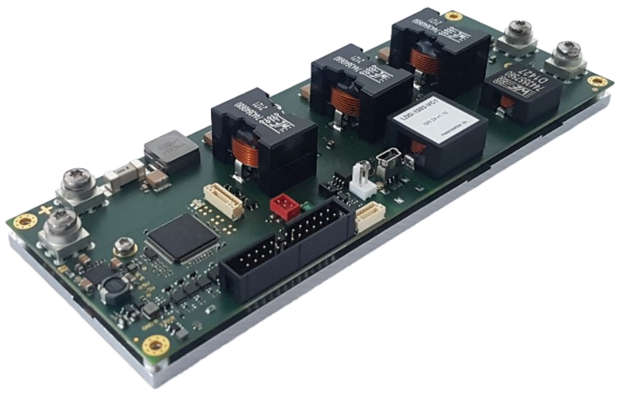
User Manual – LDD-130x



LDD-130x:

LDD-1301
LDD-1303

meerstetter engineering
Member of Berndorf Group

Developed, assembled, and tested in Switzerland

Index

Meerstetter Engineering GmbH
Schulhausgasse 12
CH-3113 Rubigen
Switzerland

Phone: +41 31 529 21 00
Email: contact@meerstetter.ch

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Document 5261H

LDD-130x Firmware Version v2.20

Release date: 27 February 2025

1 Introduction

This manual covers the functionality of the LDD-130x digital (laser) diode drivers.

Most of the explanations in this document assume that you use the “LDD-130x Service Software”, but all the operations can also be done by your own application if you implement the functionality. Most of the commands are documented in our communication protocol documents.

If you cannot find the feature or setting you need, please do not hesitate to contact our support. We do also provide customized firmware solutions.

1.1 Important Documents

- Datasheets
  - Technical specifications
  - Hardware configurations
  - Ordering information
- Communication Protocols
  - Protocol specification
  - Commands, Parameters
  - Example Applications and APIs
- Temperature & Light Sensor Cable Specifications
  - Pinout
  - Temperature sensor and photodiode assembly
- Temperature Sensor Suggestions
  - Description, part numbers and distributors for NTC sensors
- Application Notes
  - Additional Information about various usages of our devices

1.2 How to Contact Support

For optimal technical assistance we need the following information:

- Configuration file, exported while the error is present
  - Click “Export Config” in the footer
- Monitor History
  - Click “Maintenance” tab → “Monitor Data Logger” → activate Checkbox “Export all Monitor Values to CSV File (Debug)” → “Export Logged Monitor Data to CSV File”
- A picture showing your system, the controller and the sensor leads.
- Datasheets of your Peltier element, power supply and any other important parts involved in your setup.

You can also use the TeamViewer software from our website for a remote-control session. As soon as you start the tool we will recognize you, but please make sure to call or write us beforehand.

2 Basic Functions

2.1 The Status Bar of Service Software

The bottom row of the software is always visible and shows the following information:

- Connection status
- Device status
  - Ready: Normal standby status (no errors). Output stage disabled
  - Run: Normal operating status (no errors). Output stage enabled
  - Error: Error occurred. Output stage disabled
  - Bootloader: Firmware is being updated
- Operating parameters
  - Output current and voltage

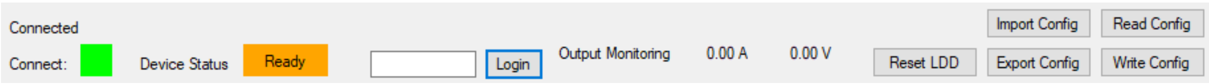

Figure 1. Status bar in the bottom row of the Service Software.

2.1.1 Status LEDs and Service Software Status

LDD-130x devices feature two status LEDs. In normal operation, the green LED is blinking.

In the case of any error occurring, the device enters an error status and the red LED is lit. Power circuitry (output stage) is immediately deactivated to ensure safety. Control, monitoring and communication circuitry remains active. In case of software / configuration errors (i.e. not hardware faults), parameters can be reconfigured on the fly. The device needs to be software-reset or power-cycled to the clear the error status.

Table 1. Status LED description.

Green LED	Red LED	Signification
Blinking slowly (~1 Hz)	-	“Ready” status (no errors). Output stage disabled
Blinking fast (~2 Hz)	-	“Run” status (no errors). Output stage active
-	Static on	“Error” status. Output stage disabled
Static on	Static on	“Bootloader” status

When the Service Software is connected to a device, its status is displayed in the bottom of the software window.

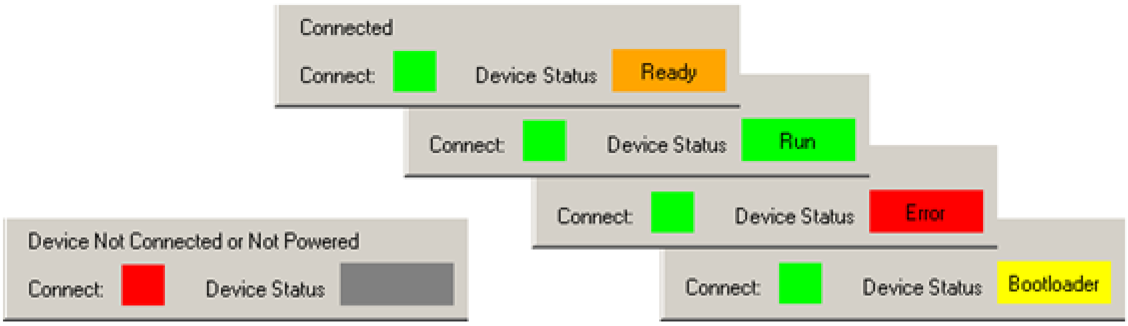

Figure 2. Service Software color codes for connection and device status.

Error Status:

If the device enters the error status, please go to the “Monitor” tab, there you can find the error number and description on the right side of the window.

Alternatively, you can find a list of all errors at the end of this User Manual.

2.1.2 Writing and Reading Device Parameters

Changed parameters are saved to the controller by clicking “Write Config” in the footer. Multiple parameter fields can be written at once. Be aware that also fields in tabs which are not currently displayed are written to the controller.

Parameters are read automatically when a connection to the controller is established.

2.1.3 Importing and Exporting .ini Configuration Files with the Service Software

Device configuration sets can be exported as backup or for support purposes. They are specific to each unit as they contain calibration data.

- Export
  - To save a configuration file on the PC, click on “Export Config” in the bottom right corner of the Service Software.
  - All actual values are also stored. The values are useful for support and analysis.
- Import
  - To load a configuration file from the PC, click on “Import Config” in the Service Software.
  - By default, calibration data is only imported when the serial number in the configuration file matches the connected device’s serial number (this option can be disabled in the relevant tabs at the bottom).

2.2 Remote Control Options

This is an overview of the different remote-control options for the device. It's possible to configure, control and monitor the device using any software which can communicate over an appropriate interface. In the "LDD-130x Communication Protocol 5260" document a list of the software options available from us can be found.

Generally, all parameters available in the Service Software can be read and written by other means using the communication protocol.

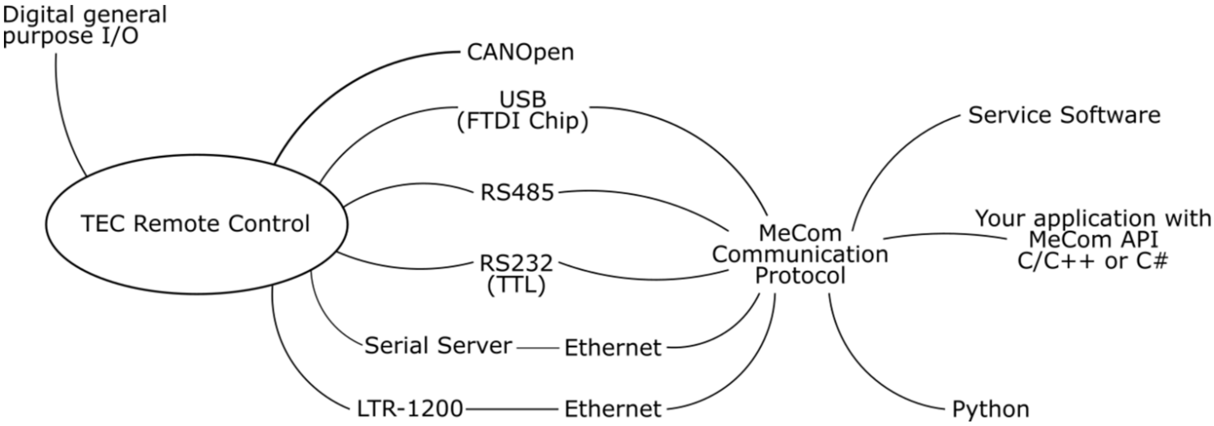

Figure 3. Remote control options.

2.2.1 Serial Communication

Serial communication is used to send data from a host to an LDD-130x and receive data from the device, respectively. The following physical interfaces are supported:

- USB
- RS485 (check out our TEC Application Note - RS485 Interface, valid for LDD-130x too)
- RS232 TTL[1]

Communication using the Service Software and RS485 is only possible using a USB–RS485 adapter or an Ethernet serial server, since the Service Software only connects to FTDI[2] chips or TCP port 50'000.

2.2.1.1 Addressing specific devices

Assign a unique "Device Address" to the device if multiple devices are operated on the same bus. The "Device Address" can be set on the "Operation" tab when the Service Software has already connected to the device. You can then tell the Service Software to use a specific device address to communicate. To do this, open the "Maintenance" tab and look for "Service Communication Settings". For more application arguments, check our communication protocol document. All devices have a 1-unit load receiver input impedance, allowing up to 32 transceivers on the RS-485 bus.

2.2.2 Ethernet Communication

It's possible to use a standard Serial Server to connect our devices to an Ethernet interface. We have tested devices from Lantronix (e.g. XPort, UDS1100) and Moxa (e.g. NPort 5130). Please check TEC Application Note - RS485 Interface, valid for LDD-130x devices too.

