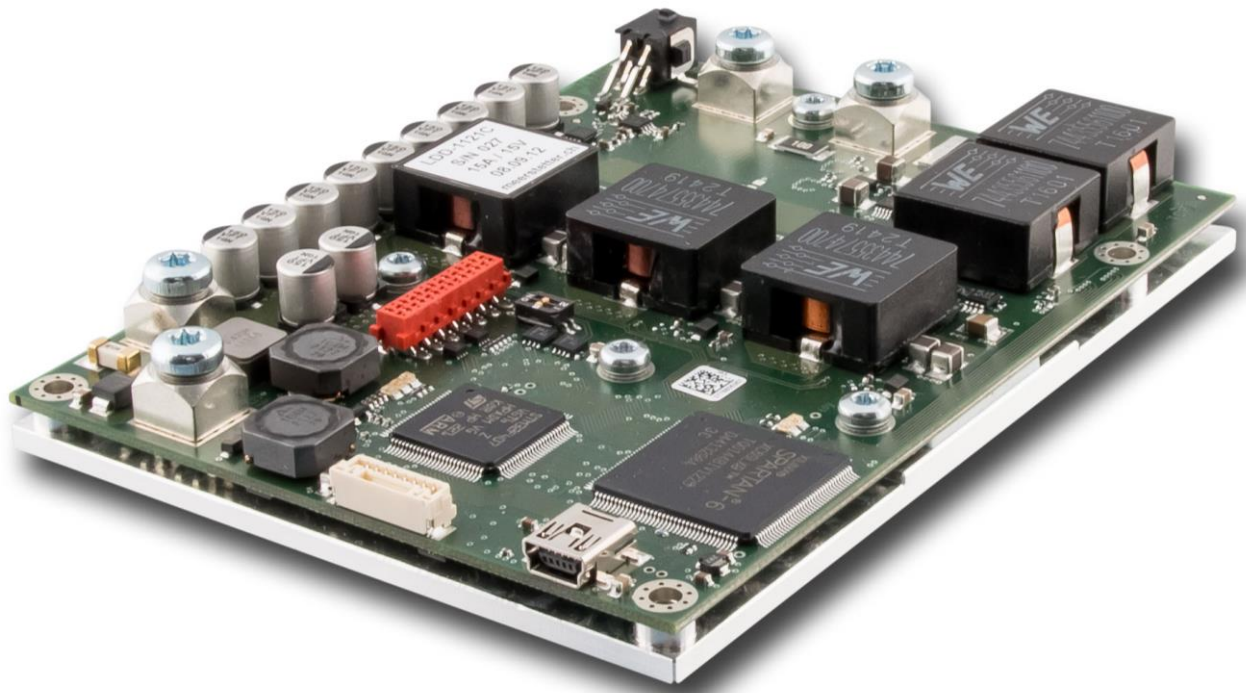




Developed, assembled and tested in Switzerland

User Manual

Laser Diode Driver



LDD-Family:

LDD-1124

LDD-1121

LDD-1125

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Meerstetter Engineering GmbH (ME) reserves the right to make changes without further notice to the product described herein. Information furnished by ME is believed to be accurate and reliable. However typical parameters can vary depending on the application and actual performance may vary over time. All operating parameters must be validated by the customer under actual application conditions.

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1 Overview LDD-1121-based Laser Diode Drivers

Mounting (M3-size Bores, 7.5mm in Length):

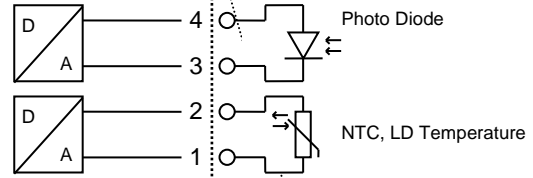
- M1: x = 4.0 mm, y = 86.0 mm
- M2: x = 98.0 mm, y = 86.0 mm
- M3: x = 4.0 mm, y = 4.0 mm
- M4: x = 98.0 mm, y = 4.0 mm

Power Terminals: M4-size Screws

Pin Descriptions Platform Bus X3:

- 1: GND for TYCO Plug 14-POL 8-215083-4
- 2: RES1
- 3: RES2
- 4: RES3 (Analog Input)
- 5: RES4
- 6: RES5 (PULSE Trigger Output)
- 7: RES6
- 8: RES7 (PULSE Trigger Input)
- 9: RES8 (ENABLE)
- 10: GND
- 11: RS485_A1 [120Ω Termination, DIP-Switch J1, 1]
- 12: RS485_B1
- 13: RS485_A2 [120Ω Termination, DIP-Switch J1, 2]
- 14: RS485_B2

LDD Board



for TYCO 4-POL Plug Housing 794617-4

with AWG 20-24 Crimp Contacts 794610-1

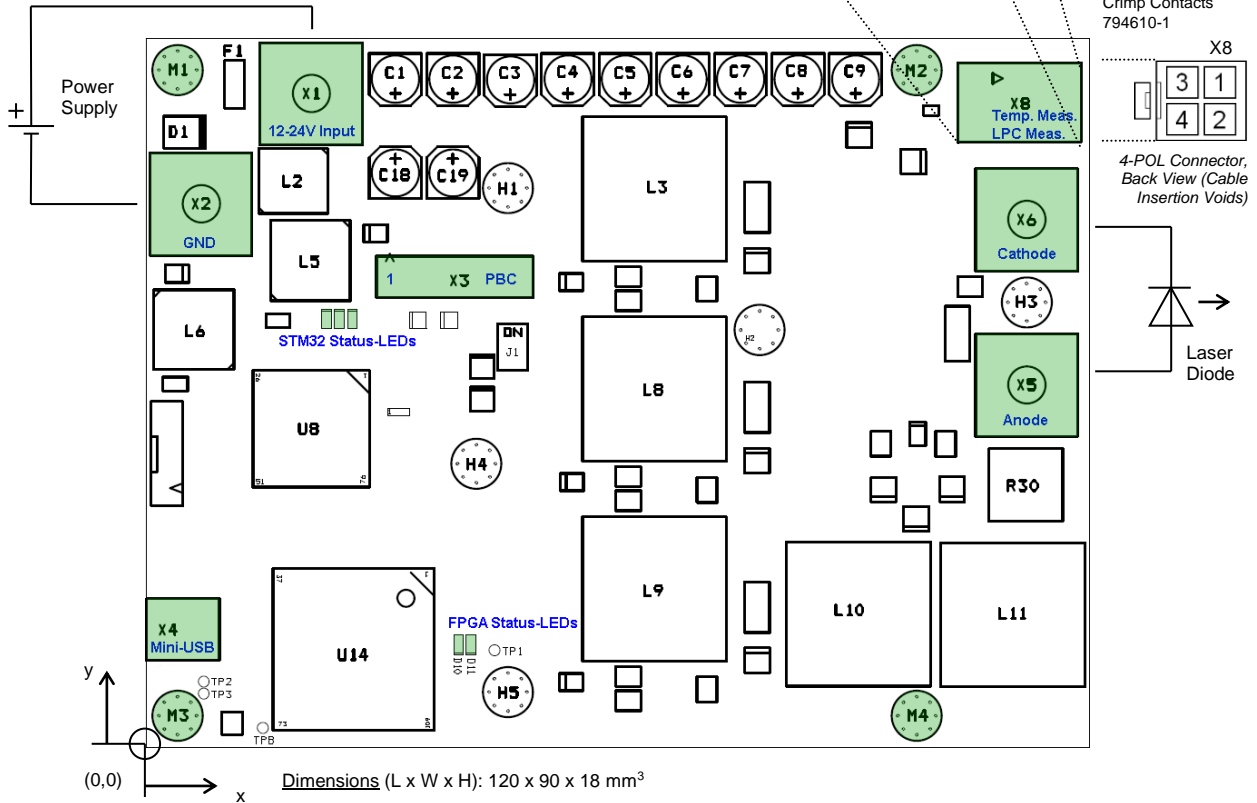


Figure 1. Schematic top view of an LDD-1121-based laser diode driver. Elements relevant to the end-user are highlighted.

The Platform Bus (X3) allows connection to a TEC-1122-based TEC controller.

Power supply, laser diode, temperature sensor and photo diode not included.

2 Introduction to the LDD-Family of Laser Diode Drivers

This manual is written for products that are part of the LDD-Family of advanced laser diode drivers/controllers, based on the LDD-1121.

LDD-Family devices have two operation modes, continuous and pulsed. In continuous (CW) mode, the low-ripple current output can be modulated up to intermediate frequencies. In pulsed mode, high-frequency pulses with steep edges can be generated by CW chopping.

Individual laser diode drivers can be remotely-controlled (RS485/USB, HW lines), or they can operate as stand-alone units, controlled by internal generators. These internal generators are again remotely-configurable.

LDD-1121-based laser diode drivers are controlled by powerful microcontroller (STM32), fast signal paths and critical safety features are implemented in hardware (FPGA).

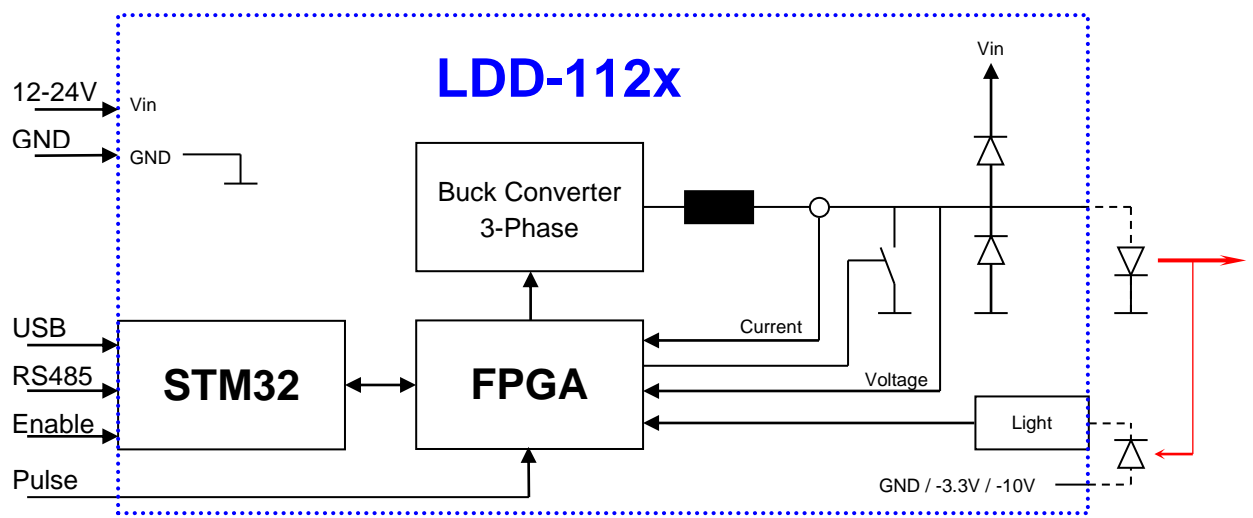


Figure 2. Functional Diagram of an LDD and its periphery.

Laser diode temperature monitoring (using NTC sensors) and thermal shut-down comes as standard. Optionally, laser diode drivers can be equipped with light measurement hardware (to be used in conjunction with a photodiode) which will allow laser power monitoring or laser power closed-loop control, depending on the firmware.

The LDD-Family has been developed to work along the dual channel members of the TEC-Family of advanced TEC controllers/drivers that share the same platform bus, communication protocol and hardware architecture. See Table A for an overview over the current LDD- and TEC-Families.

