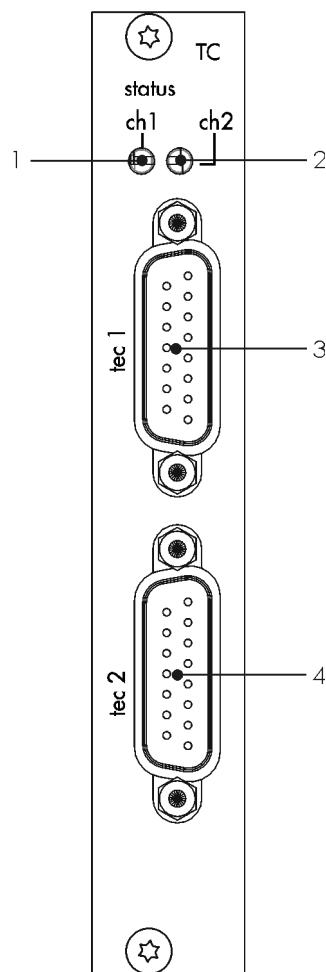


Figure 125 Block diagram of the TC module

**Figure 126** 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 10.8.3.
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 10.8.3.

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 1 μ F. For typical TOPTICA laser heads, the scan amplitude corresponds to a wavelength tuning of several 10 GHz.

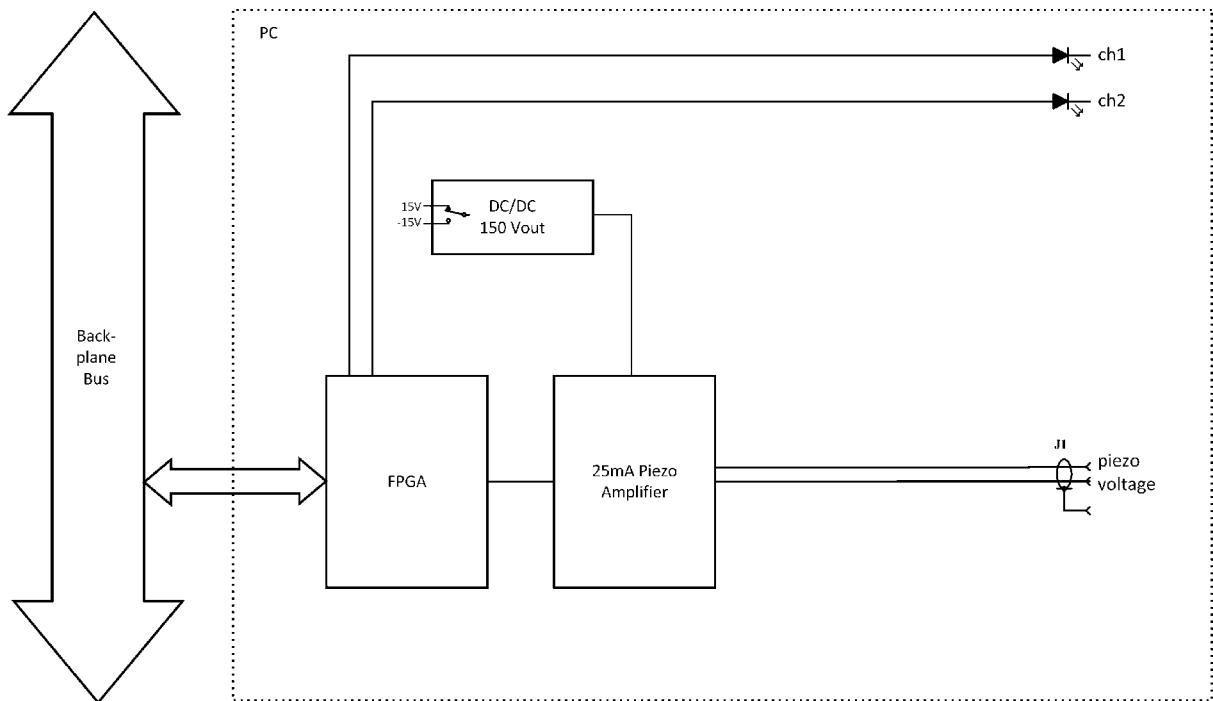
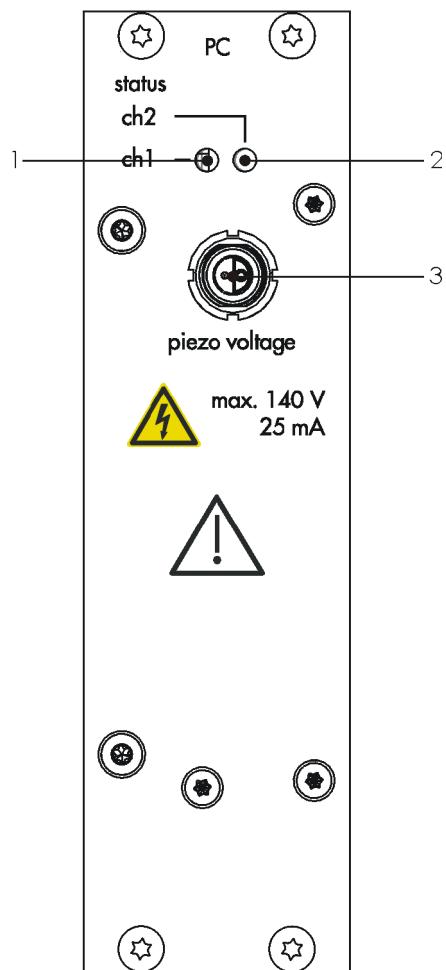


Figure 127 Block Diagram of the PC module

**Figure 128** 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 OS.302 -connector	Analog voltage output for piezo control. Voltage range: - 1 V .. + 140 V. For pin assignment, please refer to section 10.8.5. 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 1 μ F. For typical TOPTICA laser heads, the scan amplitude corresponds to a wavelength tuning of several 10 GHz.