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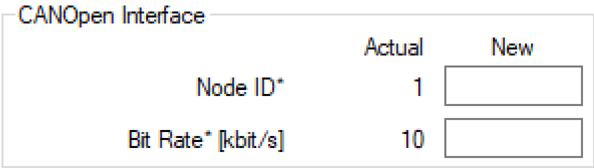
[1] Availability dependent on device.
[2] One option is the USB RS485 converter cable from FTDI Chip, available in different lengths.

2.2.3 CANopen

This device supports CANopen according to CiA 301. Please refer to the "LDD-130x Communication Protocol 5260" for further details



2.3 Firmware Updates

You can download the firmware (contained in the software package) from our website and update your devices using the Service Software.

The Service Software and the Firmware are strongly related. Only when a Service Software and a Firmware with a matching Version Number are used the full functionality can be guaranteed. However, it is usually possible to connect to a device with an old Firmware with a new Service Software and vice-versa. Functionality will be limited, but firmware updates are possible.

Matching version numbers: All our published software has a version number similar to this: “vX.YZ”. It is important that at least X and Y is matching. Z can be different.

Follow these steps to update devices:

- Read the LDD-130x Software Release Notes
- Backup the current configuration. This is important because it is possible that the current configuration will be lost during the update.
- In the tab “Maintenance” locate “Device Boot Loader”.
- If the *.msi* installation package has been used, the correct hex file is already selected, otherwise
    - Click to browse and choose the new .hex file
- Click to “Update”
- The device will reboot once the update completes.
- You can check the firmware version in the tab “Monitor”.
- Re-import the before exported *.ini* file (if necessary).
- Fill missing parameter values into new parameter fields (if applicable).

3 Operating the Current Driver

3.1 Theory of Operation

LDD-130x devices feature an output current stage controlled by a PID Controller implemented in the microcontroller.

The devices differentiate themselves in their capabilities. For technical reasons, the position of the current measurement differs, as shown in the diagrams. As a consequence, while in the LDD-1301 the cathode is connected to the board's ground, in the LDD-1303 the cathode also needs to be floating.

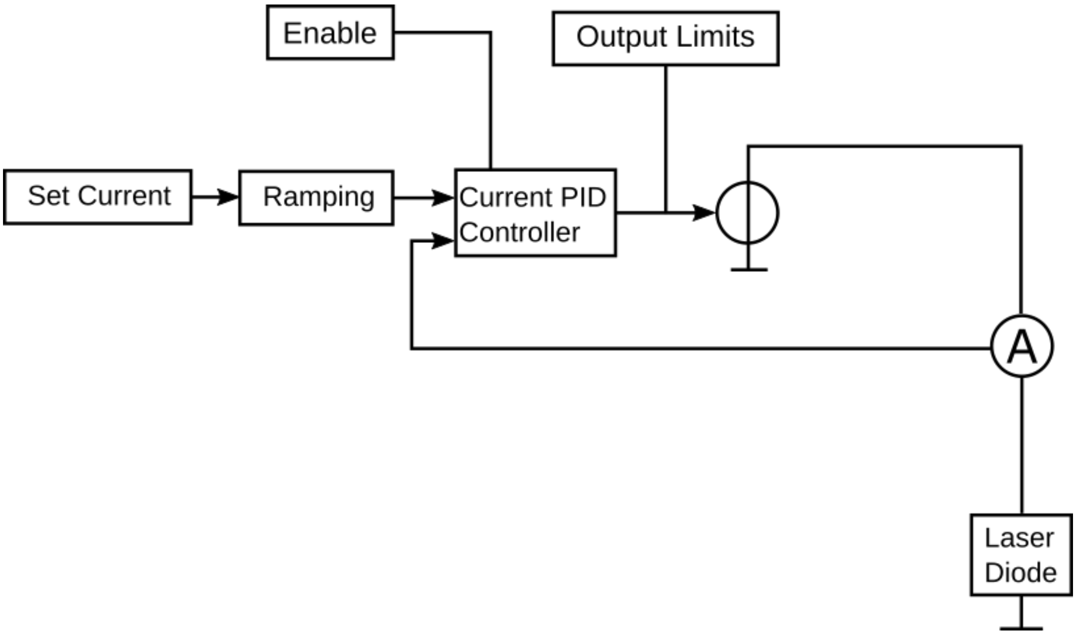


Figure 4. Functional overview of the LDD-1301.

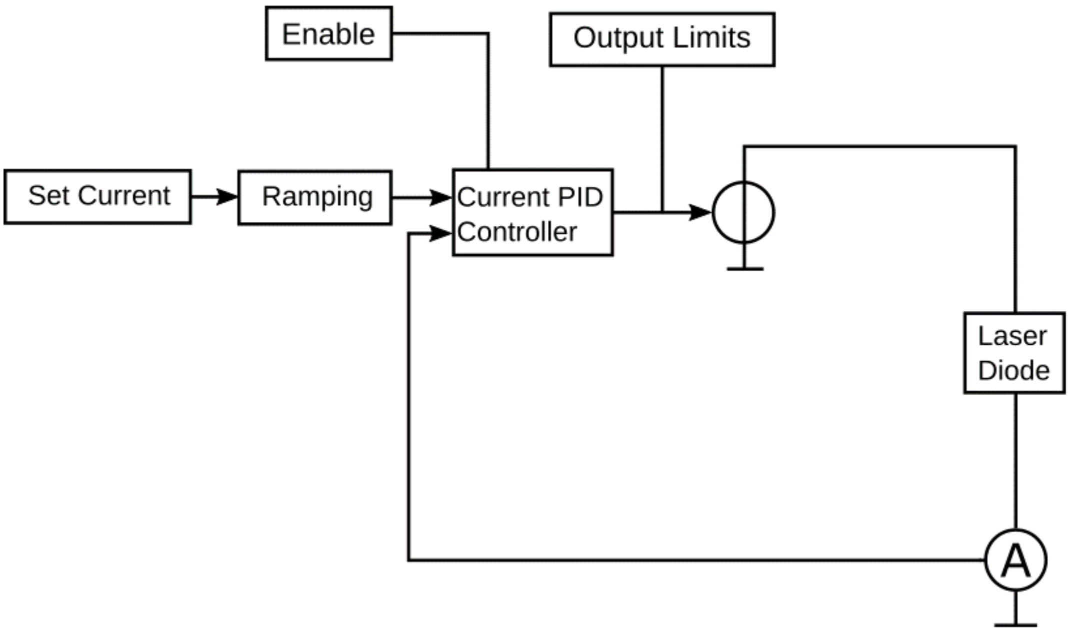


Figure 5. Functional overview of the LDD-1303.

3.2 Driver Settings

3.2.1 Output Settings

In the tab “Operation” you can set the Nominal Output Current to be controlled from five sources:

- a parameter (“Set Current”),
- from the light power control feature[3] (“LPC”),
- from the analog input feature[4] (“Analog”),
- from the lookup table feature (“LUT”),
- from the signal generator feature (“Signal Gen.”).

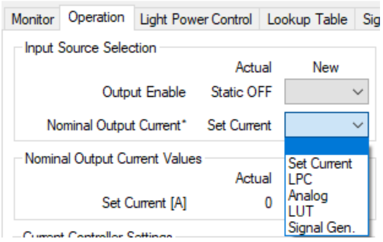


Figure 6. Output Current Selection.

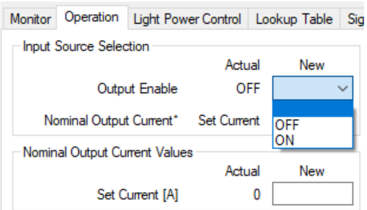


Figure 7. Output Enable Selection.

The output is activated by “Output Enable”. If saved to flash, this remains active after a power cycle or reset.

The output stage nominal current limit settings allow to define limits for the nominal current that will be enforced regardless of the current you set. These should be set to reflect the normal operation range.

The error thresholds are important safety settings which when crossed, will cause the device to go into error mode and consequently shut down its output stage. You should set these in order to protect your connected diode from regulation or configuration issues. This value should always be set within the absolute maximum current rating of the laser diode you’re using.

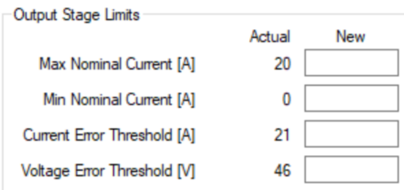


Figure 8. Output Stage Limits.

[3] See the relevant chapter for how to set up the light power control
[4] See the relevant chapter for how to set up the analog input control

3.2.2 Current Controller Settings

These settings, again in the tab “Operation”, define the behavior of the current regulation. The current stage is regulated by a PID controller.

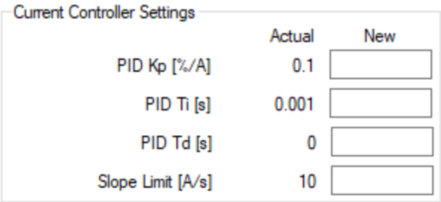


Figure 9. Current Controller Settings.

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 “Slope Limit” acts on internal nominal current ramping and allows the use of more aggressive PID settings.

4 Operating the Light Power Controller

4.1 LPC Prerequisites

This feature is only available on devices which contain -LPC-?? in their product string and requires a software license to use. See chapter 12 Feature Unlock for more information.

4.2 Theory of Operation

LDD-130x devices feature an optional cascaded PID Controller to control the emitted light power of laser diodes. This control is also implemented in the microcontroller.