	Model	Description
LDD-Family Laser Diode Drivers	LDD-1124	0-1.5 A / 0-15 V, Low-Ripple CW and Pulsed-Mode Operation
	LDD-1121	0-15 A / 0-15 V, Low-Ripple CW and Pulsed-Mode Operation
	LDD-1125	0-30 A / 0-15 V, Low-Ripple CW and Pulsed-Mode Operation
TEC-Family Peltier Drivers	TEC-1089	± 10 A / ± 19 V, Compact, Single Channel
	TEC-1090	± 16 A / ± 19 V, Compact, Single Channel
	TEC-1122	2x (± 10 A / ± 19 V), Dual Channel
	TEC-1123	2x (± 16 A / ± 19 V), Dual Channel

Table A. Overview over the Meerstetter LDD- and TEC-Families of advanced controllers. Meerstetter Engineering GmbH is specialized in supporting custom laser solutions.

The present manual covers LDD-Family Firmware and Service Software version 1.50.

3 Getting Started, Step-by-Step

In the following steps, setting up an LDD-Family laser diode driver for basic operation is described. Bullet points (•) designate actions, tick boxes (☐) feedbacks/reactions, and arrows (←) further information.

3.1 Software Installation

Step 1 Install USB Driver

- Start up a PC running Windows XP or Windows 7
- Use a Mini-USB cable to connect the laser diode driver to the Service PC

☐ *Windows recognizes the USB interface and installs a (Serial Interface) driver*

← In case Windows cannot locate the FTDI USB driver by itself, get it from the Meerstetter LDD and TEC products CD or download the executable 2.08.24 (or newer) from: http://www.ftdichip.com/Drivers/CDM/CDM20824_Setup.exe

← This installation does not require the LDD to be powered, yet (the isolated USB interface is bus-powered)

Step 2 Install LDD Service Software

- Please ensure the Service PC meets the following requirements:
 - .net Framework 4.0 (.net Web Installer* *dotNetFx40_Full_setup.exe* and Windows Update)
 - Microsoft Visual C++ 2010 [SP1 or above] Redistributable Package**
 - Display resolution: 1024x768 or greater
- Copy the latest version of the Service Software executable (e.g. LDD Service [version].exe) to the Service PC and launch it

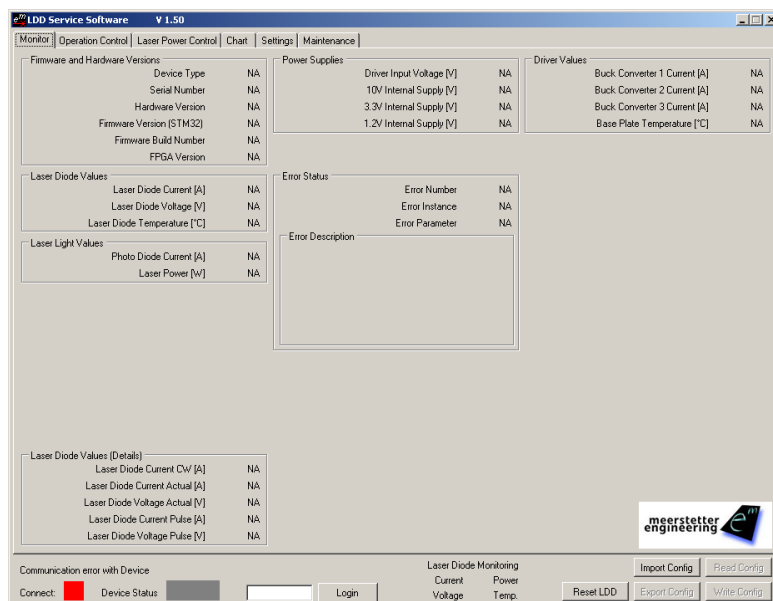
← All required software and drivers are located on the Meerstetter laser diode driver (LDD-Family) and TEC controller (TEC-Family) products and support CD [me5145]

← *Online/web installer for .net Framework 4.0: <http://www.microsoft.com/download/en/details.aspx?id=17851> followed by patching via www.windowsupdate.com (several files) and restart

← **32bit version *vcredist_x86.exe*: <http://www.microsoft.com/download/en/details.aspx?id=8328>
On 64bit versions of Windows 7, the additional installation of *vcredist_x64.exe* may be necessary:
<http://www.microsoft.com/download/en/details.aspx?id=13523>

← The present LDD Service Software is a tool that has been programmed by Meerstetter Engineering for internal use, namely for device configuration, monitoring, and debugging during product development. It is being made available to customers for OEM device evaluation, commissioning and integration

☐ *LDD Service Software displays 'Device connected, establishing communication...' in the bottom left corner and the red indicator confirms 'Communication error with Device'*



Screenshot: USB connected, laser diode driver unpowered

3.2 Mounting and Powering-Up the Laser Diode Driver

Step 3

Mount LDD onto System Carrier Plate

- Locate the four mounting holes M1-M4 (see Figure 1)
- Use M3 size screws to fasten the laser diode driver to the system

← For initial tests / operation at low power, placing the LDD on a metal plate / heat sink should be sufficient

Step 4

Connect Laser Diode Driver to Power Supply

- Connect X1 (VIN) and X2 (GND) to the outputs of the external power supply

← Do not connect the laser diode, yet

Step 5

Power up Laser Diode Driver

- Enable power supply and check device status

Either the green or the red STM32 Status-LED (see Figure 1) should be blinking / lit. The status of the blue LED can be ignored

Either the green or the red FPGA Status-LED should be blinking / lit

Step 6

Successful Connection

- Check active connection between laser diode driver and LDD Service Software

The square in the bottom left corner of the LDD Service Software should be green and 'Connected'

The 'Device Status' indicator should be amber and 'Ready'

← A color-coded indicator informs about the current device status, refer to Appendix 1 for more information

3.3 Hardware and Status Verification

Step 7

Identify 'Software and Hardware Versions'

- Locate the corresponding group box in the 'Monitor' tab (Tab1)

Take note of the firmware, FPGA and hardware versions

Check the serial number matches the sticker on your laser diode driver

Step 8

Check 'Power Supplies'

- Locate the corresponding group box in Tab1

Check the input voltage matches the one of the external power supply

Check the internal 10V, 3.3V and 1.2V supplies are working at nominal voltage

Step 9

Check 'Error Status'

- Locate the corresponding group box in Tab1

Take note of the three error indicators. 0s are shown when no error is present

← If applicable, a brief Error Description is displayed in the corresponding field. Please consult the reference section for more information on LDD-Family laser diode driver and on TEC-Family TEC controller error conditions

3.4 Laser Diode and Driver Monitoring

Step 10 **Check 'Laser Diode Values' with no Laser Diode or Temperature Probe Connected**

- Locate the corresponding group box in Tab1

Note that current and voltage values are static and close to zero (no LD connected, LDD disabled)

Note that laser diode temperature is at end of range (no °T probe connected, default thresholds are set such that no diode temperature error is generated)

← The above monitoring values will be revisited once the LDD is driving a load and temperature acquisition is set up

Step 11 **Check 'Driver Values' with no Laser Diode Connected / Driver Disabled**

- Locate the corresponding group box in Tab1

Note that there are three buck converter channels / phases and that their current is balanced (currently near nil)

Take note of the laser diode driver's base plate temperature

← The LDD is driven by three buck converters at 120° phase shift. The FPGA takes care of channel balancing

3.5 Configuration Tab 'Settings', Entering New Parameters

Step 12 **Move from the 'Monitor' Tab to a Configuration Tab, Check System Settings**

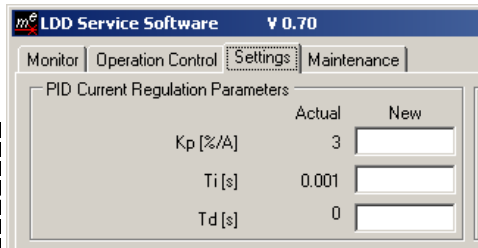
- Switch to Tab5 'Settings'
- Locate the 'Current PID Regulation Parameters' group box

Please check the PID parameters are set according to the illustration to the right

← Current regulation by PID is covered in the reference section

← Tab5 is a configuration tab (not a monitoring tab, such as Tab1). In configuration tabs, each parameter displays an actual value next to a blank field for entering a new value

← New values need to be transferred to the device by clicking 'Write Config' in the bottom right corner of the Service Software. See chapter 5.1 for more information about parameter transfer



Step 13 **Check 'Maximum Values' (Limits)**

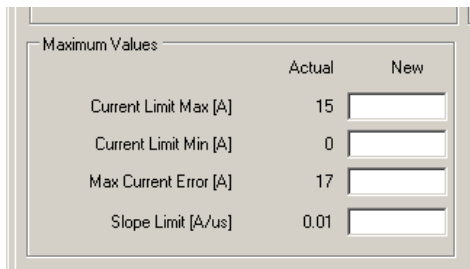
- Locate the corresponding group boxes in Tab5

Please take the time adjust factory settings to your requirements

← Current limits define the permitted range of user-settable nominal values. Chose values limiting the range you intend to employ

← 'Max Current Error' is an important safety setting that limits the LDD's power output to protect the connected diode. Reaching this threshold triggers ultrafast (<4 μs) switchoff! Always set this value below or at the absolute maximum current rating of the used laser diode (please refer to the manufacturer's data sheet)

← Again: Transfer new values the laser diode driver by clicking 'Write Config'

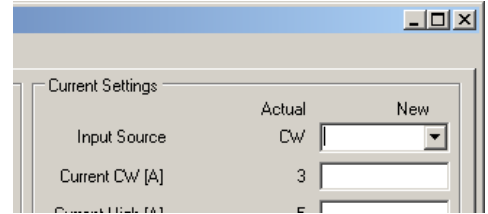


3.6 Operation Control, Driving a Load in CW Operation

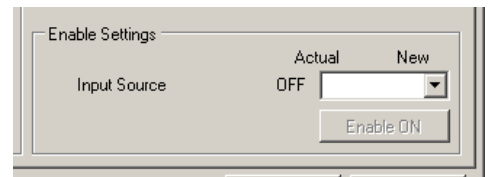
Step 14 **Make Sure Laser Diode Driver is in CW Mode and DISABLED**

- Switch to Tab2 'Operation Control'
- Identify the numerical and graphical sections for current (CW, modulated) and pulse settings

□ Make sure 'Current Settings' 'Input Source' is set to 'CW' and that 'Current CW' is set to a value supported by the first device (laser diode or dummy load) to be connected



□ Make sure 'Input Source' for 'Enable Settings' is set to 'OFF', else toggle to 'OFF' [+ 'Write Config' button]



Step 15 **Connect and Drive Load (Laser Diode or Dummy Load)**

- Connect an adequate load* to sockets X5 (Anode) and X6 (Cathode)
- If you intend to use the LDD's pulsed mode, use low inductivity connection lines and place the diode / load as close to X5 and X6 as possible
- Toggle 'Enable Settings' 'Input Source' to 'ON' [+ 'Write Config' button]

□ Switch to Tab1 'Monitor' and observe how 'Laser Diode Current Actual' and 'Laser Diode Current Pulse' now indicate the set CW current

□ 'Laser Diode Voltage Actual' and 'Laser Diode Voltage Pulse' indicate the resulting voltage

□ Also, 'Driver Values' (Tab1) should now indicate three balanced buck converter currents, delivering one third of the total current each

← *For early evaluation and training purposes, the use of a dummy load over a laser diode is recommended

← Meerstetter Engineering also encourages you to crosscheck the current and voltage through/across the load with your own instruments. For static CW mode, the use of multimeters is sufficient. For modulated CW and pulsed mode, adequate current probe and oscilloscope will be necessary. (Note that a bandwidth of DC-10 MHz or above is required for analyzing pulse edges.)