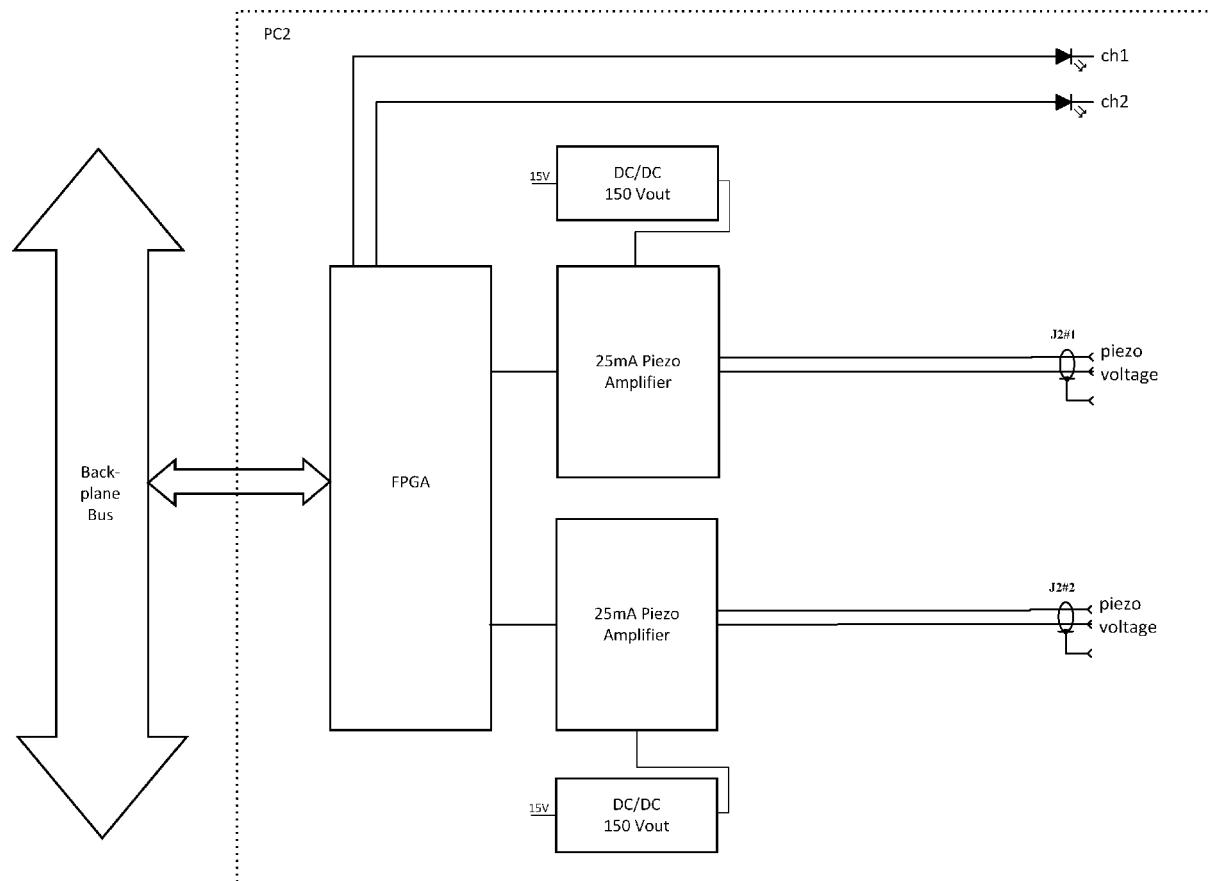


Figure 129 Block Diagram of the PC2 module

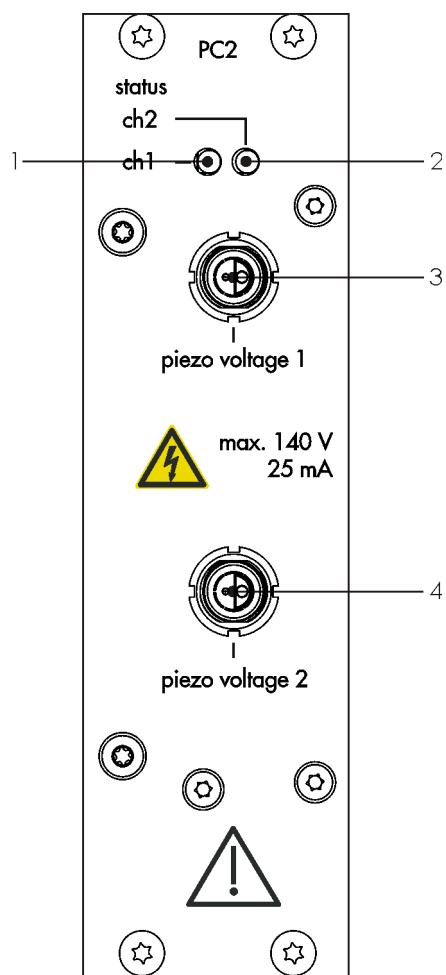


Figure 130 Panel of the PC2 module

- | | |
|-------------------------------|----------------------------|
| 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 OS.302 -connector	Analog voltage output for piezo control. Voltage range: - 1 V .. + 140 V. For pin assignment, please refer to section 10.8.5. 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 OS.302 -connector	Analog voltage output for piezo control. Voltage range: - 1 V .. + 140 V. For pin assignment, please refer to section 10.8.5. 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 10.4 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 6.13.3), a separate 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.