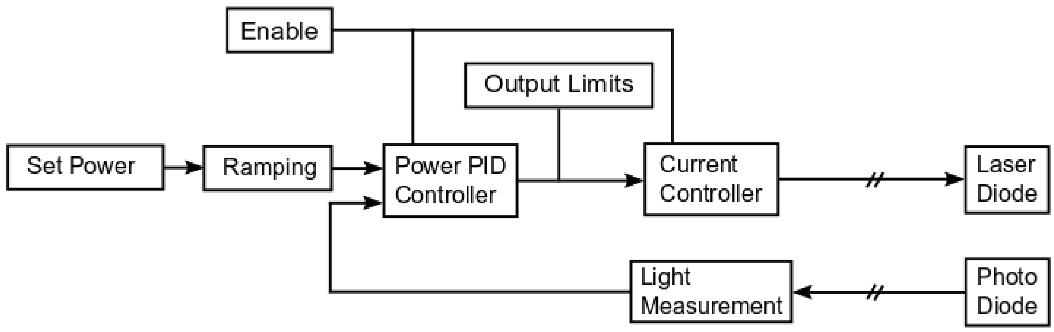


Figure 10. Functional overview of the light power control on LDD-1301/1303.

4.3 Controller Settings

4.3.1 Output Settings

In the tab “Operation” the Nominal Output Current can be set via the normal parameter (“LPC”), meaning the light power PID controller’s output is connected to the input of the PID controller of the current driver.

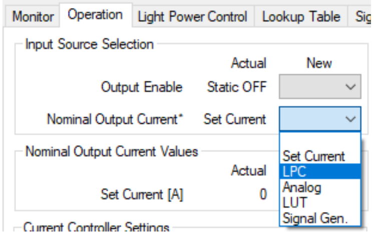


Figure 11. LPC selection.

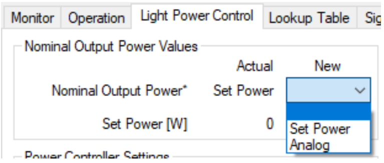


Figure 12. Output Power selection.

In the tab “Light Power Control” the Nominal Output Power can be controlled either over a parameter (“Set Power”) or over the Analog input.

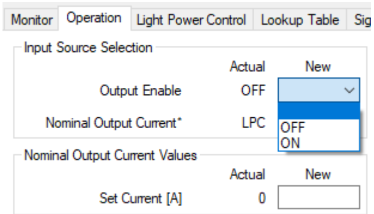


Figure 13. Output Enable selection for LPC.

The output is activated by “Output Enable”. If saved to flash, this setting remains active after a power cycle or reset.

The output stage nominal power limit settings allow to define limits for the nominal light power that will be enforced regardless of the light power you set. These should reflect your target operation range.

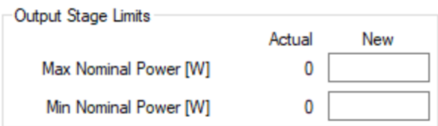


Figure 14. Output Stage Limits for LPC.

4.3.2 Power Controller Settings

These settings, again in the tab “Light Power Control”, define the behavior of the light power regulation. The current stage is regulated by a PID Controller that is regulated by a cascaded PID Controller.

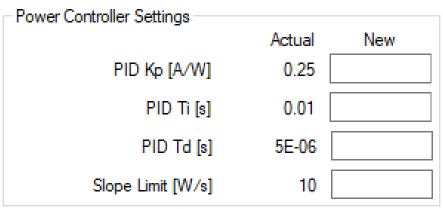


Figure 15: Power Controller Settings for LPC.

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

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 “Slope Limit” acts on internal nominal light power ramping and allows the use of more aggressive PID settings.

5 Lookup Table

It is possible to download a table containing a customized waveform. This waveform can be used to control the laser diode current.

Please make sure that the input source selection is set properly when using a lookup table.

All lookup table functionality is also provided by the communication protocol using the LUT parameters.

5.1 Table Definition

The .csv file is structured as follows.

The header row contains 2 or more columns, the first row being “Table Instance” followed by columns containing the table instance numbers. A maximum of one table instance is currently supported. The following rows define the table instance values, starting from the second row. For further information see “LookupTable Example.csv”.

Up to 1000 samples are possible in each table. Please keep the analog bandwidth and current update rate in mind when defining waveforms. Furthermore, make sure the configured slope limit is suitable for the defined waveform.

For a visualization of the example waveform open the “LookupTable Example.xlsx” Excel sheet.

5.2 LUT Configuration

From within the LDD Service Software, the lookup table configuration can be found in the "Lookup Table" tab.

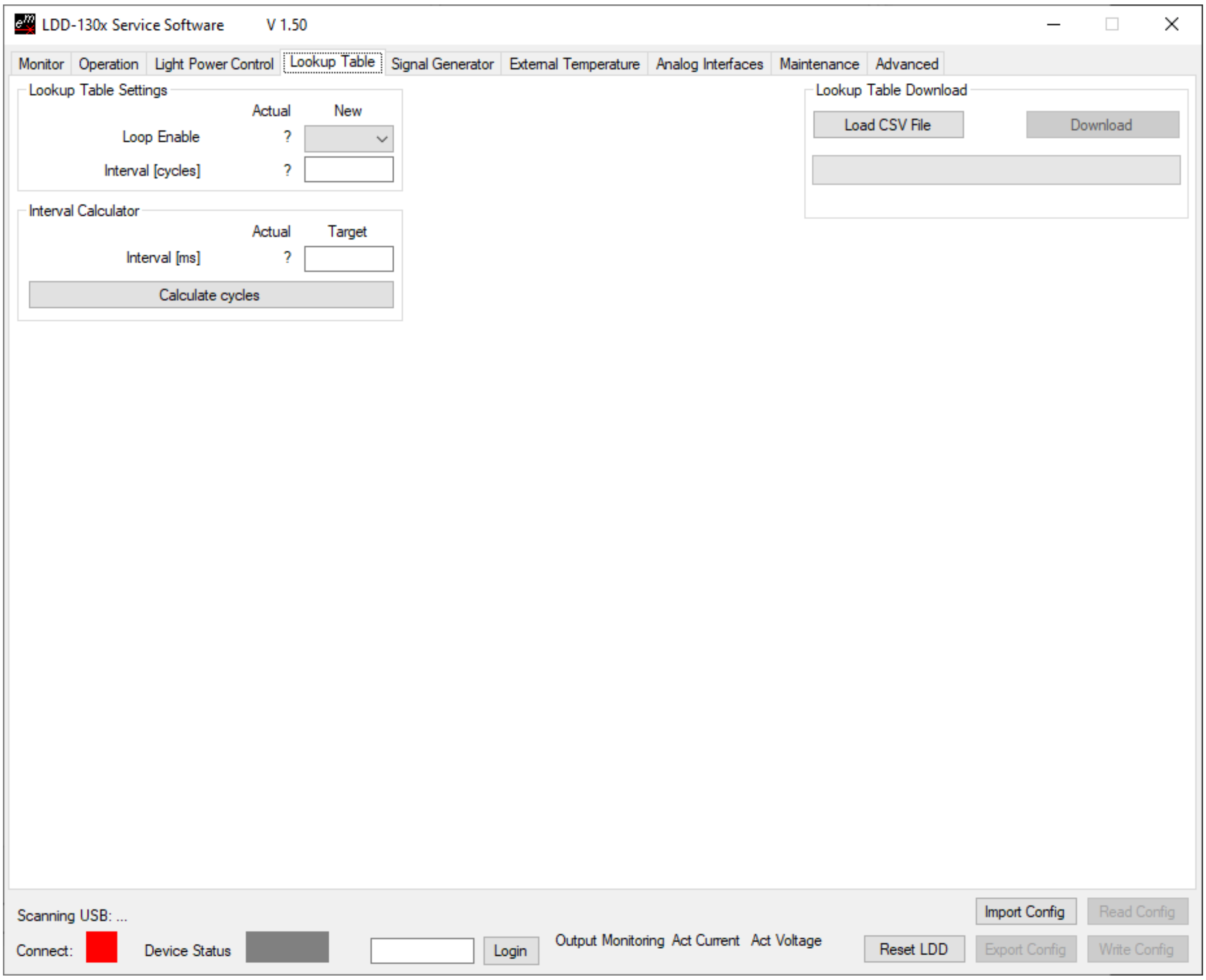


Figure 16. Lookup Table tab

The "Loop Enable" parameter controls whether the table repeats itself indefinitely or stops upon reaching the last record.

The "Interval" parameter controls the sample interval of the table defined in cycles which are 22.85714 microseconds each. Use the interval calculator utility to calculate the closest approximation of your desired interval.

Load the externally generated table into the LDD's memory by using the "Load CSV File" and "Download" buttons. The table is downloaded as a .csv file.

6 Signal Generator

The LDD can generate a set of predefined waveforms which can be used to shape the laser diode current. It is also possible to specify a waveform using a Lookup Table, however the number of data points the table can hold is limited and defining certain waveforms manually may be difficult or tedious. When using the signal generator, the LDD will derive the signal from the mathematical definition of the signal instead.

Please make sure that the input source selection is set properly when using the signal generator. Furthermore, care must be taken when using the communication protocol as time parameters are specified in cycles.

6.1 Signal Generator Configuration

Open the “Signal Generator” tab and select the waveform you need.