3.7 CW Modulation by Internal Generator

Step 16 **Configure Internal Generator to Control CW Current**

- As demonstration for the laser diode driver's current modulation capability, and as a basis for PID optimization, you want to modulate the current source in a synthetic waveform as shown in the top of Tab2
- Enter 'High' and 'Low' current values and residence times and define the rising and falling ramps in-between
- Toggle 'Current Settings' 'Input Source' to 'Int. Generator' [+ 'Write Config' button]

□ Observe how 'Current Graph' becomes active (not grayed out) and set values are displayed

□ Switch to Tab1 'Monitor' and observe how 'Laser Diode Values' now fluctuate between the high and low values for current and voltage

3.8 Continuous Current Regulation (PID), Output Enabling via USB

Step 17 Optimize PID Regulation

- You want to find PID values that allow the CW current source to follow given nominal values (internally generated or externally given) as fast and accurately as possible. As for all regulation problems, system tuning depending on the actuator, the feedback, the signal and the load will be a trade-off between speed, precision and stability
- For the optimization of PID regulation, external online monitoring (oscilloscope, current probe) is required. Also, starting with a dummy load connected is highly recommended

← The internal generator produces a nominal value that the current source attempts following using PID regulation. Very conservative ("mild") PID values were factory-set. It is likely that you will not observe a trapezoidal waveform with these initial settings

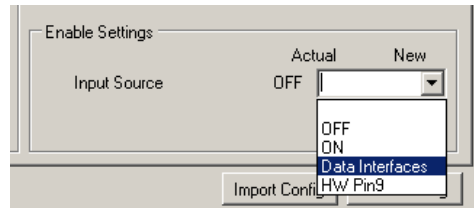
← Refer to the reference section for information on PID parameters and configuration.

Step 18 Enable Laser Diode Driver from within LDD Service Software

- The best way for enabling and disabling the LDD output is to use a digital "interlock" signal on the platform bus hardware line 'ENABLE'. To use this feature, please select 'HW Pin9' from the dropdown menu [+ 'Write Config' button]
- During PID optimization or general USB-controlled operation, the most convenient way for enabling and disabling your LDD is to use the 'Enable ON' button that becomes available if 'Data Interfaces' is selected from the menu (see illustration below)

□ Observe the 'Enable NA' button become live after selection of 'Data Interfaces' as 'Enable Settings' input source

← This button allows the user to toggle 'Enable' between ON and OFF without pressing 'Write Config' each time



3.9 Pulse Generation by Internal Generator

Step 19 Configure Internal Generator to Control Pulse Generation

- The laser diode driver can generate pulses with very steep edges by chopping of the CW current with a binary pulse signal
- For individual / rare pulses, one might use the software button
- As demonstration for the LDD's fast pulse generation capability, you want to chop the modulated current source by a higher frequency square wave as shown in the bottom of Tab2
- Enter 'High' and 'Low' residence times
- Toggle 'Pulse Settings' 'Input Source' to 'Int. Generator'

□ Observe how 'Pulse Graph' becomes active (not grayed out)

□ Switch to Tab1 'Monitor' and observe how the '...Pulse' parameters in 'Laser Diode Values' now indicate peak/plateau readings (This way of signal monitoring is for quick reference only. Please use a current probe and an oscilloscope to assess signals)

← The edge steepnesses of the chopped signal are hardware-given and not influenced by rise times or slope limits

← To the CW source, the chopped output represents a different 'load' than the unchopped one. It may therefore be possible, that PID values need slight re-adjustment when a CW signal is being submitted to chopping

← Again, internal generation is ideal for evaluation and stand-alone operation. For integrated application the pulse source can be remotely controlled by RS485 and USB data interfaces, or by a digital PULSE signal on the hardware platform bus

4 LDD Signal Generation and Control Operating Principle

LDD-1121-based laser diode drivers all have a common operating principle. The output current stage consists of power electronics that are modulated by a PID controller. The stage's input can either be an external line, an internal generator or the output of the light control stage (selected models only). That laser power control gets feedback input from light power measurement hardware and can again be controlled by external input or internal waveform generation. Please refer to Figure 3 for a graphical description.

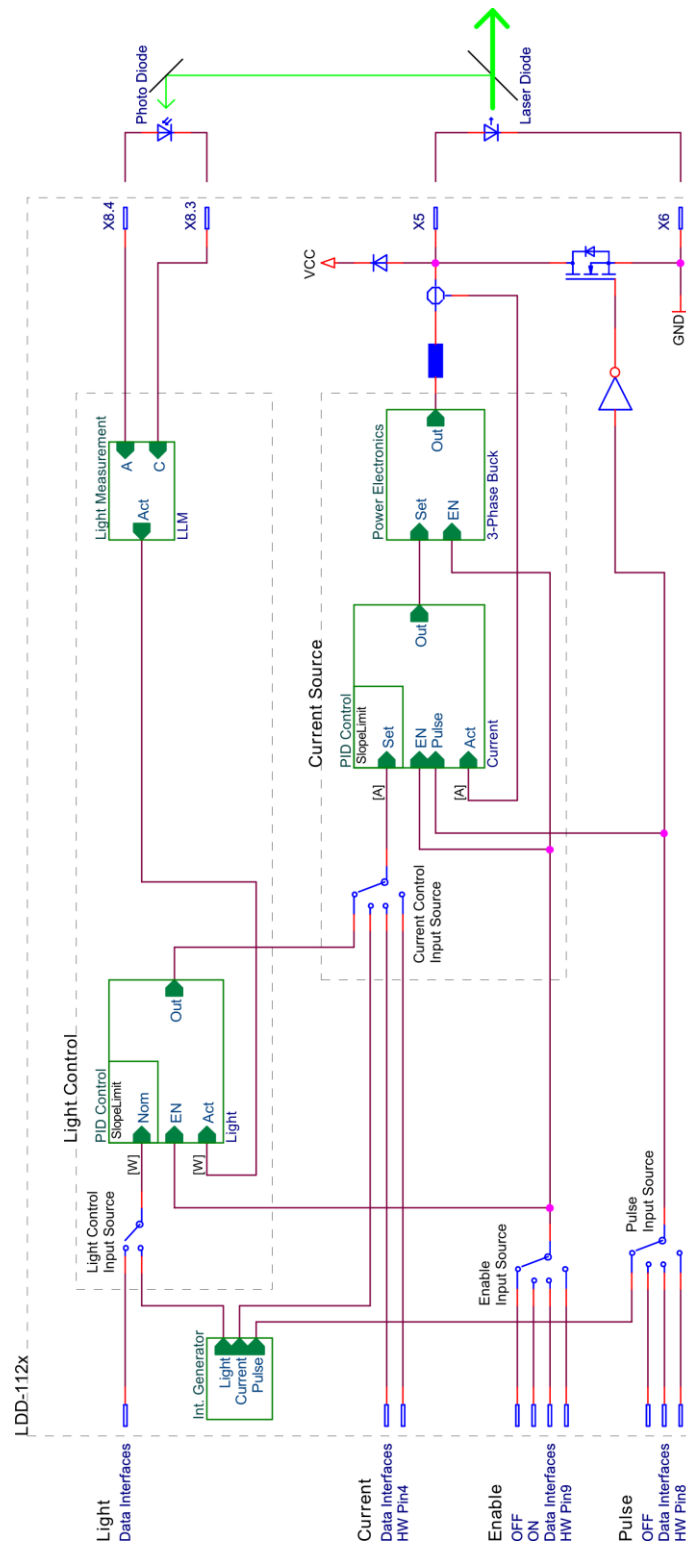


Figure 3. Functional Diagram of external and internal LDD operation control including optional LPC hard- and software.

5 LDD Service Software Reference

5.1 Laser Diode Driver Configuration via LDD Service Software

Configurations and Parameter Activation

When establishing a connection with the laser diode driver, the LDD Service Software reads all current device settings. During operation, the current settings can also be loaded manually by clicking the 'Read Config' button.

If LDD parameters are to be changed from the Service PC, enter the new values into the fields provided and press the 'Write Config' button to transfer the data to the LDD's memory. The Service Software checks if an entered value is within the permitted range for that parameter, it will automatically restrict it to the minimal or maximal limit, in case the value entered fell out of range.

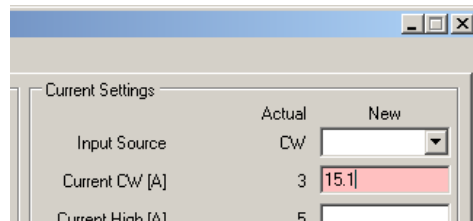


Figure 4. Out-of-range parameters are highlighted and restricted by the Service Software

Please note that several fields can be written at once. Actually, all non-empty field values are written to the laser diode driver, including the ones not visible in the foremost tab. Leave fields empty when switching between tabs in order to prevent accidental misconfiguration.

Storing a new parameter set to the LDD takes a certain amount of time. To prevent data corruption, the 'Reset LDD' button is deactivated and grayed out for 3.5 sec after the 'Write Config' button has been pressed. If during that period power is cut, only the latest parameter changes will be lost. (The laser diode driver features redundant sets of configuration parameters and will revert to the last valid set in the unlikely event that data corruption has occurred in the freshly changed data.)

Importing and Exporting .ini Configuration Files

LDD configuration sets can be backed up as .ini files. In the LDD Service Software, click on 'Export Config' in the bottom right corner. It is recommended to create filenames that clearly identify individual devices (e.g. by their serial numbers).

To import configuration sets into a connected laser diode driver, click on 'Import Config' in the Service Software and select the .ini configuration file. Corresponding parameter boxes will be filled. You can review / change the values that are about to be written. Finally, press 'Write Config' to transfer the configuration to the LDD.

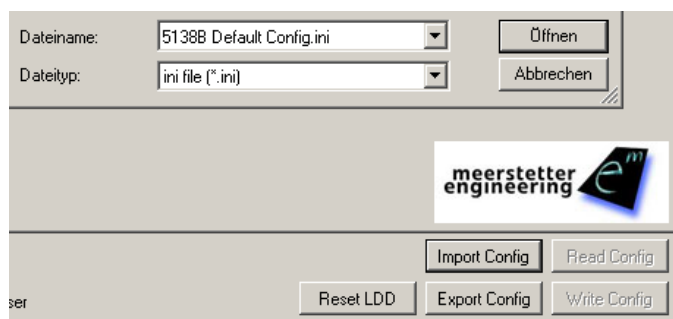


Figure 5. Configuration sets can be exported and imported via the LDD Service Software

Settings Dump (*.mepar File)

For cases where many or all settings are to be changed from a host software or from a host microcontroller, a Settings Dump functionality is available. TEC Service Software is used to generate a file which can be dumped to TEC controllers using third party host systems.

Any information in 'New' fields can be stored to a *.mepar File, which is a text file where every line contains a parameter string that is specific to function, firmware and device type.

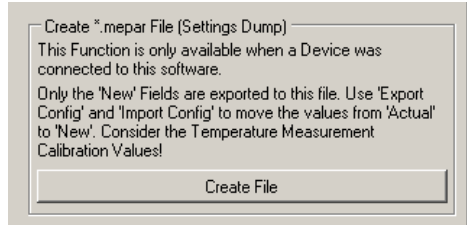


Figure 6. Creation of a *.mepar File (Tab 'Maintenance') for settings dump by third party host.