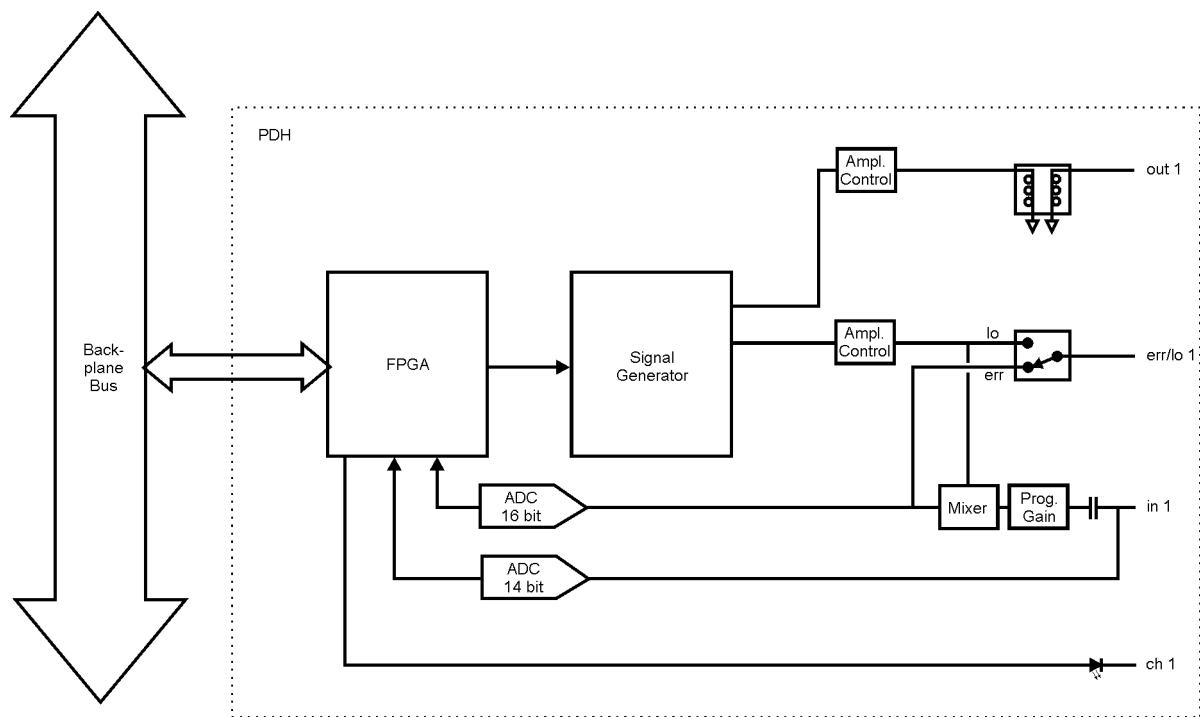


Figure 131 Block diagram of the PDH module (only channel 1 shown)

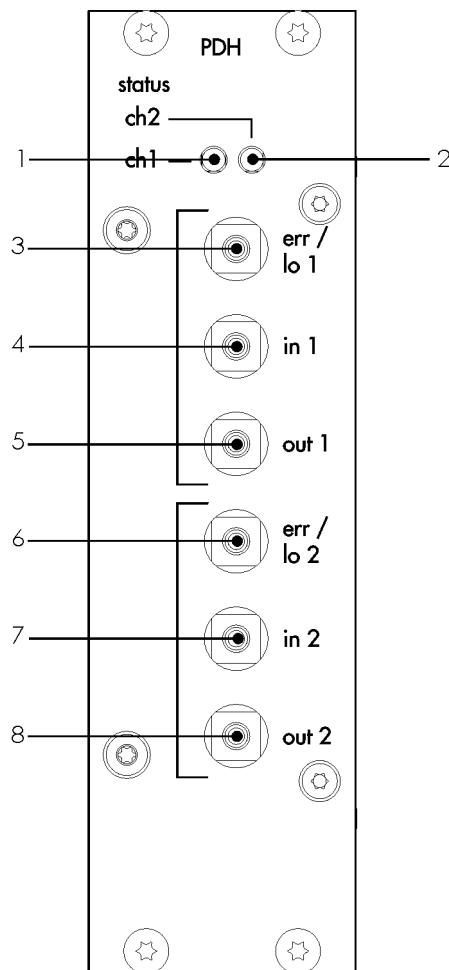


Figure 132 Panel of the PDH module

- | | | |
|-----------------------------------|-----------------------------------|-------------------|
| 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 6.18) 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 6.18) 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 6.18) 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: 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: 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 OS.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 OS.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 10.5.1 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

Digital Scan Generators and Lock Engines on Main Controller MC+	
# of Scan Generators (DDS1)	1
DDS1 outputs (each DDS1)	1
DDS1 Scan Generator Waveforms	sine, triangle
DDS1 output routing	to PC or CC (adds to setpoints)
DDS1 frequency range	0.5 Hz .. 20 kHz, 27 mHz resolution
# of Lock-In Units (LI)	1
LI input routing	Fine In 1, 2; Fast In 3, 4
# of LI frequency generators (DDS2)	1
DDS2 outputs (each DDS2)	2
DDS2 output routing	output 1 to demodulator, output 2 to PC or CC
DDS2 frequency range	11 Hz .. 30 kHz
DDS2 phase range	0x .. 360x, 0.09x resolution
# of PID controllers	2
PID input routing	from LI or Fine In 1, 2; Fast In 3, 4
Main summation point input routing	from PID1, PID2, DDS1, DDS2
Main summation point output routing	to CC (addition to setpoints)
Auxiliary summation point input routing	from PID1, PID2, DDS1, DDS2
Auxiliary summation point output routing	to PC (addition to setpoints)
Feed Forward from PC to laser current	-1.5 mA/V .. +1.5 mA/V