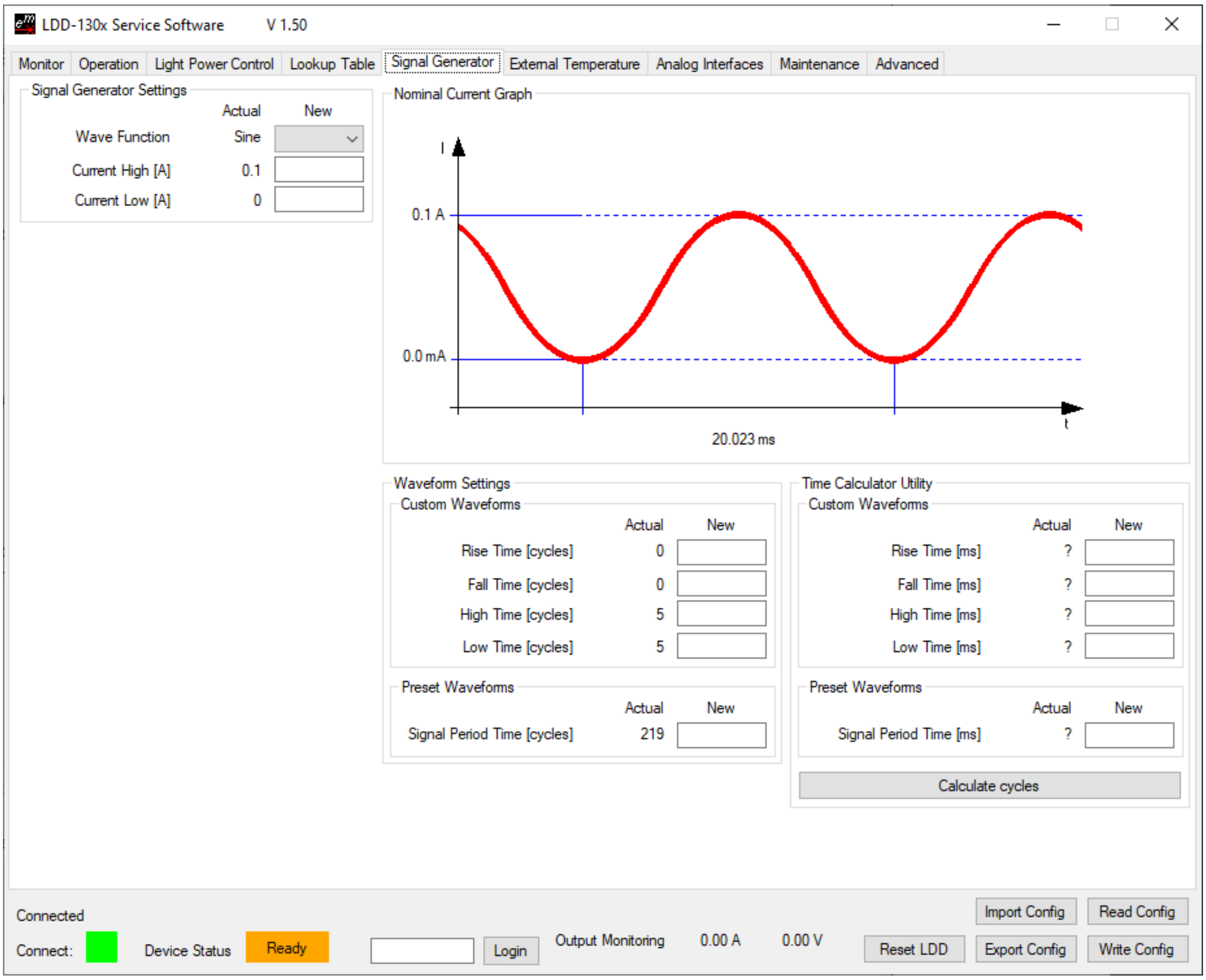


Figure 17. Signal Generator tab

There are two parameters which apply to every kind of waveform: “Current Low” and “Current High”. Those two parameters define the lowest and the highest point of the waveform respectively. “Current High” must be higher than “Current Low”.

The timing parameters are different depending on whether the selected waveform is a custom waveform or one of the preset waveforms. All time parameters are specified in cycles which vary in length depending on the kind of waveform. Custom waveform cycles are 22.86 µs long while preset waveform cycles are 91.43 µs long (the minimum amount of cycles is 5).

Use the time calculator utility to calculate the closest approximation. If you are unsure how the final waveform will look like you can use the current graph as a reference.

6.1.1 Custom Waveform

The custom waveform is the most configurable waveform and allows to define arbitrary trapezoidal waveforms. It has four parameters which are used to configure the rise, fall, high and low time.

6.1.2 Preset Waveforms

Preset waveforms only have one additional configuration parameter “Signal Period Time” which defines the length of the signal. There are three waveform presets: sine, square and triangle.

7 Temperature/Light Measurement and Analog Interfaces

7.1 Temperature Measurement

This input can accommodate NTC sensors.

Error thresholds to protect your load against overheating are available in the "External Temperature" tab. They can be activated via the setting in the "External Temperature Errors Enable" box. The error limits can be set for each input in the "External Temperature Error Limits" box.

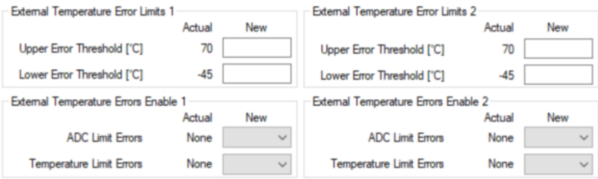


Figure 18. External Temperature Error Settings.

If the "ADC Limit Errors" are enabled, an error will be thrown if the NTC sensor has reached a resistance value that is at the edge of the measurable range of the controller. It offers a selection of different threshold detections, one for only the upper value, another only for the lower value and one for both.

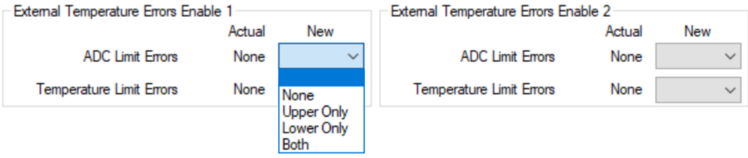


Figure 19. External Temperature Errors Enable for ADC Limit Errors.

If the "Temperature Limit Errors" are enabled, the crossing of the thresholds set in "External Temperature Error Limits" will be detected and cause an error. It offers a selection of different threshold detections, one for only the upper value, another only for the lower value and one is for both.

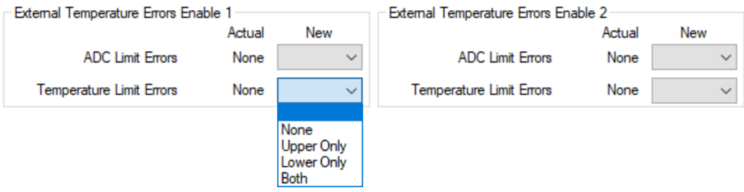


Figure 20. External Temperature Errors Enable for Temperature Limit Errors.

The "External Temperature Measurement Settings" allow an additional user calibration for each input.

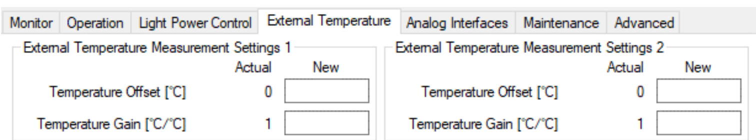


Figure 21. External Temperature Measurement Settings.

The “External Temperature Measurement Limits” are calculated values showing the range of measurable resistance of the input. The corresponding maximum and minimum temperatures are calculated for each temperature input using the sensor characteristic found in tab “Advanced” > “External Temperature Measurement”, in “External NTC Sensor Characteristics”.

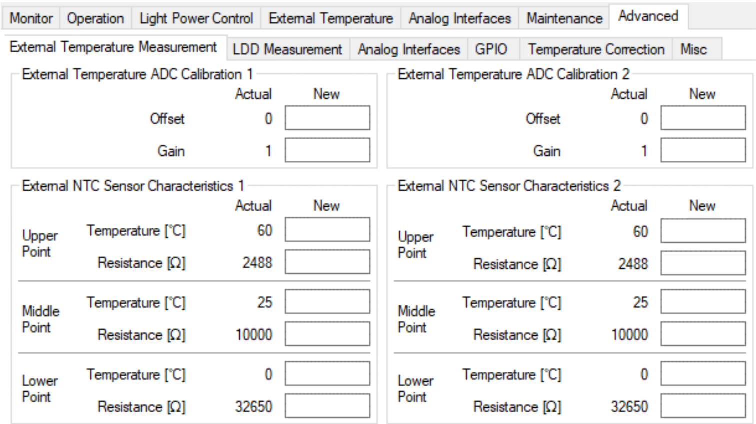


Figure 22. External NTC Sensor Characteristics settings.

7.1.1 Temperature Correction of the Output

In the “Advanced” > “Temperature Correction” tab you can activate a temperature-dependent contribution to the set current.

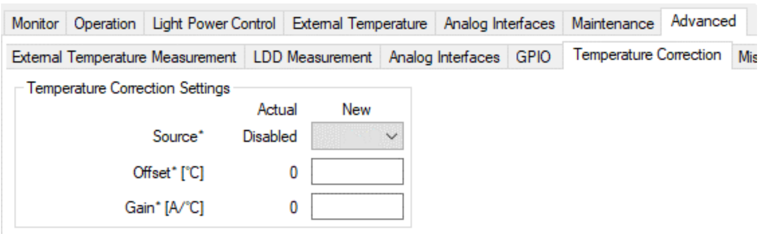


Figure 23. Temperature Correction Settings.

This can be used to compensate variations in the light output of your laser due to temperature variations, in the absence of optical feedback. The Gain and Offset parameters are used in the following formula:

$$I = I_{set} + \text{Gain} \cdot (T - \text{Offset})$$

Where T is the temperature input you selected via Source, I_{set} is the nominal current you set as when using the controller normally, and I is the actual nominal current that the LDD will follow. This final value can be observed in the Monitor tab as the “Nominal Output Current (Ramp) [A]” parameter.

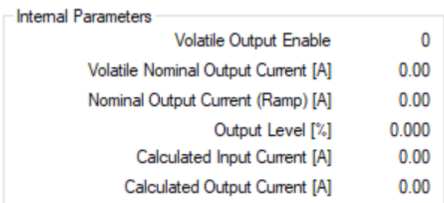


Figure 24. Monitor Value of the Nominal Output Current (Ramp).

7.2 Light Measurement

The optional light measurement input offers the possibility to observe the photodiode current via a parameter shown on the Monitor tab. In absence of the feature the value will be stay on NA.

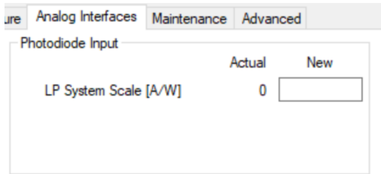


Figure 25. Light Power Factor.