Using the communication protocol 'MeCom', this *.mepar file can be dumped line-by-line to one or several devices. These batch configurations will immediately become active.

It is also possible to download just one single setting (*i.e.* one line of the *.mepar File) directly from within Service Software to a TEC controller. Therefore, a single mepar string is entered in the field provided and sent.

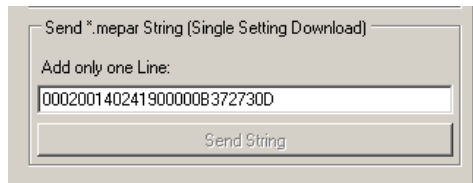


Figure 7. Download and activation of one *.mepar setting form within Service Software.

5.2 Tab1: Monitor

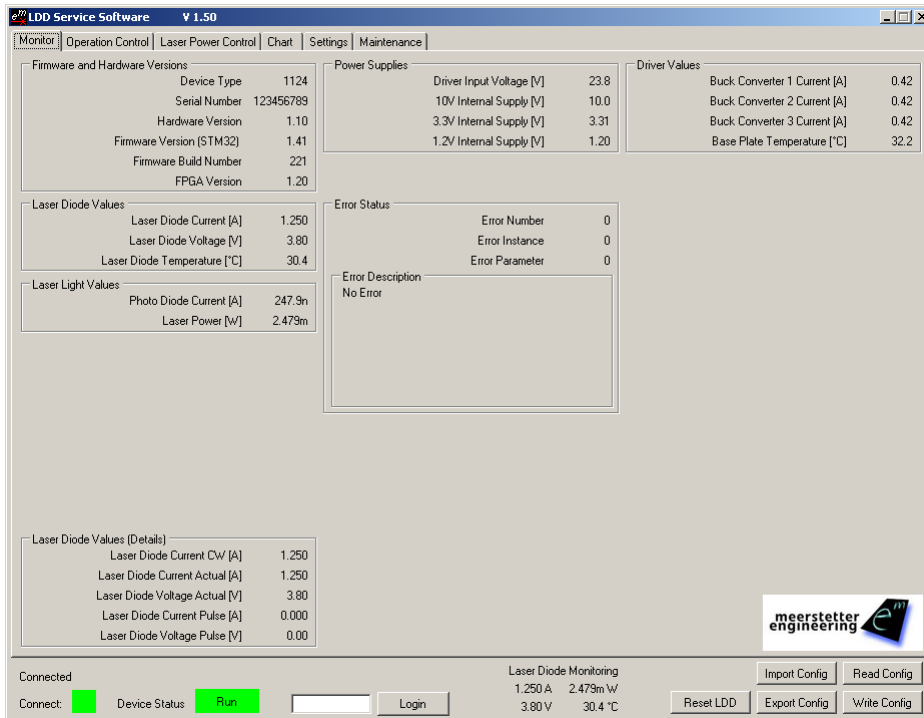


Figure 8. Tab1 'Monitor' (laser diode driver running under CW conditions)

System Monitoring

The LDD Service Software's 'Monitor' tab displays current system status:

- 'Firmware and Hardware Versions' shows said parameters, the serial number and type should match the sticker on your device.
- 'Laser Diode Values' displays current, voltage and temperature. Current and voltage are smart selections of the following detail values.
- 'Laser Diode Values (Details)' features three fields that display the laser diode current according to different measurement modes, suitable for different operation modes:
 - 'Laser Diode Current CW' shows the output current, averaged over 100 ms. It is most suitable for CW-like slow signals
 - 'Laser Diode Current Actual' displays the measured output current, averaged over 100 μ s. It will oversee fast pulses.
 - 'Laser Diode Current Pulse' shows the value of the last averaged pulse current plateau. This measurement method is designed to determine pulse amplitude, independently of duty-cycle and repetition rate.

The same is valid for 'Laser Diode Voltage Actual' (100 μ s average) and 'Laser Diode Voltage Pulse' (last plateau).

- 'Laser Light Values' shows real-time information on the collected 'Photo Diode Current' and the calculated corresponding 'Laser Power', which may be internally used / fed back for direct Light Control [selected models only]
- 'Power Supplies' displays voltages of external supply and different internal subnets.
- 'Error Status' shows error codes: 'Error Number' designates the error condition, 'Error Instance' normally indicates the channel concerned ('1' for LDDs). 'Error Parameter' is additional information helping the software engineers with diagnosis and remote debugging. A brief error description is shown in the corresponding text box. See Appendix 1 for more detail on the implemented error system.

- 'Driver Values' displays device temperature and individual currents flowing through the laser diode driver's three buck converter channels. Those three currents should be balanced.

Current and Voltage Display Smart Selection

The most relevant current and voltage values to be displayed in the main 'Laser Diode Values' group box are chosen by smart selection.

In the case of the current display, smart selection decides in 100 ms cycles:

- If at least one pulse has occurred, the 'Laser Diode Current Pulse' value is selected.
- Else if 'Laser Diode Current CW' and 'Laser Diode Current Actual' are very similar one to another (i.e. max. 50 mA apart), the more stable 'Laser Diode Current CW' is selected.
- Else (i.e. no pulse has occurred and 'Laser Diode Current CW' and 'Laser Diode Current Actual' are dissimilar) 'Laser Diode Current Actual' is selected.

The same selection is also followed by the voltage display: 'Laser Diode Voltage Pulse' if at least one pulse has occurred, 'Laser Diode Voltage Actual' if not.

Laser Diode Monitoring from the Status Bar

The most relevant information about the laser diode being operated are shown in the status bar at the bottom of the LDD Service Software window. 'Laser Diode Monitoring' is always visible.

The four parameters displayed are diode current and diode voltage (smart selection as described above), as well as laser power [for LPC models] and diode temperature [NTC measurement].

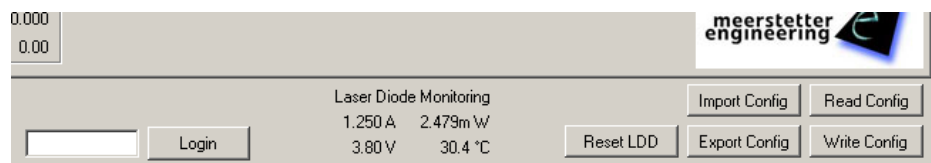


Figure 9. Most relevant 'Laser Diode Monitoring' values displayed in the center of the LDD Service Software status bar.

5.3 Tab2: Operation Control

As described earlier in this manual, each LDD-1121-based laser diode driver has got two stages / operation modes: first a continuous current mode (current-stage) that is PID controlled and can be modulated, then a pulse mode (pulse-stage) in which the CW signal is chopped. For both of these modes, various control sources are available (internal, external, hardware, software).

Internal generation is ideal for evaluation and stand-alone operation. For integrated applications remote control by RS485 and USB data interfaces is preferable. The use of an analog voltage signal is also possible, but not recommended for precision applications.

Tab2 provides a convenient interface for configuration and/or control. Two graphs facilitate the setting up of internal generators.

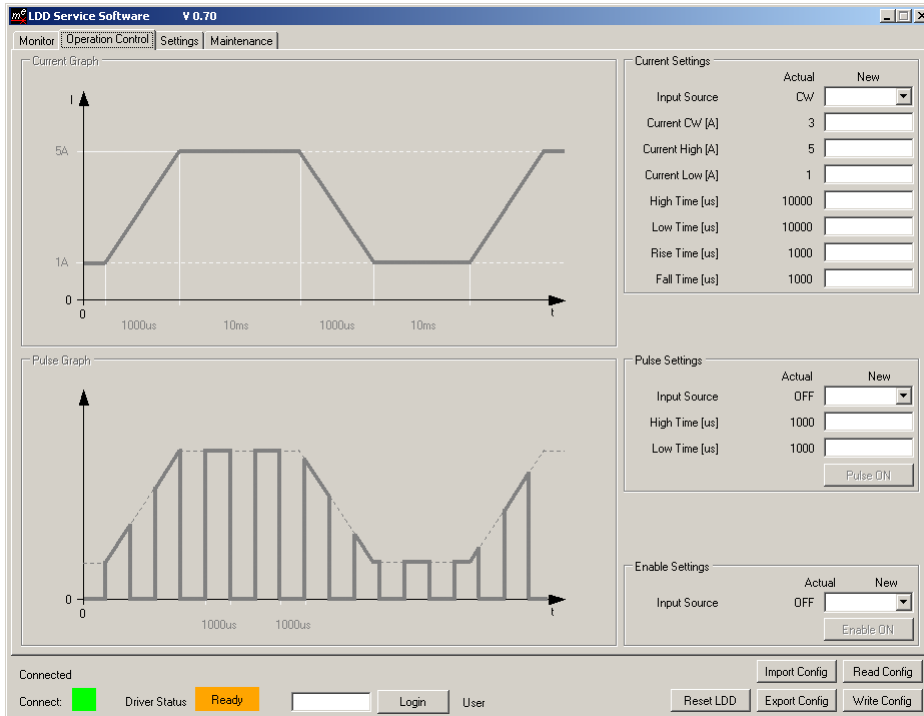


Figure 10. Tab2 'Operation Control' (laser diode driver power output disabled, no internal generator activated). Consult below table for latest factory settings / default values

Current Settings	Input Source	'CW'
	Current CW	3 A
	Current High	5 A
	Current Low	1 A
	High Time	10'000 µs
	Low Time	10'000 µs
	Rise Time	1000 µs
	Fall Time	1000 µs
Pulse Settings	Input Source	'OFF'
	High Time	1000 µs
	Low Time	1000 µs
Enable Settings	Input Source	'OFF'

Table B. Factory Settings for Tab2 'Operation Control'

Modulated CW Current (Current-Stage)

- Input Source: 'CW'
Laser diode driver output current is set to the value 'Current CW'.
- Input Source: 'Int. Generator'
The internal generator produces a nominal value signal according to the values of 'Current High', 'Current Low' and the high/low and rise/fall times. Maximum achievable rise and fall slopes are governed by 'Slope Limit' (Tab5), if applicable.
The CW current source stage follows the generated nominal value signal using PID regulation. The achievable current output will depend on the PID settings / tuning.
- Input Source: 'Data Interfaces'
The nominal current value is controlled by digital RS485 or USB transmission.
- Input Source: 'HW Pin4'
The nominal current value is controlled by an analog signal (scalable by 'Current Factor', Tab5). Analog control is not recommended for precision applications.
- Input Source: 'Light Control'
The nominal current value is dictated by the Light Control stage (see Figure 3, Tab3 and chapter 5.4 for more detail).

Current Pulses: Chopped CW (Pulse-Stage)

- Input Source: 'OFF'
The pulse-stage is inactive and laser diode driver output is following to the status of the current-stage.
- Input Source: 'Int. Generator'
The internal generator produces a digital signal according to 'High Time' and 'Low Time'. This signal is used to chop the output of the CW stage. The steepness of the edges of the chopped signal are hardware-given and not influenced by rise times or slope limits.
- Input Source: 'Data Interfaces'
The digital output chopper is controlled by RS485 or USB, or by the Service Software's 'Pulse' button.
- Input Source: 'HW Pin8'
The state of the pulse stage is controlled by a dedicated hardware line. Please refer to the laser diode driver's data sheet for the requirements on this digital signal.