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 DLC pro Main Dimensions

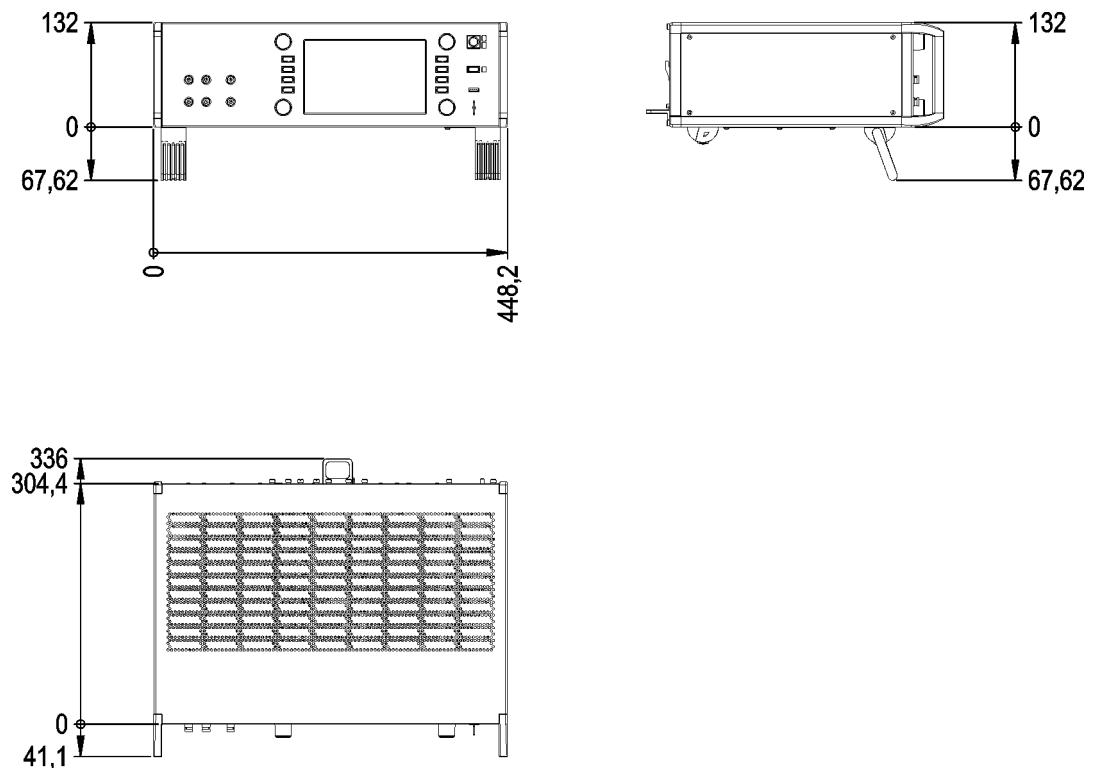


Figure 133 DLC pro main dimensions

10.3 Upgrade for Control of a 2nd Laser

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. 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 is already installed.

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. Please follow the instructions noted in section 10.5 accordingly and observe the mounting positions which are noted in section 10.6.
3. Perform a DLC pro system software update (see section 10.17) 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 10.18.

10.4 Installation of a PDH Module

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 10.5 accordingly and observe the mounting position which is noted in section 10.6.
3. Perform a DLC pro system software update (see section 10.17) 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.

10.5 Changing Plug-In Modules

DANGER ! Before removing a plug-in module, the DLC pro must be switched off and disconnected from the mains supply.

CAUTION ! 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 10.17) to ensure that all modules have the same system software version.

10.5.1 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 10.17) to ensure that all modules have the same system software version.
6. Perform a TOPAS DLC pro software update (see section 10.15).
7. Load the factory settings of the laser system (see section 4.11) 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 10.18).

10.6 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:

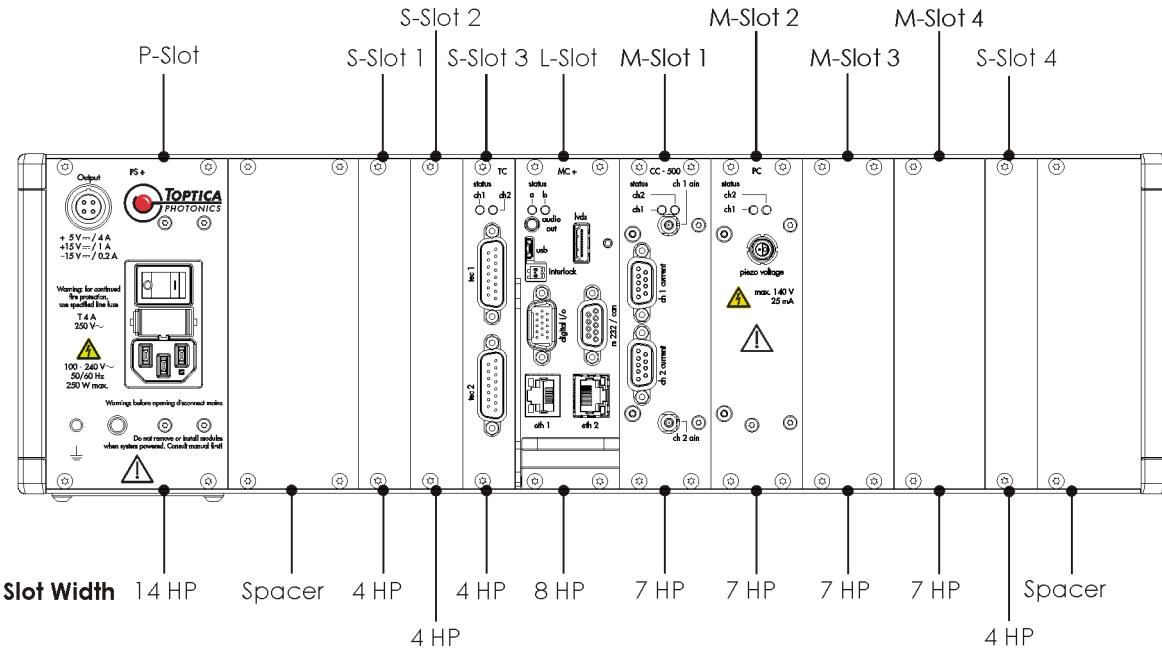


Figure 134 Different slot widths at the rear of the DLC pro Laser Control Electronics (example DLC DL pro)

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 134).