Through the parameter “LP System Scale” LP_{Gain}, the conversion factor to translate the photodiode current I_{Ph} into an emitted light power P_{Light}, can be defined, this is required for operating with the light power control. This parameter depends on the photodiode and the optical coupling of the system. You can set this arbitrarily in the absence of an absolute reference measurement.

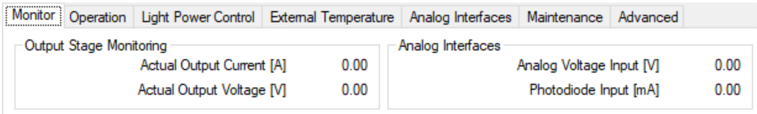


Figure 26. Monitor value of the Photodiode Input.

$$P_{Light} = \frac{I_{Ph}}{LP_{Gain}}$$

The above formula shows the relationship between the emitted light power and the photodiode current LP_{Gain}. The value is also displayed in the Monitor tab plus the output level of the PID.

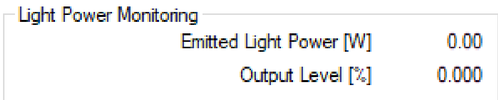


Figure 27. Monitor value of the Emitted Light Power.

7.2.1 Photodiode Input Setting

In the tab “Advanced” >“Analog Interfaces” you can set a resistance value for the photodiode input. Note that “Photodiode Rs” depends on the LPC hardware configuration and does not need to be modified by the end user.

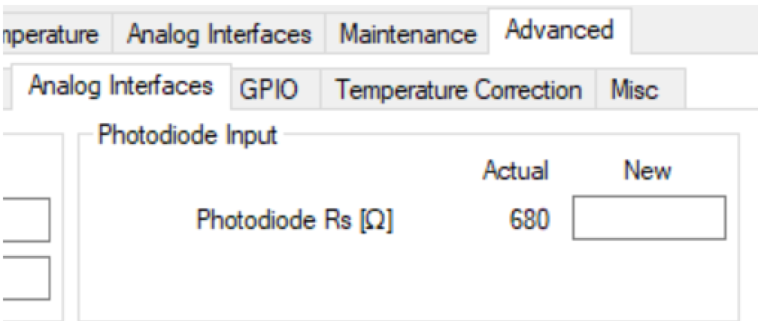


Figure 28. Photodiode Input setting.

The values correspond to each LPC configuration according to the following table:

Photodiode Rs [Ω]	LPC Configuration [mA]
5600	0.5
2700	1
1300	2
680	4

Table 2. LPC configurations.

7.3 Voltage Output

The voltage output (tab "Analog Interfaces") can be used to provide a synchronization output (i.e. a voltage signal with the same waveform as the measured output current) or a voltage signal controlled by the "Set Value [V]" parameter. Configure the "Signal Source" to select between those two modes.

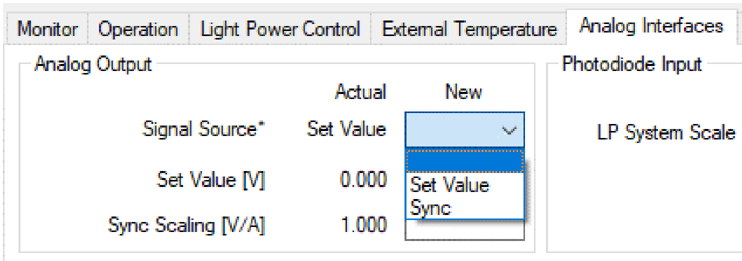


Figure 29. Analog Output settings.

This output runs with a frequency of 10 Hz.

"Sync Scaling [V/A]" allows to set the output current to output voltage ratio.

7.4 Voltage Input

The analog voltage input is displayed in the "Monitor" tab. To control the output current through this analog input, the Nominal Output Current in the tab "Operation" can be set to "Analog" (this needs to be followed by a reset).

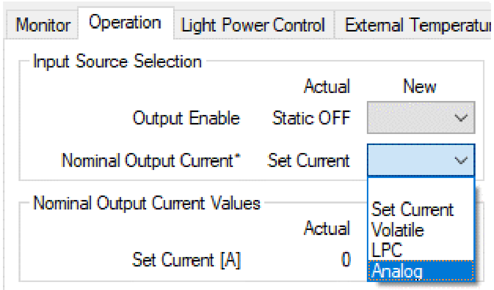


Figure 30. Output Current Setting for Analog Input.

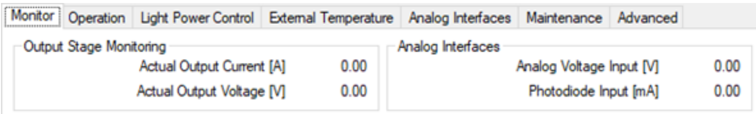


Figure 31. Monitor value of the Analog Voltage Input.

The output current set by the Analog Input follows the formula below where *I* is the output current, $V_{AnalogIN}$ is the input voltage and *G* is the scaling factor "Current Factor [A/V]"

$$I = V_{AnalogIN} \cdot G$$

The Current Factor parameter is used to convert the Analog Input Voltage into a corresponding Output Current and can be found in the tab "Analog Interfaces", in the "Analog Input" box.

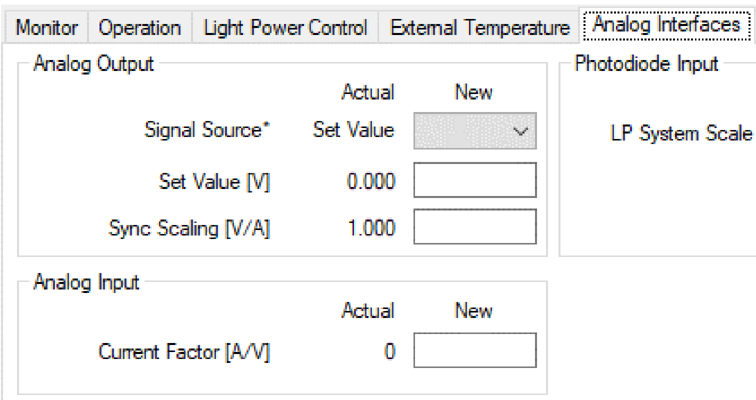


Figure 32. Analog Input Setting.

8 Data Logging

8.1 Monitor Data Logger

For external plotting and data analysis, logged data can be exported to a .csv file, in the "Maintenance" tab in the box "Monitor Data Logger".

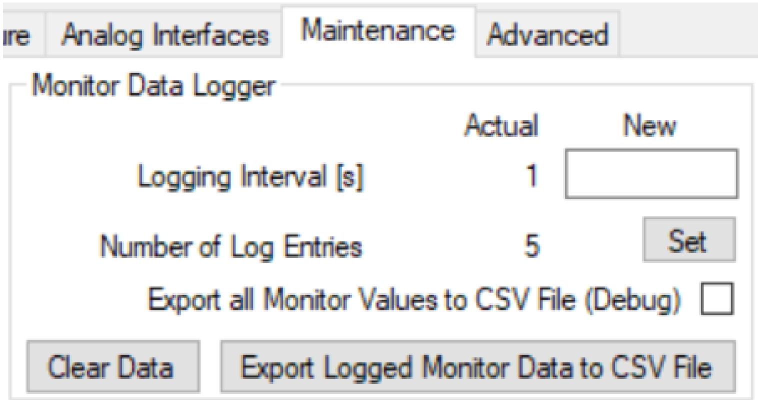


Figure 33. Monitor Data Logger.

- Each log entry is time stamped.
- At relaunch of the software the log is erased and the log interval is set to the smallest value of 1 s.
- The general data logging duration is not limited. It depends on the available RAM on the PC and the logging interval.
- For critical long-term monitoring we recommend exporting the log regularly and to relaunch the Service Software occasionally (e.g. every couple of days).
- The exported file of the logged data contains the value of various monitor parameters such as the output current.
- Select "Export All Monitor Values to CSV File (Debug)" to export more values, which can be useful if you send the file to Meerstetter for diagnosis.

9 External Hardware

9.1 GPIO Control Signals

The GPIO control signals can be used for general purpose I/O (GPIO) or for predefined functions. The functions described in Table 3 can be independently assigned to the GPIO signals in the “Advanced” → “GPIO” tab. Many functions are separately available as several channels. For those functions, the channel can be chosen in the “Advanced” → “GPIO” tab as well. For the functions which are not available in multiple instances this setting has no effect.

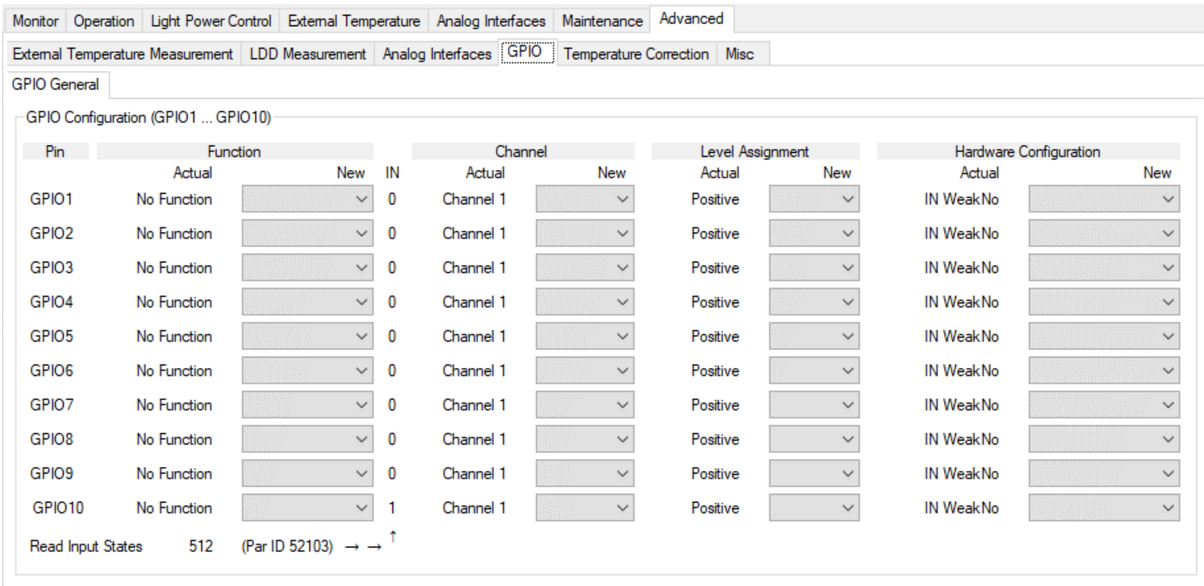


Figure 34. GPIO settings.