Laser Diode Driver Output Enable

- Input Source: 'OFF'
LDD output current is disabled, regardless of the current-stage and pulse-stage settings.
- Input Source: 'ON'
The laser diode driver's current output is enabled and working according to present settings.
- Input Source: 'Data Interfaces'
The LDD's current output is enabled/disabled by RS485 or USB, or by the Service Software's 'Enable' button. This button allows the user to toggle 'Enable' between ON and OFF without pressing 'Write Config' each time. Upon device power-up or reset, the LDD always starts in 'Disabled' status and can be conveniently enabled using that same button.
- Input Source: 'HW Pin9'
The LDD's current output is enabled/disabled by a dedicated hardware line. Please refer to the laser diode driver's data sheet for the requirements on this digital signal.

5.4 Tab3: Laser Power Control – LPC [NOT ON ALL MODELS]

Selected LDD-1121-based laser diode drivers feature laser power metering hardware. On such devices, the amount of currently produced light can be used to closed-loop control the amount of electrical current flowing through the laser diode. Laser Power Control has its own PID controller, that is outputting an electrical current value and which depends on the history of the amount of light measured. The light controller's output serves as nominal value instructor for the subsequent output stage (see Figure 3).

The nominal amount of light is dictated by one of three sources: In 'Laser Power (LP) Settings', the 'Input Source' can be set to continuous (CW), internal generation or external data input.

Laser Power Control is the most complex and therefore the most delicate of all operation modes. It requires all involved elements and subordinate processes to function reliably. It is also highly hardware and application dependent. Laser Power Control should only be set up and activated when all other system parameters are well controlled and understood. A check-list / step-by-step instruction is provided at the end of this chapter.

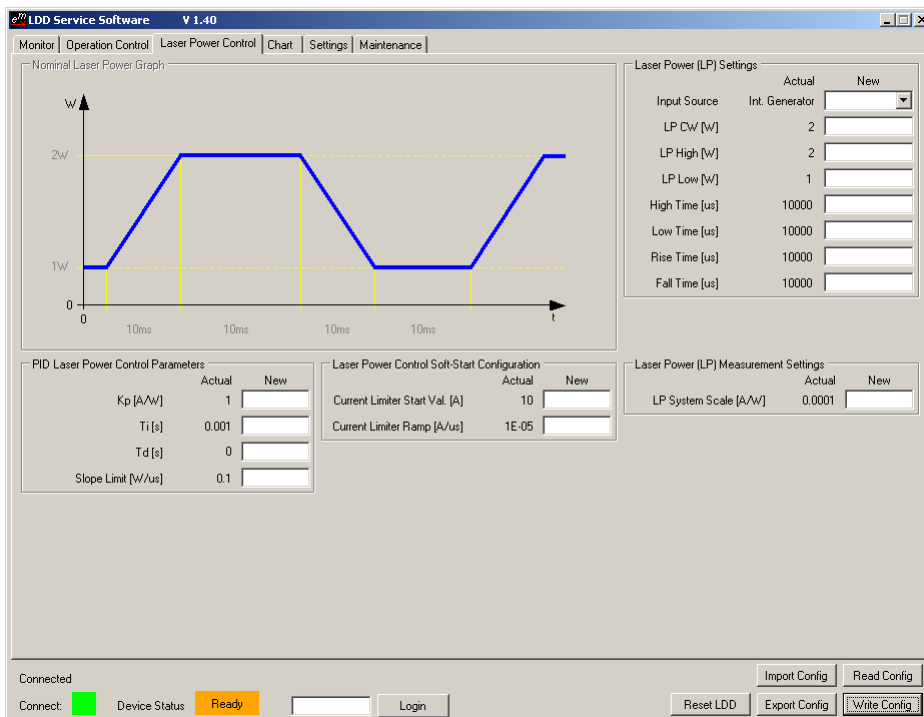


Figure 11. Tab3 'Laser Power Control'. Some LDD models allow for closed-loop light power control as laser power is constantly metered. In that advanced operation mode, the output of the PID LP controller is linked to the input of the PID current controller.

Laser Power (LP) Settings	Input Source	OFF
	Light CW	2 W
	Light High	2 W
	Light Low	1 W
	High Time	10'000 µs
	Low Time	10'000 µs
	Rise Time	10'000 µs
	Fall Time	10'000 µs
PID Laser Power Control Parameters	Kp	1 A/W
	Ti	0.001 s
	Td	0 s
	Slope Limit	0.1 W/µs
Laser Power Control Soft-Start Configuration	Current Limiter Start Val.	10 A
	Current Limiter Ramp	10 µA/µs
Laser Power (LP) Measurement Settings	Light System Scale	0.01 A/W

Table C. Suggested start values for Tab3 'Laser Power Control'. Must be user-optimized.

Step-by-Step Instructions / Check-List Laser Power Control

- Make sure the PID current controller (Tab5, 'Settings') is set such that pulses (Tab2, 'Operation Control') are optimally generated. Please refer to chapter 5.6 for brief information on PID optimization
- Understand the serial arrangement of the current controller that is instructed by the laser power controller (refer to Figure 3). In particular, note the importance of the current controller's slope limit, which should be set such that it reflects its output's performance characteristics
- Ensure the 'Light System Scale' has been calculated reasonably well. This is the conversion between the total light power leaving the laser diode and the fraction that is entering the light metering system that is producing photocurrent. The conversion factor depends thus on the optical coupling (e.g. beam splitter), the optical system's losses as well as the photodiode's characteristics
- Chose a very conservative 'Light Control Soft-Start Configuration', e.g. have the 'Current Limiter Start Val.' set to 0 A and the 'Current Limiter Ramp' to microamps per microsecond
- Set conservative 'PID Light Control Parameters' and 'Slope Limit'
- Switch on LPC (laser power control), observe light and current closely
- Optimize light controller, using the built-in chart functionality or external metering equipment
- Progressively, adopt more aggressive soft-start behaviors, if required

Laser Power Control Soft-Start

LDD Service Software permits the temporary modification of the output current limits at start. At any time, the 'Current Limit Max' and 'Current Limit Min' (Tab5, 'Settings') are valid. When in Laser Power Control, an additional set of 'Current Limiter' values are active upon laser enabling: 'Current Limiter Start Val.' and 'Current Limiter Ramp' define the offset and slope of an additional limit line.

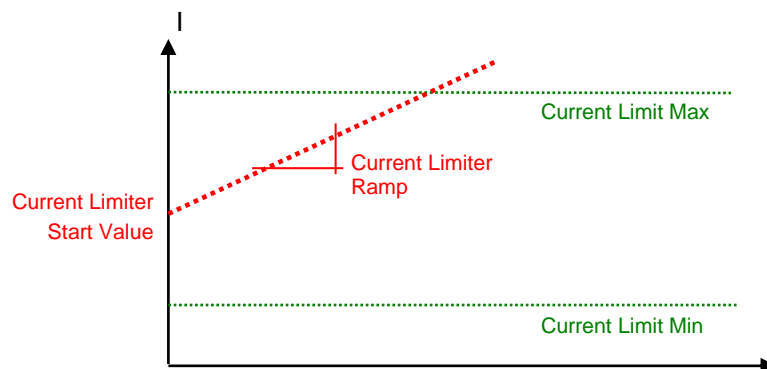


Figure 12. Light control 'Soft-Start' limiter (red) valid with system current limits (green).

5.5 Tab4: Chart

The LDD Service Software's charting feature help system monitoring and analysis. All buffers and parameters for charting are stored on the PC running the service software, no configuration is written to the LDD device.

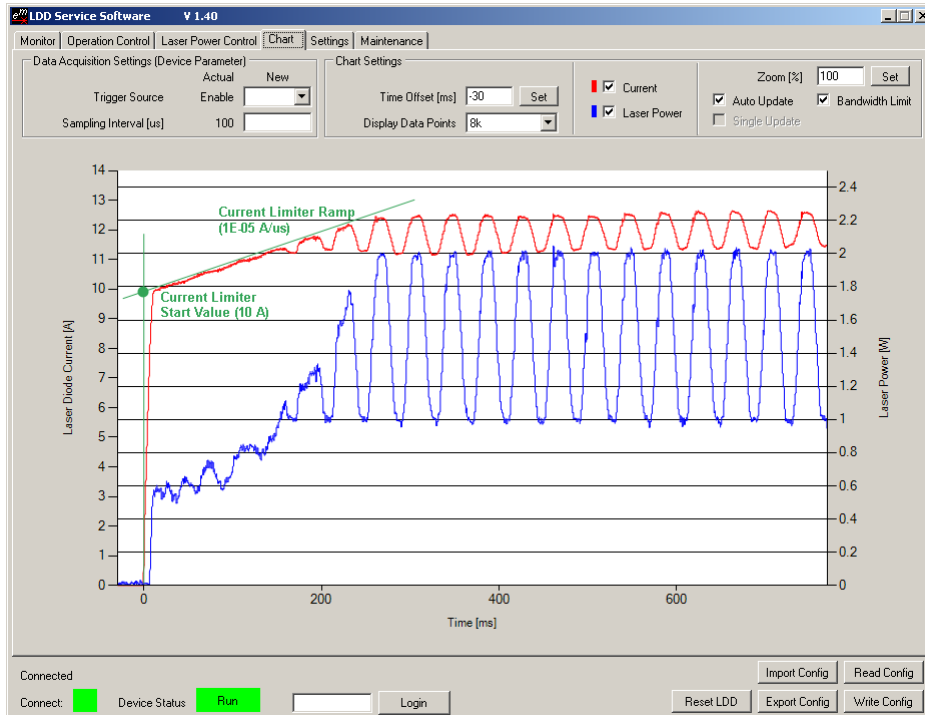


Figure 13. Tab4 'Chart' in operation, showcasing the soft-start current limiter for laser power control. [LDD Service Software screenshot with green annotations overlay].

Current and Laser Power Charting

- Laser diode current (red) and laser power (blue, on selected LDD models) traces are selected using the tick boxes
- Signals can be triggered upon 'None', LDD 'Enable' or current 'Pulse' at a chosen sampling interval
- Data is acquired upon each trigger event and a subset of points (1k to 16k) is displayed
- Negative time offsets allow for the display of data prior to the trigger signal
- Traces can be single shots or 'Auto Update'
- Zoom allows values >100% for zooming into the time axis. In conjunction with 'Single Update' this can be handy for recording a great number of points at fast interval for offline detail viewing
- 'Bandwidth Limit' filters out noise for smoother signal display

5.6 Tab5: Settings

Figure 14. Tab5 'Settings'. Consult below table for latest default values

PID Current Regulation Parameters	Kp	3 %/A
	Ti	0.001 s
	Td	1E-09 s
Analog Control	Current Factor	1 A/V
Maximum Values	Current Limit Max	1.5 15 30 A
(not the same for all LDD-Family devices, please refer to the MeCom Document 5130)	Current Limit Min	0 A
	Max Current Error	1.85 18.5 35 A
	Slope Limit	0.01 A/μs
Trigger Output Settings	Pulse Trigger Output	OFF
Communication	Comm. Watchdog	0 s
Device Address	Device Address	1
RS485 Channel 1 Settings	Baud Rate	57600
	Response Delay	0 μs
Laser Diode Temperature Settings	Lower Error Threshold	-20 °C
	Upper Error Threshold	60 °C
NTC Sensor Characteristics	Lower Point Temperature	0°C
	Lower Point Resistance	32650 Ω
	Middle Point Temperature	25°C
	Middle Point Resistance	10000 Ω
	Upper Point Temperature	60°C
	Upper Point Resistance	2488 Ω

Table D. Factory Settings for Tab5 'Settings'

PID Current Regulation

An LDD-1121-based laser diode driver's current-stage is regulated by a PID controller. For the optimization of PID parameters, external online monitoring (oscilloscope, current probe) is required. Also, starting with a dummy load connected is highly recommended.