Please refer to the table on the next page.

Plug-In Module	Width (Horizontal Pitch)	Mounting Position to be observed
PS+ 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
MC+ Module	8 HP	L-Slot
CC-500 Module	7 HP	M-Slot 1
CC-5000 Module	4 HP	S-Slot 2
Combination of two CC-5000 Modules	2 x 4 HP	S-Slot 1 + 2
PC Module	7 HP	M-Slot 2
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

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.

10.7 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).

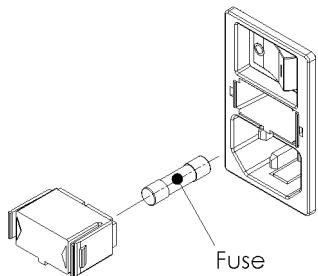


Figure 135 Fuse at the DLC pro connector block

To replace the fuse, open the connector block cover and pull out the fuse cartridge as shown in Figure 135. 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 Pin Assignment of the DLC pro Connectors

10.8.1 CC-500 Module Current Connectors

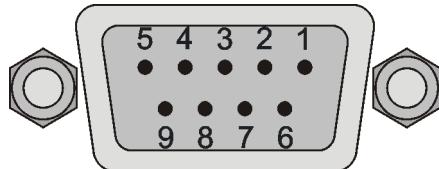


Figure 136 Pin assignment of the current connector (D-Sub-9 female)

- 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

10.8.2 CC-5000 Module Current Connector

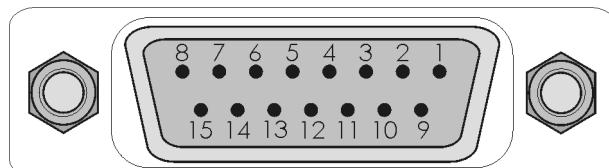


Figure 137 Pin assignment of the current connector (D-Sub-15 female)

- 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

10.8.3 TC Module TEC Connectors

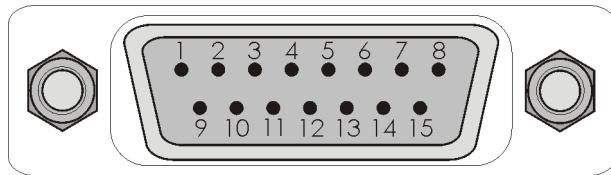


Figure 138 Pin assignment of the temperature control connectors (D-Sub15 male)

- Pin 1** Supply for digital electronics + 3.3 V
- Pin 2** Serial clock signal I²C
- 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 I²C
- 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

10.8.4 MC+ Module Digital I/O Connector

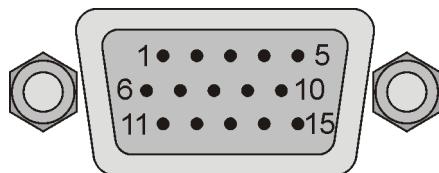


Figure 139 Pin assignment of the Digital I/O connector (D-Sub15 HD male)

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

10.8.5 PC Module LEMO Connector

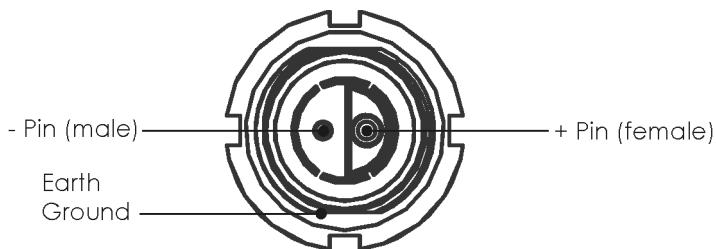


Figure 140 LEMO 0S.302 connector on the PC module

10.8.6 PS+ and PS HP LEMO Connector

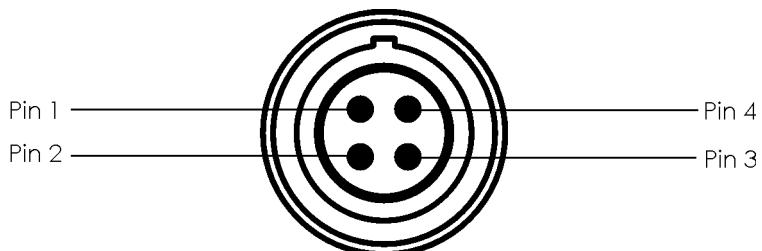


Figure 141 LEMO 2B.304 connector on the PS+ module

Pin 1	5 V/4 A
Pin 2	GND
Pin 3	+15 V/1 A
Pin 4	- 15 V / 0.2 A

10.9 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.

10.9.1 Analog Remote Control Configuration for CC/PC/TC

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

- 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

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

10.9.2 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.

10.10 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 6.12). 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 5.11).
- 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 document 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**.

10.11 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.

10.12 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.

10.13 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 for laser heads with EEPROM 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 142. In case of an amplified laser system, the parameters of the Master Oscillator (dl) and the Amplifier (amp) are treated separately.