Table 3. Available functions for the GPIO signals.

Function Name	Description
No Function	The GPIOx has no function. The pin is at high impedance state.
Signal Control	The GPIOx signal is used as digital I/O, controlled by the communication interface. Refer to the communication protocol document for more information.
LDD OK	The GPIOx signal is logic 1 if the device is in the “Ready” or “Run” status.
HW Enable (edge)	Same as “HW Enable” but requires an active edge after reset.
HW Enable	The GPIOx signal is used as input to enable the output of the driver. If the signal is logic 1, the driver output is enabled.
Fan PWM	The GPIOx signal is used as PWM output for the Fan Control feature. Only selectable for GPIO5 and GPIO6 (see chapter 9.2 Cooling Fans). For this function, the "Hardware Configuration" is usually set to "Out PushPull" to properly drive the PWM input of the fan.
Fan Tacho	The GPIOx signal is used as frequency input for the fan control feature (see chapter 9.2 Cooling Fans). For this function, the "Hardware Configuration" is usually set to "IN Weak Up", because the fan’s tacho output usually has an open collector output.

Function Name	Description
Toggle HW Enable	Toggled version of the hardware enable. A button press causes the state of the hardware enable to switch. Debouncing is built-in in the firmware.
LDD Run	The GPIOx signal is logic 1 if the device is in the “Run” status.
Pump	The GPIOx signal is set to logic 1 to enable a pump or other cooling devices. Use the "CHx Pump Control" settings to configure the behavior. Two pump control channels are available.
Dev Addr +1 Dev Addr +2 Dev Addr +4	The GPIOx signal is used as input signal. For each pin which is logic 1 and with this function enabled, 1, 2 or 4 is added to the device address. This is only done once at startup.
Fan Stop	The GPIOx signal is used as input signal. If this function is enabled and the corresponding pin is 1, the fan is disabled. If the pin is 0 the fan runs normally.
Fix 0	Sets the GPIO output to fixed 0. Can be inverted using the "Level Assignment".
Pulse Input	When this pin is logic 0 the target current used by the current control loop is set to the Value of “Min Nominal Current”. When the pin is logic 1, the target current is left unaltered. (= Nominal Current) When multiple pins are configured as Pulse Input the GPIO with the highest number is used. If no GPIO is configured as Pulse Input the target current is left unaltered.

The Logic Level of each pin can be assigned under “Level Assignment” in the “GPIO” tab. For inputs, Logic Level “Positive” means that a high voltage is read in as logic 1 while a low voltage (Pin connected to GND) is logic 0. This can be inverted by setting the parameter to “Negative”. For outputs, the logic level inverts the Signal when set to “Negative”. This means that the “LDD OK” signal outputs 0V when the LDD is in “Ready” or “Run” status and the Level Assignment is set to “Negative”

The Pins can be Individually configured under “Hardware Configuration” in the “Advanced” → “GPIO” tab. When a signal is used as an input the hardware configuration must be set accordingly or the function will not be operational.

Table 4. GPIO Pins Hardware Configuration

Function Name	Description
In WeakNo	The GPIO Pin is configured as Input. No PullUp or PullDown Resistor is activated.
In WeakUp	The GPIO Pin is configured as Input. A weak PullUp Resistor to 3.3V of approximately 50kΩ is activated.
In WeakDown	The GPIO Pin is configured as Input. A weak PullDown Resistor of approximately 50kΩ is activated.
OUT PushPull	The GPIO Pin is configured as Push Pull Output. No PullUp or PullDown Resistor is activated.
OUT OD NoPull	The GPIO Pin is configured as an Open Drain Output. No PullUp or PullDown Resistor is activated.
OUT OD WeakUp	The GPIO Pin is configured as an Open Drain Output. A weak PullUp Resistor to 3.3V of approximately 50kΩ is activated.

For input signals like buttons, it is usually easier to set the pin to “Negative” logic and “In Weak Up”. This way the switch can be connected between the GPIO pin and GND.

9.2 Cooling Fans

Up to two fans can be connected and controlled by the device. The "Fan Control Feature" is intended to keep the temperature below a specified temperature, by using the slowest fan speed possible. This can be used to cool the LDD itself. Please refer to chapter 9.1 on how to configure the fan control signals.

9.2.1 Fan Requirements

The "Fan Control Feature" is only compatible to fans with the following features:

- PWM control signal input to control the fan speed. The device generates a 25 kHz or 1 kHz PWM signal from 0 to 100%. 3.3 V voltage level.
- Optional, but recommended: frequency generator signal output which represents the rotation speed. The output should be an open collector output signal.

For the logic level voltage definitions of the LDD, please refer to the datasheet.

9.2.2 Fan Recommendations

To obviate the need for a separate power supply, it is recommended to use a fan with the same supply voltage as the LDD needs.

We have tested the following fans, which fulfill the above-mentioned requirements. All fans stop (0 rpm) at 0% PWM signal.

Table 5. Recommended fans.

Fan	**Manufacturer P/N**	**DigiKey P/N**	**Voltage [V]**	**Power [W]**	**Dimensions [mm]**		
					L	H	W
1	FFB0424VHN-TZT4	603-1818-ND	24	2	40	40	28
2	AFB0624EH-SP50	603-1803-ND	24	6	60	60	25
3	PFB0824DHE-YDG	603-2028-ND	24	32	80	80	38
4	AFB1224EHE-EP	603-1735-ND	24	20	120	120	38
5	FFB0412VHN-TP03	603-1206-ND	12	2	40	40	28
6	AFB0612DH-TP11	603-1211-ND	12	10	60	60	25
7	EFC0812DB-F00	603-1159-ND	12	4	80	80	15
8	FFC1212D-F00	603-1789-ND	12	17	120	120	25
9	PF40281BX-000U-S99	259-1666-ND	12	11	40	40	28

9.2.3 Optimized Settings

The following values are optimal settings for the CHx Fan Speed Controller parameters in combination with the corresponding fan. The bypass option ("Bypassing Speed Controller") is used for fans with integrated speed controller, to disable the speed controller.

Table 6. Suggested fan settings.

Fan	0% Speed [rpm]	100% Speed [rpm]	Kp [%/rpm]	Ti [s]	Td [s]	Bypass
1	-	-	-	-	-	Yes
2	-	-	-	-	-	Yes
3	-	-	-	-	-	Yes
4	-	-	-	-	-	Yes
5	0	10000	0.005	0.5	0	No
6	0	10000	0.005	0.5	0	No
7	0	4200	0.005	0.5	0	No
8	0	4400	0.005	0.5	0	No
9	0	22500	-	-	-	Yes

9.2.4 Connecting the Fan to the Device

- If the fan supports the same supply voltage as the LDD, it is recommended to connect the fan's GND and VCC to the LDD’s GND and VIN, respectively.
- If a separate power supply is used for the fan, make sure that the two GND terminals of the power supplies are connected. Never leave the fan's GND unconnected when the fan is powered. Otherwise, the GPIOx pins may be destroyed.
- Assign the correct function to the GPIO signals (see chapter 9.1 GPIO Control Signals).
- The PWM input of the fan must be connected to GPIO5 or GPIO6, since only these outputs generate a PWM signal. As an example, you can configure the GPIO as follows:
    - Pin: GPIO5
    - Function: Fan PWM
    - Level Assignment: Positive
    - Hardware Configuration: OUT PushPull
- The frequency output signal of the fan can be connected to any of the GPIO signals. As an example, you can configure the GPIO as follows:
    - Pin: GPIO4
    - Function Fan Tacho
    - Level Assignment: Positive
    - Hardware Configuration: IN WeakUp

9.2.5 Control Function

The fan control feature uses two PID controllers.

The first PID controller sets the required cooling power depending on the temperature of the heatsink. In most cases only P control is used. We recommend a value of 30 %/°C for Kp. Thus, for a target temperature of 40 °C the fan will rotate with 0% speed at 40 °C and 90% speed at 43 °C.

This required cooling power is then converted into a nominal fan speed. For example, if the minimum and maximum fan speeds are set to 1000 rpm and 11000 rpm, respectively, the required cooling power of 50% is converted into a nominal fan speed of 6000 rpm.

The second PID controller sets the fan speed by varying the PWM output signal until the nominal fan speed is reached.

The "Fan Speed Controller" should be set up before without temperature regulation of the heatsink. This can be done by setting both the "Target Temperature" and the "100% Speed" to a high value. This allows to use the "0% Speed" as a fixed rotation speed. The fan should reach the nominal speed as fast as possible.

It is possible to stop the fan by an external GPIOx signal. This is useful, e.g., if a door of a compartment is opened (see chapter 9.1 GPIO Control Signals).

If a hysteresis is needed the parameters "Min Speed Start" and "Min Speed Stop" can be used. If those values are set to zero, they will be ignored.