Depending on the current to be drawn from the laser diode driver, different starting parameter sets are used (see below).

The proportional term K_p defines the portion [%] of available current that is used to correct the difference [A] between actual and nominal CW current.

The integral term T_i defines the reset time [s] the regulator is allowed to take for correcting a given control deviation. The effect of T_i is weak for large values and strong for small values.

The derivative term T_d opposes changes in control deviation, weighed by unit time [s]. The dampening effect of T_d increases with larger values (e.g. a value of 0 results in bypassing the D component).

The following PID parameter sets are start values that proved to work well at factory. You will need to optimize them for your application and your system.

Very conservative settings for low currents and low frequencies:	$K_p = 3, T_i = 1E-03, T_d = 1E-09$
Good midrange starting values, also valid for higher frequencies:	$K_p = 10, T_i = 1E-04, T_d = 1E-08$
Rather aggressive settings with high risk of overshoot / instability:	$K_p = 18, T_i = 2E-05, T_d = 1E-07$

Table E. Suggested PID parameter sets, to be optimized for target applications

In an empirical optimization procedure one would first increase K_p (allowing oscillations and offsets), then dampen the system (still allowing offsets) by increasing T_d and finally minimize offset by lowering T_i .

Refer to literature on control engineering for descriptions of systematic optimization procedures.

Analog Current Control and Limits

- 'Current Factor' is a conversion factor for analog control [optional], when selected as 'Input Source' in Tab2.
- 'Current Limit Max' and 'Current Limit Min' define the permitted range of user-settable nominal values and should reflect normal operation.
- 'Max Current Error' is an important safety setting that limits the LDD's power output to protect the connected diode. Reaching this threshold triggers ultrafast (<4 μ s) switchoff! This value should always be set below or at the absolute maximum current rating of the used laser diode.
- 'Slope Limit' acts on internal nominal current value generation and allows the use of more aggressive PID settings.

Trigger Output

If the laser diode driver's internal pulse generator is active (Tab2) and if 'Pulse Trigger Output' is set to 'HW Pin6', a digital signal is available for external syncing onto the internal pulse status. That a 0..3.3V signal is available on line RES5 on the Platform Bus (please refer to Figure 1 or to your LDD's data sheet).

If 'Pulse Trigger Output' is set to 'OFF', the hardware output is set to Z (high impedance).

Remote Control / Bus Control by Communication Protocol 'MeCom'

LDD-Family devices can be remotely operated over a USB or an RS485 (half-duplex, properly terminated) connection. Depending on hardware, Ethernet communication is available as well. All parameters and status information available via the LDD Service Software can be read or written by either type of remote connection.

In addition, bus-control allows access to live parameters that are stored in volatile memory ('RAM') and that are designed for frequent or fast update (such as bus-controlled current curves, pulses or enable toggling / interlock).

Full bus-control is accessible over the serial (RS485 / USB / ...) communication protocol 'MeCom'. Live parameters have IDs starting from 50000.

Direct **USB operation** and 'MeCom' communication require no Service Software to be running, and the LDD-Family laser diode driver to appear as a virtual COM port (USB Serial Port) on the PC.

All USB and RS485 activity is monitored by the 'Communication Watchdog'. The laser diode driver will enter error status if no communication has occurred within the set time span. A value of 0 disables the watchdog functionality and values >0.5 s are required for communication with LDD Service Software.

For **RS485 operation** the Channel1 Baud rate and the laser diode driver's device address must be specified in Tab 'Settings' (restart required). A response delay can improve compatibility with host hard and software.

RS485 communication is implemented over hardware interface Channel 1, using lines RS485_A1 and RS485_B1 (see Figure 1). Interface Channel 2 is currently reserved for service communication with LDD/TEC Service Software (see paragraph below).

All RS485 lines are part of the Platform Bus that allows connecting one or several LDD-1121-based laser diode drivers as well as one or several TEC-1122-based TEC controllers to a common control system. Individual devices are identified by addresses, starting from 1 up to 254. 0 and 255 are broadcast addresses to all devices on the bus.

Ethernet operation requires additional hardware, such as the LTR-1200 Rack Enclosure with HMI.

The 'MeCom' protocol is not covered in this manual. Please refer to documents 5117 [general] and 5130 [LDD-Family-specific]. Feel free to contact Meerstetter Engineering if you require the implementation of a customized protocol.

	USB	RS485 (Channel 1)	Ethernet	RS485 (Channel 2)
MeCom	✓	✓	✓*	not recommended
Service SW	✓	-	✓*	✓

Table F. Compatibility chart of currently available protocols and LDD data interfaces.

*Additional Ethernet hardware required.

Service Communication

Complementary information about parameters in group boxes 'Communication', 'Device Address' and 'RS485 Channel 1 Settings' is given in the next chapter, in conjunction with other communication settings.

Laser Diode Temperature Monitoring

Each LDD-1121-based laser diode driver is factory-set to acquire temperature in the range of 0 to 60°C using a "B_{25/100} 3988K, R₂₅ 10k" NTC probe.

'Lower Error Threshold' and 'Upper Error Threshold' define the permitted range of temperature measurement. To avoid the generation of system errors before the connection of a probe, the lower error threshold was factory-set to -20°C. The lower and the upper error limits should be set to more meaningful values once a temperature probe is connected and configured.

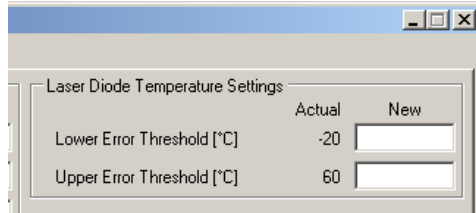


Figure 15. Lower error threshold factory setting of -20°C before connection of a temperature probe

The NTC temperature probe on cable and plug should be assembled according to below extract of Figure 1 to fit the X8 connector of the laser diode driver. That same connector also houses the optional light intensity measurement input.

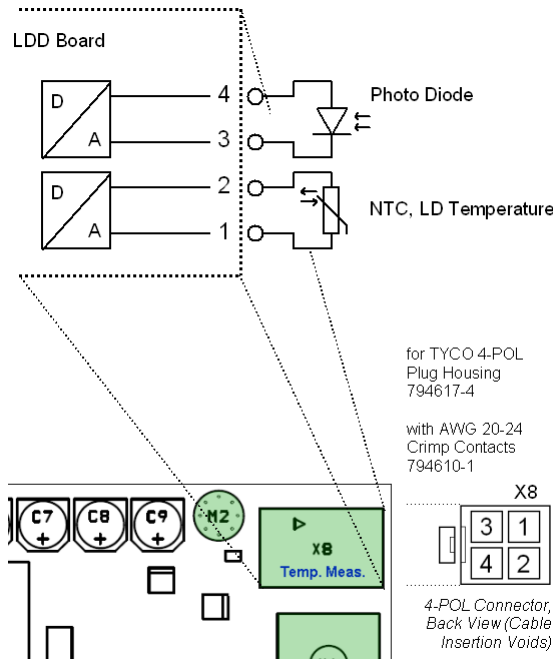


Figure 16. Pin-out of the connector for temperature acquisition and light intensity measurement [optional] inputs

The laser diode driver is designed to accommodate various NTC temperature probes and their characteristics. Three ['Temperature', 'Resistance'] pairs are needed to fix a characteristic curve according to the Steinhart-Hart model. Decide for three temperatures ('Lower Point', 'Middle Point' and 'Upper Point') and look up their corresponding resistances in your NTC sensor's data sheet. The resulting curve will be most precise for small ranges and with a centered middle point located at nominal temperature.

NTC Sensor Characteristics		Actual	New
Lower Point	Temperature [°C]	0	<input type="text"/>
	Resistance [Ω]	32650	<input type="text"/>
Middle Point	Temperature [°C]	25	<input type="text"/>
	Resistance [Ω]	10000	<input type="text"/>
Upper Point	Temperature [°C]	60	<input type="text"/>
	Resistance [Ω]	2488	<input type="text"/>

Figure 17. NTC sensor characteristics are defined by three user-definable points. The factory settings correspond to a "B_{25/100} 3988K, R₂₅ 10k" NTC probe operating in the range of 0 to 60°C

5.7 Tab6: Maintenance

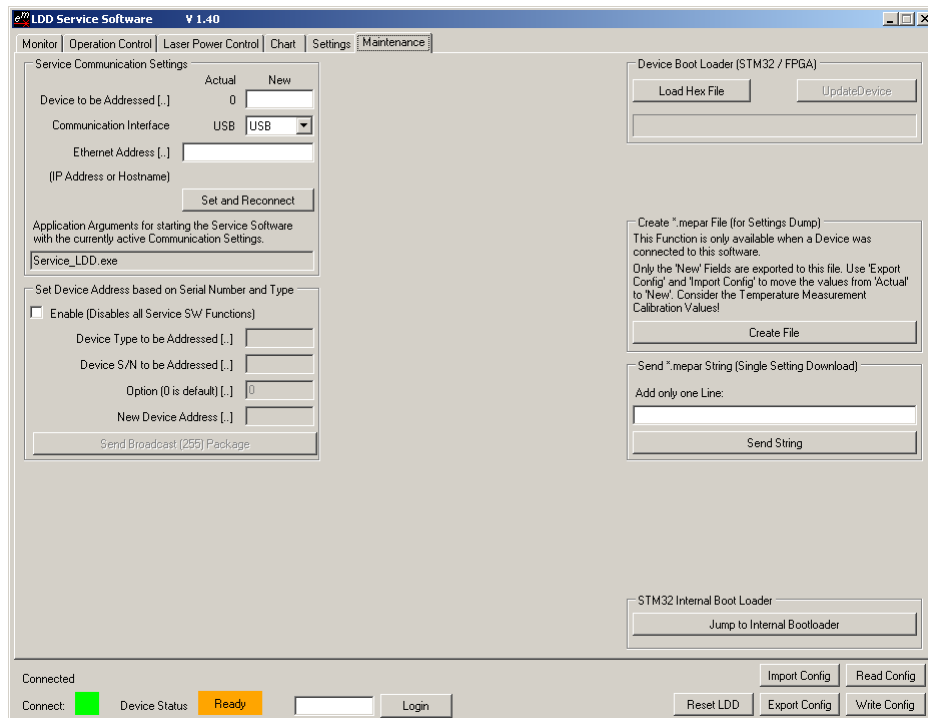


Figure 18. Tab6 'Maintenance' for STM32 and FPGA firmware updates and for RS485 communication with target device

Remote Control / Service Communication by LDD Service Software

LDD Service Software can address one laser diode driver, even if several devices share a single communication interface. It is also possible, to have one or several TEC-Family Peltier controllers connected to that same bus, and to control them by TEC Service Software. These functionalities can be used as stand-alone, or as complement to an existing 'MeCom' control implementation.

Starting the Service Software with Application Arguments

Further below, three possibilities of connecting to a specific device over a specific interface are described. These settings are volatile and need to be reentered every time the LDD Service Software is launched. Starting the software with application arguments allows to directly load the desired communication settings.