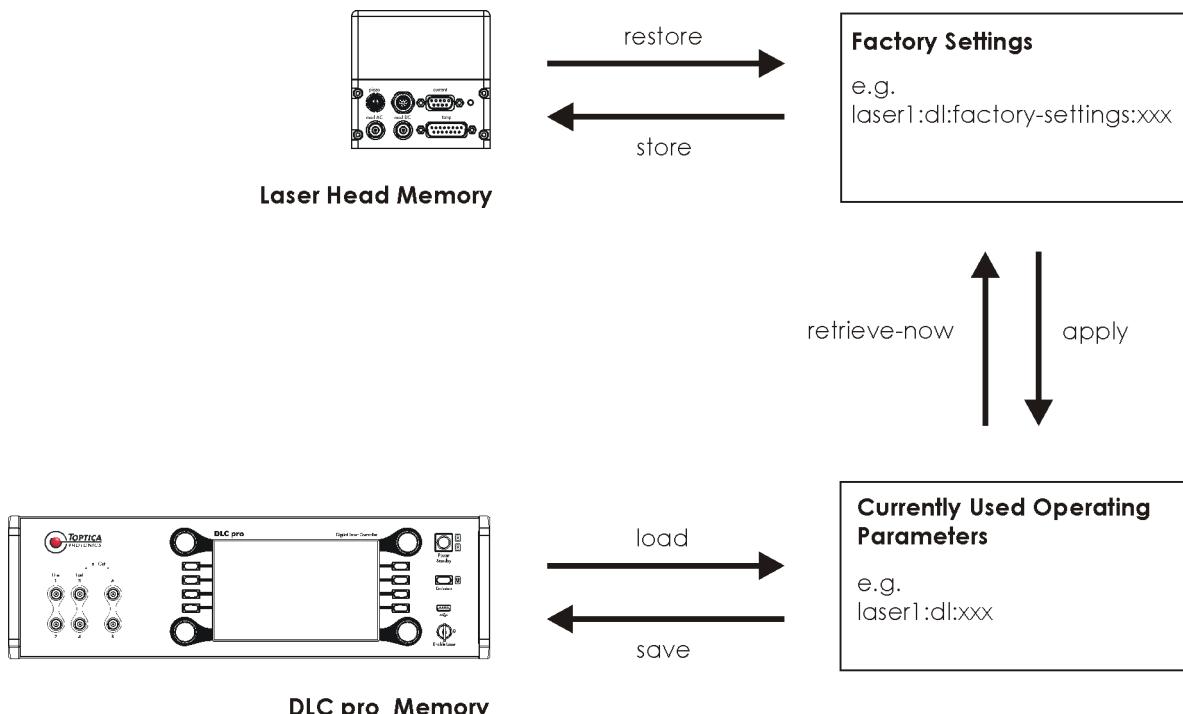


Figure 142 Internal handling and storage of operating parameters (laser heads with EEPROM)

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 6.9).

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.

10.13.1 DLC pro Boot Behavior with Laser Heads without EEPROM

When the DLC pro is booted and a laser head without EEPROM is connected, the boot behavior is as follows:

- Previously connected laser head was without EEPROM: The operating parameters are set to the same values as at the time of the last save.
- Previously connected laser head was with EEPROM: A warning message is displayed, the operating parameters are set to default values and must be set according to the values noted in the laser head Production and Quality Control Data Sheet. Please refer to section 4.5.5 for details. Once the operating parameters are set, save the settings to make them available after the next DLC pro restart and to avoid the warning message.

10.14 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 when clicking on the error indicator in the header.

The system message is displayed on the touchscreen 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.

10.15 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.

10.16 DLC pro Firmware 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 system software update, please refer to section 10.17) 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

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 10.17 for instructions on the system software update.

10.16.1 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 10.17).

NOTE ! Firmware updates can also be performed via the TOPAS DLC pro PC-GUI (please refer to section 10.16.2).

1. Create a directory **toptica** on a FAT formatted USB flash drive. Copy the firmware update file 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 143 Touchscreen display during firmware installation

- When the firmware update is complete, the following screen will appear:



Figure 144 Touchscreen display when firmware installation is completed

- 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.

10.16.2 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 6.9) via TCP/IP.
- Firmware update file (*.fw) 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.

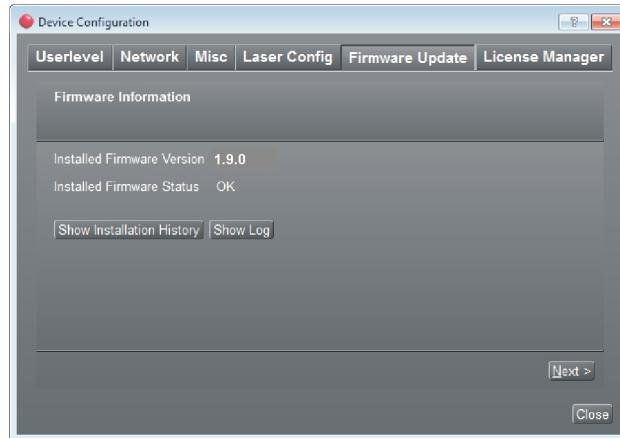


Figure 145 Device Configuration Window, section Firmware Update

2. Click **Next >** to open the **Upload Firmware Archives** window.

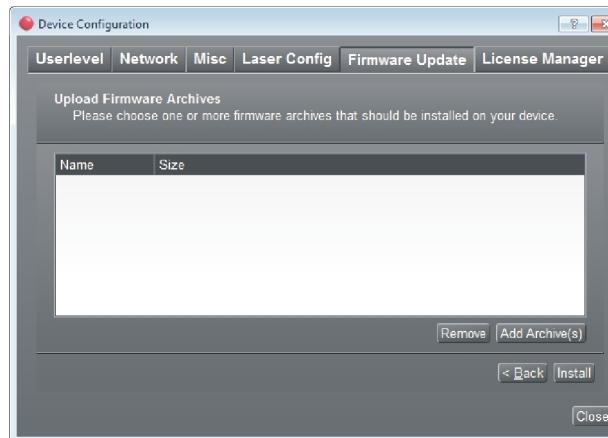


Figure 146 Upload Firmware Archives Window

3. Click **Add Archive(s)** and browse to the location of the downloaded firmware file (*.fw). Double-click the firmware file to select.