9.2.6 Fan Parameter Description

Table 7. CHx Fan Control Enable

Parameter Name	**Options and Description**
Fan Control Enable	• Disabled • Enabled: Enables the fan controller

Table 8. CHx Fan Temperature Controller

Parameter Name	**Options and Description**
Actual Temperature Source	• External 1: the actual temperature for the temperature controller is taken from the external temperature input 1. • External 2: the actual temperature for the temperature controller is taken from the external temperature input 2. • Device: the actual temperature for the temperature controller is taken from the temperature of the LDD's output stage.
Target Temperature	Target temperature (set point) for the temperature controller
Kp, Ti, Td	PID controller parameters for the temperature controller

Table 9. CHx Fan Temperature Controller

Parameter Name	**Options and Description**
0% Speed	Minimum rotation speed
100% Speed	Maximum rotation speed
Min Speed Start	Minimal speed above which the fan is started
Min Speed Stop	Minimal speed below which the fan is stopped
Kp, Ti, Td	PID controller parameters for the Fan Speed Controller
Bypassing Speed Controller	• Yes: Disables the Fan Speed Controller. "Relative Cooling Power" is written directly to the PWM output. • No: The built-in speed controller is used.
Fan Surveillance	Disables Error 175 (`ERROR_FAN_CONTROL_LIMIT`) and Error 176 (`ERROR_FAN_BLOCKED`) This can be used when no tachometer signal is available.

10 Advanced Output Limit Configuration

Figure 35. Output Limits

There are additional safety limit parameters in the "Advanced" tab section which should be used with caution. In Advanced > Output Limits the following parameters can be found:

Max Nominal Voltage

Defines the maximal voltage applied on the output. This is only an approximation and should always be chosen with sufficient margin. The use-case and load temperature will heavily influence the current that flows at a certain output voltage. For typical applications, it's recommended to define limits using current.

Min Nominal Voltage

Defines the minimal voltage applied on the output. This is only an approximation and should always be chosen with sufficient margin. Testing recommended. Make sure you do not set this value too high since it can quickly lead to a significant overcurrent. Setting this value to zero will disable the minimal nominal voltage limit.

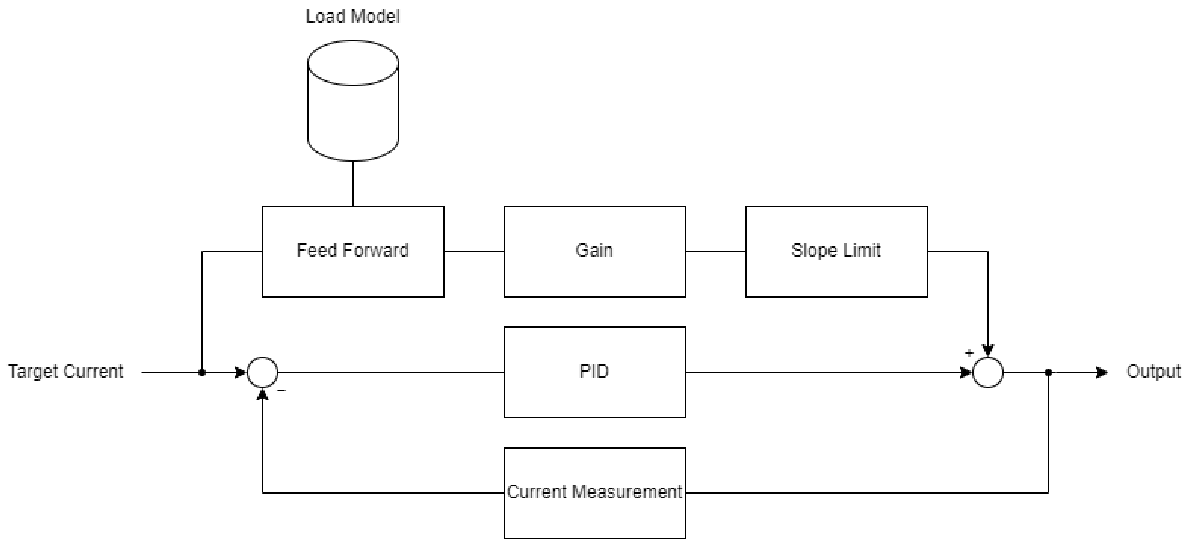
Fast Current Error Threshold

Defines whether parameter 2120 "Current Error Threshold" uses the built-in fast current switch off for the user defined current error threshold. This reduces the switch off time at the cost of accuracy. If this option is disabled the fast switch off will only trigger if the current exceeds a value above the operating area of the device. If enabled it will trigger at the user defined threshold. This requires a larger margin to the current threshold since the accuracy of the threshold value is much lower when using this mechanism instead of the regular error threshold switch off.

11 Feedforward Control

By means of a measured voltage-current-curve, the required output for a requested target current is predicted. The predicted output is immediately applied, which is faster than a PID control loop iterating to the correct output level.

Please read the chapter 11.6 Feedforward Pitfalls before using this feature.



11.1 Load Modeling and Feedforward Prerequisites

This feature requires a software license and a load characterization in CW mode to use. See chapter 12 Feature Unlock for more information about the software license.

11.2 Load Modeling and Feedforward Introduction

For use cases where a very fast rise time is required (<100 μs) it might be necessary to use the much faster feedforward in combination with the PID regulation. In the conventional operation mode the PID is responsible for reaching the initial set point and keeping it stable. The feedforward provides a faster controlling mechanism for highly transient set point values. Instead of slowly making its way up to the set point value, the feedforward requires a previously characterized curve of the load connected to the driver to determine the immediate output signal that needs to be applied. This is a trade-off between flexibility and speed. When used, replacing the LDD or the diode requires a new characterization. Different operating conditions may also require a new characterization.

11.3 Load Model Configuration

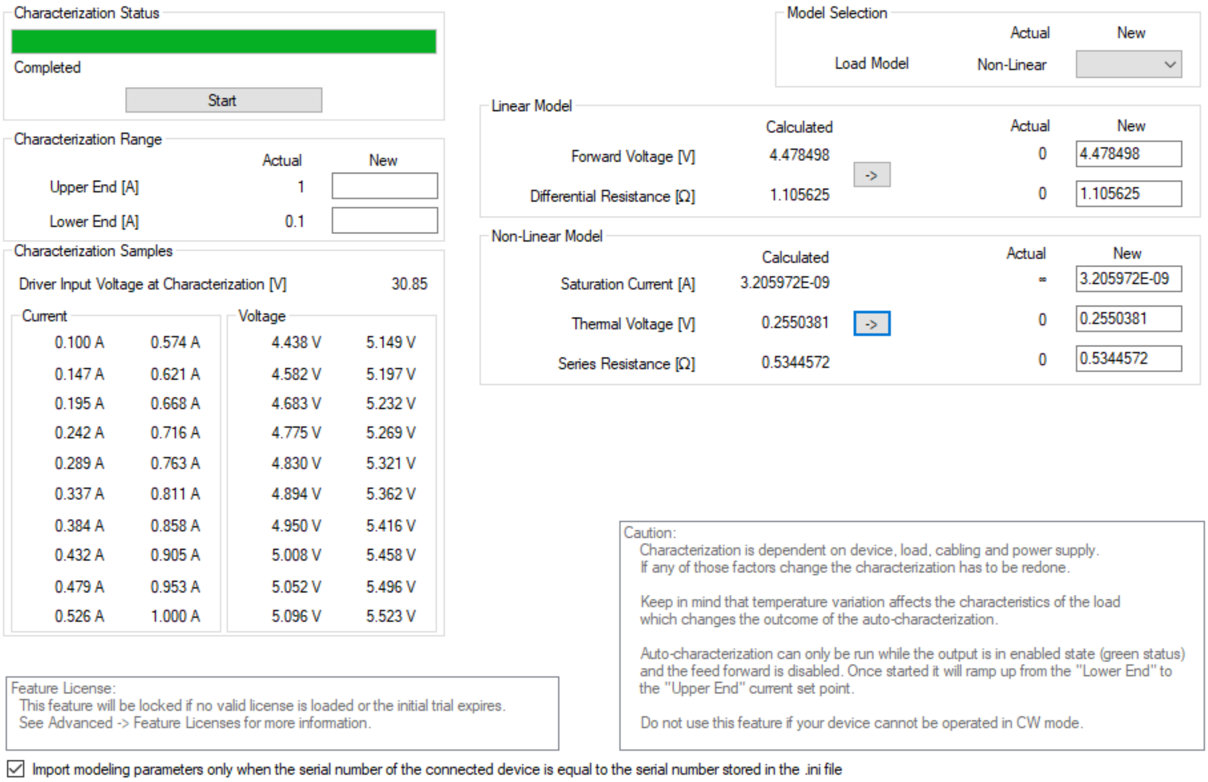


Figure 36. Auto-characterization tab

To use the feedforward the load model parameters have to be set first. To do so you have to run the auto-characterization. The only values that end up being used by the feedforward are either the two parameters of the linear model or the three parameters of the non-linear model depending on which load model is selected. The upper and lower end characterization parameters are only used during the auto-characterization.

11.4 Auto-Characterization

11.4.1 Auto-Characterization Prerequisites

Before starting, please be aware that the auto-characterization process applies a constant wave current to the diode. If your diode cannot operate in CW mode, you cannot use the auto-characterization. In this case, please contact us: support@meerstetter.ch

Furthermore, editing the model parameters manually is not recommended, except for inputting previously calculated values. Also, be aware that the model does not account for dynamic deviations, this is still done by the PID controller.

11.4.2 Auto-Characterization Range

It is recommended to characterize the full operating range you intend to use, however, the model might be able to extrapolate from a partial range as long as the modeling range sufficiently captures the characteristics of the diode. In other words, the model is most accurate when it properly captures the diode characteristics and the full application range.

Set the modeling range by changing the upper and lower end parameters in the auto-characterization tab.

11.4.3Auto-Characterization Step-by-Step

Before starting the auto-characterization, make sure that:

- The LDD is properly set up and that you can drive it to an arbitrary set point.
- The modeling range is set correctly.
- The modeling enable is turned off (requires reset).

Please read the chapter 11.6 Feedforward Pitfalls before using this feature.