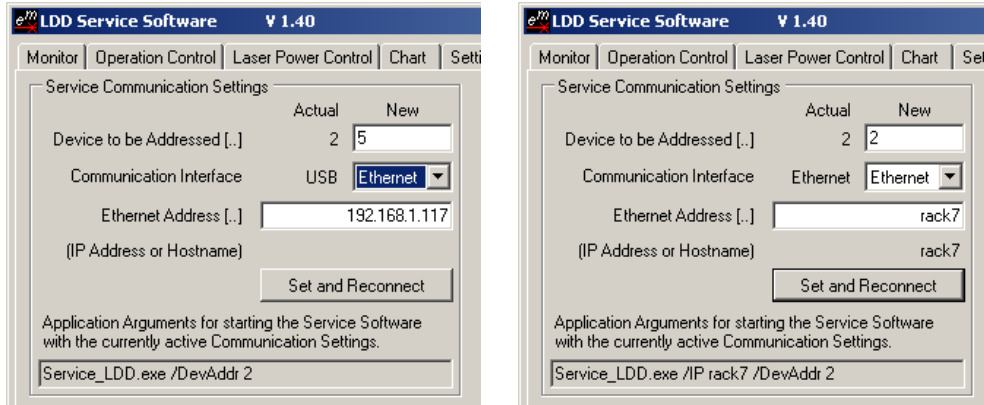


Figure 19. Service Communication Settings (Tab 'Maintenance'). USB/RS485 and Ethernet serial communication interfaces can be chosen, and individual devices on the bus can be addressed directly.

A very convenient way of saving a given configuration is to create a link to the LDD Service Software, to rename it, and to show its properties.

Copy the applications arguments – that's the information following the name of the application – displayed at the bottom of the group box (Service SW). Then paste them at the end of the 'Target:' path in the link's properties (Windows).



Figure 20. Creation of a customized link to a copy of LDD Service Software that will start up fully configured thanks to added application arguments.

Bus Operation and Device Addresses

On a bus, each device must have a unique identification (Tab 'Operation'). TEC- and LDD-Family devices can be mixed at leisure; unique addresses may range from 1 to 254 (0 and 255 are reserved: all devices respond to calls on these broadcast addresses).

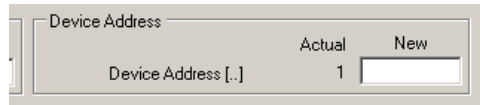


Figure 21. Device Address for bus operation. The factory-set value for LDD-Family devices is 1 (default for TECs: 2), but any value between 1 and 254 is permitted.

The device address is saved into the TEC controller's nonvolatile memory. The volatile 'Device to be Addressed' setting (Tab 'Maintenance') needs to match that ID for the service software to communicate with the device.

Service Communication over USB

This is the way, the initial connection with your laser diode driver had been established and that was used for in these instructions so far. USB is the 'Communication Interface' selection at startup, and 'Device to be Addressed' = 0 makes all devices on the bus respond.

In more complex settings, e.g. with several Peltier controllers connected via the HMI of an LTR-1200 Rack Enclosure, one single USB cable can still be used for connection, but all devices must have unique addresses.

Service Communication over Ethernet

For Ethernet to work, the device providing connection to the network (e.g. the HMI of an LTR-1200 Rack Enclosure) must be configured correctly (IP Address, Subnet Mask, Gateway, etc., see device's manual). In 'Service Communication Settings' (Tab 'Maintenance'), Ethernet is activated and an IP Address or Hostname is set. Upon 'Set and Reconnect', the connection will be established and displayed as shown in Figure 19.

As described above, the application arguments matching the currently valid communication will also be indicated.

Service Communication over RS485 (CH2) and Assembly of a USB-RS485 Converter Cable

Thirdly, a service communication alternative is implemented over RS485 Channel 2 on the platform bus.

A very convenient way for creating an RS485 connection is to use a serial converter cable driven by USB. Customers must use cables available on: <http://www.ftdichip.com/Products/Cables/USBRS485.htm> for full compatibility with Meerstetter LDD and TEC Service Softwares.

The wire-ended FTDI cable USB-RS485-WE-1800-BT (example) is configured to connect to RS485(2) on the platform bus in the following manner:

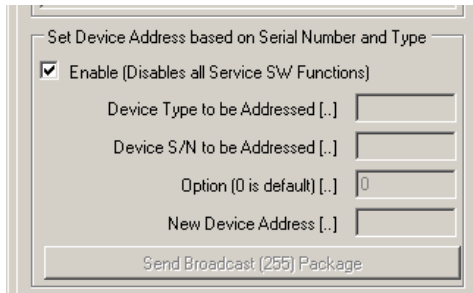
	14-POL TYCO 8-215083-4 LDD-1121-based laser diode drivers TEC-1122-based TEC controllers
FTDI Cable Wire 1: GND [black]	Platform Bus Pin 10: GND
FTDI Cable Wire 5: Data+ (A) [orange]	Platform Bus Pin 13: RS485_A2
FTDI Cable Wire 2: Data- (B) [yellow]	Platform Bus Pin 14: RS485_B2

Table G. Assembly instructions for USB-RS485 converter cables connecting RS485(2) on the 14-pol platform bus of LDD-Family devices and TEC-1122-based TEC controllers.

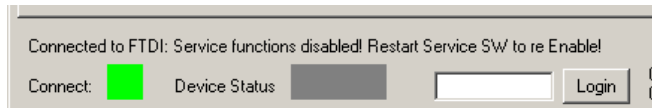
Resolution of Address Conflicts by Remote Setting of Device Addresses

If several devices are attached to one same communication bus, but are not addressable, e.g. due to either address conflict, TEC Service Software allows to change one particular device's address. That device is selected according to its Serial Number and Device Type. A 'Set Address' command is broadcast to all devices on the bus, and the device that matches type and S/N will accept it. For that procedure, all other active Service Software functions are temporarily suspended:

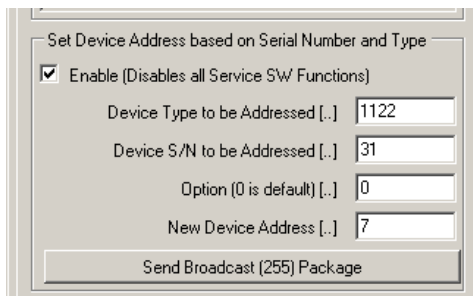
- Enable 'Set Address' functionality by ticking the box shown below (All fields are still grayed out)



- Press 'Reset TEC' in the bottom right corner of the Service Software
- Service Software confirms its suspend status



- Fill in all four fields (possible TEC device types are 1089, 1090, 1122, 1123)
- Press 'Send Broadcast (255) Package'



- Restart TEC Service Software

Please refer to the TEC Controller Communication Protocol Specifications (Document 5136) for further information.

LDD-Family Laser Diode Driver Firmware Updates

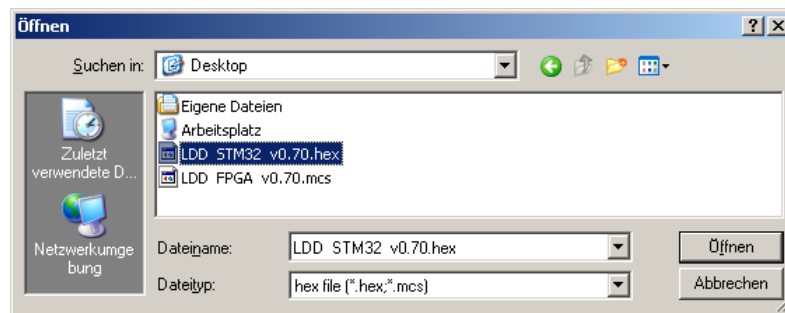
Before updating the firmware of your laser diode driver, back up its current configuration. This is very important because it is possible that the new firmware will have an extended parameter set. By importing the old configuration into an LDD with updated firmware, device-specific parameters from the former set are converted and kept.

For the installation of a new firmware, open Tab6 'Maintenance' and chose 'Device Boot Loader'.

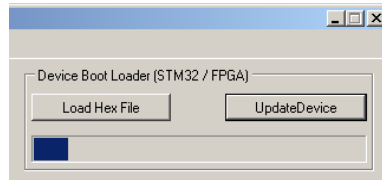
LDD-1121-based laser diode drivers have got two sets of firmware: .hex for the STM32 microcontroller and .mcs for the FPGA.

Please proceed as follows to update your device:

- Back up your LDD's current configuration
- Click on 'Load Hex File'
- Locate the new firmware hex file
 - e.g. LDD STM32 v0.70.hex for the STM32
 - e.g. LDD FPGA v0.70.mcs for the FPGA
- Select and open



- Select either the .hex or the .mcs file and click on 'Update Device'



- Repeat the previous step for the .mcs or .hex file, if applicable
- Check the firmware version(s) in Tab1
- If required, re-import the backed up configuration or complement new parameter fields

5.8 Tab7: Expert

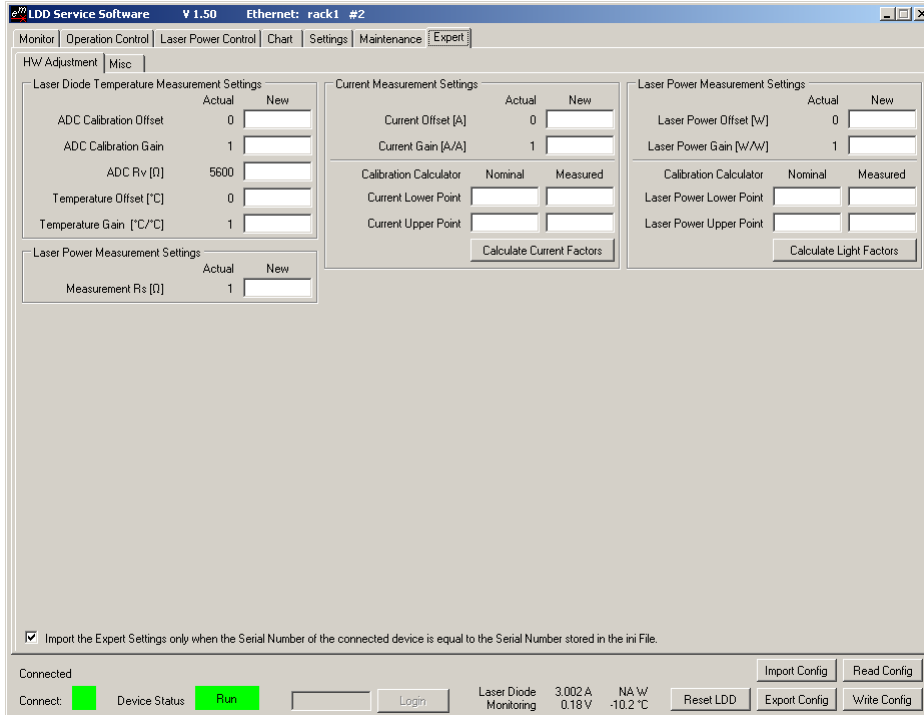


Figure 22. Tab7 'Expert' for the calibration and configuration of temperature acquisition hardware as well as for the adjustment of temperature, current and light power sensor systems characteristics

HW Adjustment	Laser Diode Temperature Measurement Settings	ADC Calibration Offset	0
		ADC Calibration Gain	1
		ADC Rv [Ω]	5600
		Temperature Offset [$^{\circ}\text{C}$]	0
		Temperature Gain [$^{\circ}\text{C}/^{\circ}\text{C}$]	1
	Laser Diode Light Measurement Settings	Measurement Rs	2000 Ω
	Current Measurement Settings	Current Offset	0 A
		Current Gain	1 A/A
	Light Measurements Settings	Light Offset	0 W
		Light Gain	1 W/W
Misc	Parameter System Save to Flash Configuration	Save Data to Flash	Enable

Table H. Factory Settings for Tab7 'Expert'

Laser Diode Temperature Measurement Settings (Temperature Acquisition System)

Users who wish to calibrate the hardware of their temperature acquisition system or to adjust the characteristics of a particular sensor can make amendments in the Tab7 'Expert'. This tab is normally hidden and the laser diode driver's settings protected from accidental misconfiguration. It is accessed by typing "expert" into the login field provided in the status bar of the LDD Service Software.