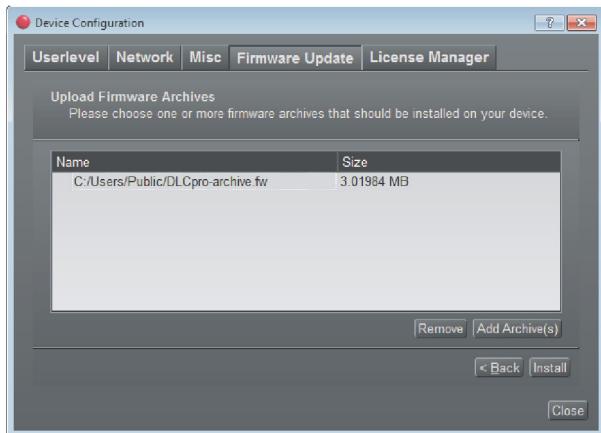


Figure 147 Firmware file selected

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 148 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.

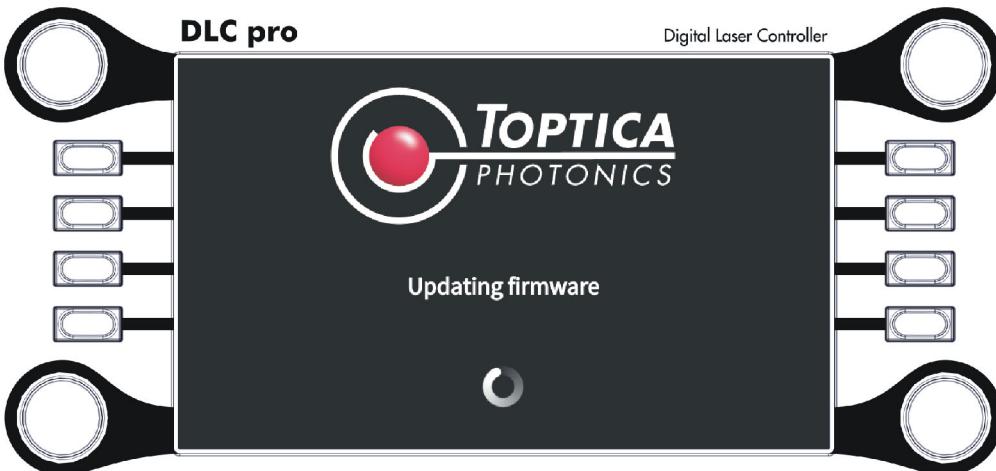


Figure 149 Touchscreen display during firmware installation

When the firmware update is complete, the following screen appears on the touchscreen:



Figure 150 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.

10.17 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 10.16) 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 10.16) 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 151 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 10.16).



Figure 152 Touchscreen display during firmware installation

5. When the firmware update is complete, the following screen will appear:



Figure 153 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.

10.18 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.

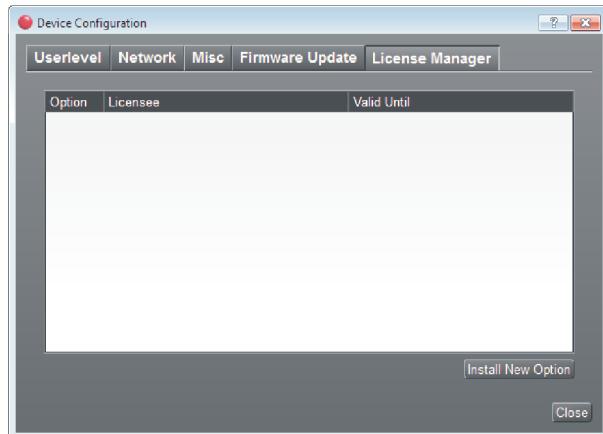


Figure 154 Device Configuration Section License Manager

2. Click **Install New Option**.
The **License Key** window opens.

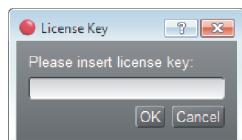


Figure 155 License Key window

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+D23LXeip21||7ho6RYsKUGr5j8bT+MuULxq+jL3S3zRhJ8lopgc106YjQo5sOCi6o
tTuTwOVwc62RhcuXyKlyh3WBp9+GhZYXiFN/oHsEjiKvmOxGfmBUpLPGEOCMHeaiM0pDwUc
G2Xpgnkz6vJKpdtH4twx7tAyR8vKZgE1xle7UUATNekcvML/6pqy3hc+ShV3eQBvsCvasO5J
AQn+ceFNAGmatuZBS7smbBHkDnPx1uhV1vJ8eaNGZTLpR54JgKkULr/wnGgl+QtepicFcBs
poq3gpthjrigCesYYldPgCBPjEhEeeX29W2dRX7RuBlg4PpfKF9PjCMuu0jDXpruRexmL+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.

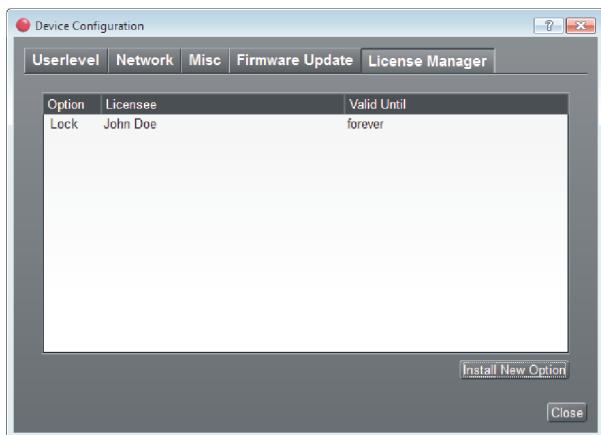


Figure 156 License Manager with Lock option installed (example)

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.

10.19 DLC pro Control via USB Connection

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 10.16 or 10.17.

10.19.1 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. **Up to Windows 7:** At the driver security warning, select the option to install the driver.
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 10.19.2.

10.19.2 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 10.19.1.
- 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.

10.20 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.

10.21 Declaration of CE Conformity DLC DL pro and DLC DFB pro

Konformitätserklärung			
Declaration of Conformity / Declaration de Conformité			
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 / déclarons sous notre seule responsabilité, 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 règlement 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

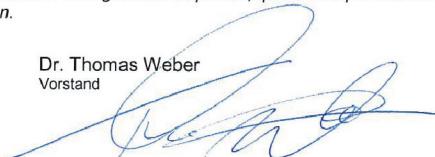
DIN EN 50581

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 déclaration.

Gräfelfing, den 02.08.2017

Dr. Thomas Weber
Vorstand



Name und Unterschrift des Befugten
Name and Signature of authorized person
Nom et signature de la personne autorisée

Ort und Datum der Ausstellung
Place and Date of Issue
Lieu et date d'établissement

10.22 Declaration of CE Conformity DLC TA pro

Konformitätserklärung				
Declaration of Conformity / Declaration de Conformité				
QM-Formular:	F-173	Stand Formular:	15.12.2016	Version Formular: 10 Seite: 1 von 1

Wir / We / Nous

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82166 Graefelfing
Germany

erklären in alleiniger Verantwortung, daß das Produkt / declare under our sole responsibility, that the product / déclarons sous notre seule responsabilité, que le produit

Bezeichnung / Name / Nom

TA PRO with digital DLC pro controller

Artikelnr. / Article No. / No. d'Article

DLC TA pro, DLC TAprom xyz

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 déclaration.

Gräfelfing, den 31.01.2017

Dr. Thomas Weber
Vorstand



Name und Unterschrift des Befugten
Name and Signature of authorized person
Nom et signature de la personne autorisée

Ort und Datum der Ausstellung
Place and Date of Issue
Lieu et date d'établissement

10.23 Declaration of CE Conformity DLC CTL

Konformitätserklärung					
Declaration of Conformity / Déclaration de Conformité					
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 / déclarons sous notre seule responsabilité, 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

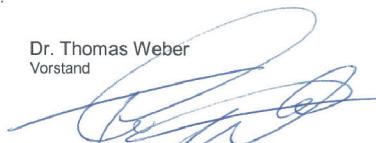
DIN EN 50581

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 déclaration.

Gräfelfing, den 15.12.2016

Dr. Thomas Weber
Vorstand



Name und Unterschrift des Befugten
Name and Signature of authorized person
Nom et signature de la personne autorisée

Ort und Datum der Ausstellung
Place and Date of Issue
Lieu et date d'établissement

10.24 Declaration of CE Conformity DLC DL-/TA-SHG pro

Konformitätserklärung					
Declaration of Conformity / Declaration de Conformité					
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 / déclarons sous notre seule responsabilité, 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 DLC-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 déclaration.

Gräfelfing, den 15.12.2016

Dr. Thomas Weber
Vorstand



Name und Unterschrift des Befugten
Name and Signature of authorized person
Nom et signature de la personne autorisée

Ort und Datum der Ausstellung
Place and Date of Issue
Lieu et date d'établissement

10.25 Declaration of CE Conformity DLC DL-/TA-FHG pro

Konformitätserklärung					
Declaration of Conformity / Déclaration de Conformité					
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 / déclarons sous notre seule responsabilité, 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 déclaration.

Gräfelfing, den 11.07.2016

Dr. Thomas Weber
Vorstand



Name und Unterschrift des Befugten
Name and Signature of authorized person
Nom et signature de la personne autorisée

Ort und Datum der Ausstellung
Place and Date of Issue
Lieu et date d'établissement

10.26 Declaration of CE Conformity DLC MDL pro

Konformitätserklärung		Declaration of Conformity / Déclaration de Conformité		
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 / déclarons sous notre seule responsabilité, 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

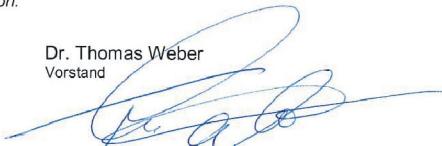
DIN EN 50581

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 déclaration.

Gräfelfing, den 16.10.2017

Dr. Thomas Weber
Vorstand



Name und Unterschrift des Befugten
Name and Signature of authorized person
Nom et signature de la personne autorisée

Ort und Datum der Ausstellung
Place and Date of Issue
Lieu et date d'établissement

10.27 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

10.28 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 contact us in the following ways:

- Internet: service.toptica.com. In our support section, you can find a list of frequently asked questions and a service contact form.
- Email: service@toptica.com
- Phone: +49-89-85837-150

Our customers in the USA and Canada may contact TOPTICA Photonics Inc.:

- Phone: +1-585-657-6663

Our customers in Japan may contact TOPTICA Photonics K.K.:

- Phone: +81-42-306-9906

Guarantee Registration Form



QM form:	F-015	Status of form:	13.10.2015	Version of form:	02	Page:	1 of 1
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return to

sender:

TOPTICA Photonics AG
Customer Service
Lochhamer Schlag 19
D- 82166 Graefelfing/Munich
Germany

FAX: +49 89 85837-200

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).