Temperature acquisition hardware calibration ('ADC Calibration Offset', 'ADC Calibration Gain' and 'ADC Rv') allow for high-precision standardization between several devices, *i.e.* fluctuations in hardware component characteristics (reference resistor, ADC circuitry) between devices can be compensated for.

Temperature sensor characteristics adjustments ('Temperature Offset', 'Temperature Gain') allow for gauging of individual sensors, *i.e.* differences between different sensor assemblies (probe, cable, connection) can be corrected for.

Please contact Meerstetter Engineering if you wish to calibrate temperature acquisition hardware or adjust temperature probe characteristics.

Current Measurement Settings (Current Acquisition System)

Starting from Firmware 1.10, it is possible to gauge the LDD's current output against the reading of a user's reference current meter. Two current/current data pairs are required. Therefore, the LDD is set to two different nominal current output values, and the resulting readings from the reference current meter are recorded. To help with the calculation of device-specific offset and gain values, the two data pairs ('Current Lower Point' and 'Current Upper Point') are entered into the 'Calibration Calculator'. The 'Current Offset' and 'Current Gain' fields are then automatically populated with the calculated values. If 'Write Config' is pressed, the suggested gauge values are saved to the laser diode driver.

Please note that only minute deviations (a few %) from the ideal values of 0 and 1 are accepted, as the LDD's current acquisition system is based on high-precision components and any deviation in excess of a few percent would not occur under normal conditions.

Laser Power Measurement Settings (Light Power Acquisition System)

Selected LDD laser diode driver models are equipped with laser power (LP) measurement hardware. Please see the corresponding information in the paragraph describing Tab3 'Laser Power Control' and in chapter 5.4.

In 'Laser Diode Light Measurement Settings' the value of the reference / shunt resistor for the laser diode light power measurement by photodiode is entered. Typically your hardware will have been custom assembled by Meerstetter Engineering to cover for your specific photodiode. The value of 'Measurement Rs' will typically be in the range of a few k Ω .

'Laser Power Offset' and 'Laser Power Gain' in the rightmost group box allow for light power calibration / gauging. Two laser powers will be measured by the built-in system and by a reference power meter. The functionality of the calibration calculator is the same as for current gauging described above, with the difference that offset and gain values that differ substantially from 0 and 1 will be permitted.

Parameter System Save to Flash Configuration

If the feature "Save to Flash" is enabled the LDD will save its configuration to the non-volatile Flash memory. This saving occurs 2 seconds after the last parameter change.

If an application requires frequent changes to one or several LDD parameters (e.g. live current modulation control, high frequency output toggle) the Flash lifetime will decrease. To prevent this the save feature can be disabled, in which case the LDD does *not* store configuration any more. All Parameters are then volatile.

At startup the last saved configuration will be loaded from Flash.

Appendix 1 Laser Diode Driver Status LEDs and Error Codes

System Status

LDD devices feature green and status LEDs both for the STM32 microcontroller and for the FPGA. In normal operation, both green LEDs are blinking.

In the case of any error occurring, the laser diode driver enters an error status and the red STM32 status LED is lit. Power circuitry is deactivated for safety reasons. Control, monitoring and communication circuitry remains active. In case of software / configuration errors (*i.e.* not hardware faults), parameter can be reconfigured on the fly. The LDD needs to be software-reset or power-cycled to clear the error status.

The blue STM32 status LED is reserved for future use.

Green LED	Red LED	Signification
Blinking slowly	-	'Ready' status (no errors). LDD power output disabled
Blinking fast	-	'Run' status (no errors). LDD power output active
-	Static ON	'Error' status. LDD power output disabled
Static ON	Static ON	'Bootloader' status

Table I. STM32 Status LED reference chart

Green LED	Red LED	Signification
Blinking slowly	-	LDD power output disabled
Blinking fast	-	LDD power output enabled
-	Static ON	FPGA error status. Error passed on to microcontroller for diagnosis

Table J. FPGA Status LED reference chart

When a laser diode driver is configured / controlled by the LDD Service Software, its status is displayed in a color code at the bottom of the window.

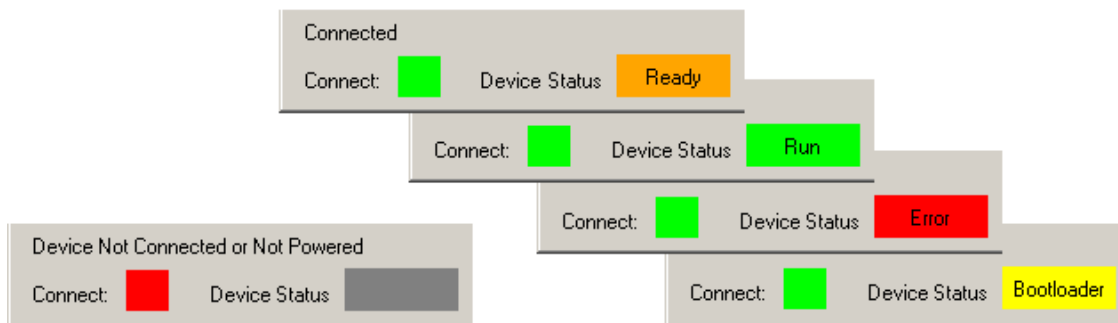


Figure 23. LDD Service Software color codes for connection and device status

Error Numbers, Instances and Parameters

- Error Numbers from 1 through 99 designate error conditions that are universal across the whole range of Meerstetter advanced laser diode drivers and TEC controllers. Error numbers starting from 100 designate conditions that are specific to LDD-Family devices (see tables below).
- Error Instance typically designates the channel involved. The LDD is a single-channel device, thus the instance value is normally 1
- Error Parameters are additional information helping the software engineers at Meerstetter Engineering in the processes of error diagnosis or remote debugging

Error Numbers 1 - 99 (Universal, for LDD-Family and TEC-Family devices)

#	Code	Description
1	STM32HANDLER_NMI	
2	STM32HANDLER_HARD_FAULT	
3	STM32HANDLER_MEM_MANAGER	
4	STM32HANDLER_BUS_FAULT	
5	STM32HANDLER_USAGE_FAULT	
6	STM32HANDLER_SVC	MCU system malfunction
7	STM32HANDLER_DEBUG_MON	
8	STM32HANDLER_PEND_SV	
9	SYS_NOT_HANDLED_INT	
10	WWDG_RESET_OCCURRED	

Table K. Processor Errors

#	Code	Description	Error Condition
11	EMERGENCY_STOP	Emergency stop pressed	
12	HMI_FREE_TIMEOUT	HMI regularly sends 'free' signals to all rack-internal devices such that they are allowed to activate their output stages (if enabled)	No signal received for more than one second

Table L. HMI Errors (when TEC is mounted into an LTR-1200 rack enclosure)

#	Code	Description	Error Condition, Remedy
20	PARAMETER_READ	Internal parameter system malfunction	
21	PARAMETER_WRITE		
22	PAR_LOAD_CRC	Parameter set corrupt	Configuration flash empty or defect (Remedy: cf. #23)
23	PAR_LOAD_PAR_VERSION	Set of parameters incompatible with current firmware version	Load .ini file saved prior to FW update, or Default.ini
24	UNKNOWN_DEVICE_TYPE	Firmware does not recognize valid device	
25	WRONG_INSTANCE	Internal parameter system malfunction	Access to a non-existing instance
26	LIMIT_SET_GET	Internal limit system malfunction	
27	WRONG_TYPE	Parameter write or read wrong datatype function used	
28	OUT_OF_RANGE	Parameter write value out of range	
29	PAR_FROM_ISR	Parameter save to flash called from interrupt	

Table M. Parameter Errors

#	Code	Description	Error Condition
30	UNDERVOL_PWR	Input voltage net out of range	< 10.5 V
31	OVERVOL_PWR		> 27 V
32	UNDERVOL_10V	Internal 10V power net out of range	< 9 V
33	OVERVOL_10V		> 11 V
36	UNDERVOL_33V	Internal 3.3V power net out of range	< 3.1 V
37	OVERVOL_33V		> 3.5 V

Table N. Power Supply Errors

#	Code	Description	Error Condition
50	FLASH_WRITE_TIMEOUT	On-board flash failure	Write Timeout
51	FLASH_ERASE_TIMEOUT		Erase Timeout
52	FLASH_INVALID_ADDR		Invalid Address

Table O. Flash Errors

#	Code	Description	Error Condition
53	USART_TX_FIFO_OVER	Send buffer overflow error	

Table P. Com (UART) Error

#	Code	Description	Error Condition
60	OVERTEMPERATURE	Device running too hot (@ base plate)	> 60 °C
61	EXT_HW_TEST_FAILURE	Communication error with I/O hardware during factory test	

Table Q. Temperature and External Hardware Errors

#	Code	Description	Error Condition, Remedy
70	FPGA_CRC	Wrong checksum for FPGA config memory	Reinstall FW / FPGA config via internal bootloader
71	FPGA_GENERAL	FPGA malfunction	
72	FPGA_VERSION	Microcontroller firmware and FPGA configuration incompatible	(Remedy: cf. #70)

Table R. FPGA Errors

Error Numbers 100 - ... (Specific, for LDD-Family devices)

#	Code	Description	Error Condition, Remedy
100	PID_LIMIT	PWM saturation error	PWM saturation time > 100 μ s (100 x 1 μ s), Check input current is sufficient and V_{out} not set too close to V_{in}
101	TLD_TEMP_RANGE_UNDER	Measured laser diode temperature out of range	< 'Lower Error Threshold'
102	TLD_TEMP_RANGE_OVER		> 'Upper Error Threshold'
103	FPGA_VALUE_READBACK	Safety monitor settings readback fault	Save .ini file for diagnosis
104	OUTPUT_OVERLOAD	Allowed total output power reached	Reduce output power

Table S. Operation Errors

#	Code	Description	Error Condition
110	FPGA_CURRENT	Overcurrent, triggers fast switch-off	> 'Max Current Error'
111	FPGA_SYM1	Overcurrent in buck converter 1,2 or 3 (hardware protection)	Try to optimize PID parameters
112	FPGA_SYM2		
113	FPGA_SYM3		
115	FPGA_MPWR	LDD input voltage out of range	10.5 V < MPWR < 27 V
116	FPGA_M10V	10 V internal supply out of range	9 V < M10V < 11 V
117	FPGA_M33V	3.3 V internal supply out of range	3.15 V < M33V < 3.45 V
118	FPGA_M1V	1.2 V internal supply out of range	1.14 V < M1V < 1.26 V
119	FPGA_SYM2_OF	Maximum possible channel balancing by PWM correction reached	Try to optimize PID parameters
120	FPGA_SYM3_OF		
122	FPGA_DM	Comprehensive 'Dead Man' safety feature: FPGA supervision over MCU, FPGA and intracommunication, will switch off LDD output power system	Timeout > 30 ms
123	FPGA_SYM	Difference between max. and min. measured currents through 3 individual buck converter channels too big	Difference > 1 A

Table T. Supervision Errors

#	Code	Description	Error Condition
130	COMMUNICATION_WATCH_DOG	USB and/or RS485 communication timeout	> 'Com. Watchdog'

Table U. Communication Timeout Error