Once you have ensured that all conditions above are true, turn on the output in the operating tab and then press start (auto-characterization tab). If an error occurs at any point, follow the error instructions displayed in the service software. Other than that, the auto-characterization should slowly progress, waiting a few seconds at each of the total 20 samples. The samples are displayed as they are gathered. Once the characterization status declares its completion, calculated values should be available and can be applied by pressing the little arrow buttons. Once applied they must be written to the LDD by pressing “Write Config”. Make sure you apply the parameters of the correct model. Once this is done you can use the feedforward.

However please note, the modeling parameters are very sensitive to changes in the operating conditions. Special care must be taken to ensure that the following do not vary too much:

- Input voltage
- Load temperature
- Driver temperature

Please do not change the input voltage once the output is enabled. The input voltage is assumed to stay the same once the output is driven. Consinder that using power cables that are too long and/or thin can lead to variation in the input voltage at increased output power levels.

There are two models available, the linear one and the non-linear one, both referring to the characteristics of voltage versus current. Usually, you want to use the non-linear, which is the one used for diodes. The linear one is meant for linear loads like resistors.

The linear model parameters only apply when the linear model is selected, likewise, the non-linear model parameters only apply when the non-linear model is selected.

The samples and the driver input voltage at modelization are stored within volatile memory until the next reset, while the model parameters are stored in persistent flash memory. A new characterization is required when changing the input voltage by more than approximately 5%, otherwise the accuracy of the feedforward might be negatively affected.

11.5 Feedforward Configuration

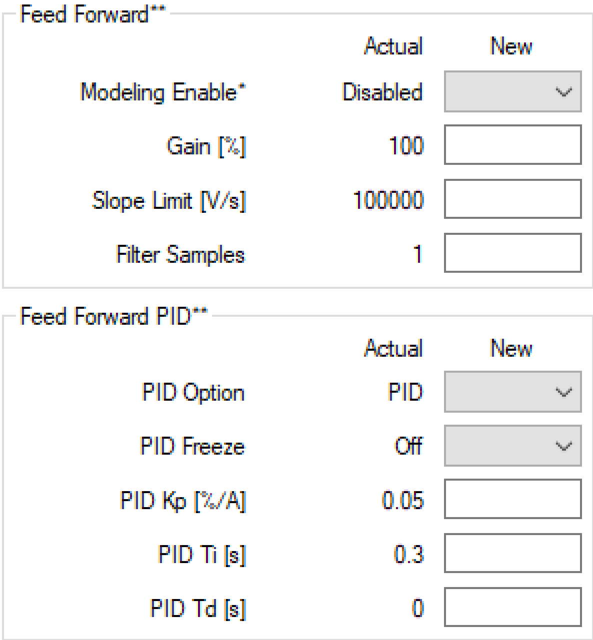


Figure 37. Feedforward Configuration

Modeling Enable
This parameter specifies whether the feedforward is used, if disabled the feedforward and diode model are not used. When enabled, none of the regular PID settings are used, including the slope limit. “Modeling Enable” must be disabled before starting a new auto-characterization. This parameter requires a reset for changes to take effect.

Gain
Only change the gain if changing the slope limit does not yield the desired results. Gain scales the output of the feedforward before it is applied. Gain can be 100% with low inductivity/low capacitive loads (should not have any overshoot) otherwise a value slightly below 100% may be better. It is generally a good idea to work your way towards the optimal settings in slow incremental steps. Keep in mind the gain defines the output voltage in percent, use smaller steps on high voltage outputs.

Slope Limit
Make sure to not set the slope limit too high. The slope limit is the main parameter to change to avoid overshoots of the feed forward. The slope limit is defined in volts per seconds instead of ampere per seconds like the regular slope limit. The reason for that is because the feedforward, unlike the PID, does not operate on the basis of feedback from the current measurement which is what makes it a lot faster. The default 100000 volts per second might be too slow depending on your use case. This is equal to 1 volt per 10 µs. To reach 20 volts this would take 200 µs, which is quite slow in terms of feedforward speed. The feedforward can usually achieve risetimes below 100 µs, in optimal situations even below 10 µs. In fact, depending on the load, 200 µs risetimes are achievable using the regular PID controller.

PID Option
Due to implementation details of the PID regulation, setting Kp to zero is not possible. Instead this option provides a way to use a pure I controller which can be useful in combination with the feedforward regulation.

PID Freeze
By default the PID (or I) controller always runs when the output is enabled. This may not be

desirable depending on how the feedforward is used. In case the PID controller is enabled during a steep slope it is possible that it oversteers causing an overshoot (the PID acts on top of the feedforward). This can be prevented by freezing the PID while the feedforward is actively changing the output level. This parameter has 3 options. Off, to always run the PID, On, to disable the PID during the feedforward phase, and reset. The last option resets the PID to its initial state in addition to freezing while the feedforward output is changing. This is useful for example when operating a square wave and the PID state during the low phase cannot be applied during the high phase.

PID Kp, Ti and Td
The PID parameters of the feedforward behave just as the regular PID parameters, refer to chapter 3.2.2 Current Controller Settings for more information. Please note that you cannot just copy the normal PID parameters for feedforward operation, usually the feedforward PID has to be much slower since it starts at approximately the forward voltage of the diode load and should only be used to balance out the dynamic deviations in the system (e.g. temperature).

Please note that it is not advisable to use a fast PID parameter set with the feedforward system. The PID is supposed to even out small errors since the feedforward already moves the output to the forward voltage of the load.

11.6 Feedforward Pitfalls

When compared to regular PID operation, using the feedforward PID is harder and more error prone. To mitigate the risk of causing damage (to the load, the LDD is pretty resilient and well protected) you should carefully read the user manual before configuring and operating the feedforward, and understand the feature using a test load.

The accuracy of the feedforward depends on the exact repeatability of the operating conditions of the device. This also includes the operating temperature of the load. A possible mistake is characterizing the diode load in a cold state right after powering up. It is advisable to run the auto-characterization at roughly the same temperature as it will run in real operation. A hot diode usually draws more current at lower voltages. This means:

Condition	Result
Diode runs hotter in use than during characterization	Feedforward too high: overcurrent possible
Diode runs colder in use than during characterization	Feedforward too low: may not achieve required risetime

Since the feedforward regulation brings the LDD and the circuitry surrounding it to its limits, it is important to consider proper wiring. The inductance and stray capacitance in the laser current path is going to oppose and slow down every change in current initiated by the LDD, this can lead to overshoot issues when using the feedforward. For this reason, make sure to keep wire length short and twist the wires to minimize inductance.

11.7 Feedforward FAQ

11.7.1 Signal Generator couldn’t reach low value

This might happen if you characterized the diode in a cold state. In this case the feedforward might apply a higher voltage to achieve the desired current since the characterization curve will be slightly too high.

If you are not satisfied with the results of the feedforward it is recommended to first rerun the characterization before tuning the PID. Tuning the PID is error prone and could lead to damage of your laser diode. Furthermore, it is important to note that you cannot just copy the PID settings you have used without the feedforward as they are most likely too fast, this is why there are separate settings.

11.7.2 Pulsed Auto-Characterization

No pulsed auto-characterization is available at time of writing this, if this is a feature you are interested in because the alternatives are not viable for you then please contact us (support@meerstetter.ch) so we can evaluate whether there is demand for this. Some diodes allow characterization at lower currents in CW, the extrapolated data might be usable, given the right model is selected, usually non-linear when working with diodes.

11.7.3 Characterization Invalid

In some cases, the LDD will show a characterization invalid error. If this occurs increase the modeling range and try again.

Furthermore, it is possible that the auto-characterization yields a negative series resistance. This usually means that the modeling range is too small. The resulting load model might not be accurate, especially outside of the characterized range. The service software will warn you if you attempt to apply auto-characterization values in this case.

12 Feature Unlock

Additional software features can be permanently unlocked by loading a license onto the device. All features are available for a trial period after purchase. Licenses can be acquired from Meerstetter Engineering; the license itself is a text string which must be copied into the license field in the feature unlock tab.

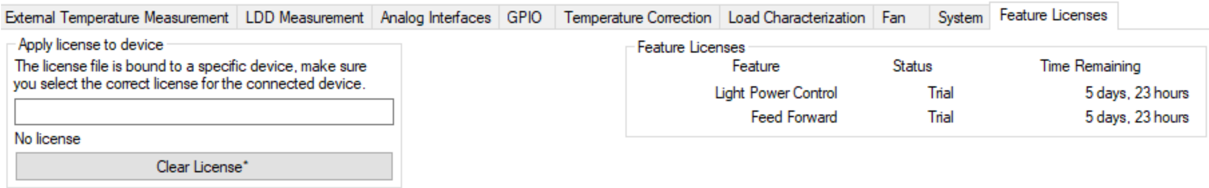


Figure 38. Feature Unlock tab

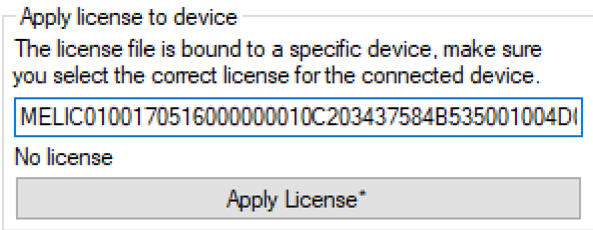


Figure 39. Filled license field

Once you have copied the license into the license field, press the “Apply License” button to apply the license. The license will be applied after a reset and the listed feature licenses should reflect this.

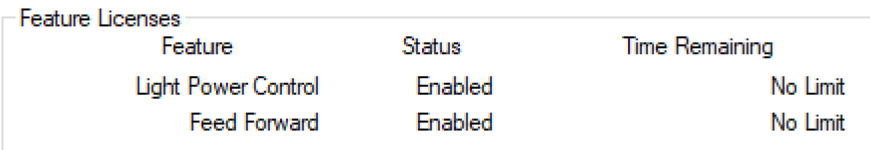


Figure 40. Enabled feature after applying license

The license is only valid for one specific device, make sure you provide the correct information: the serial number and device type uniquely identify a device. If the license does not match the device, it will not work. Pay close attention to the license status if the expected features are not enabled after loading a license.

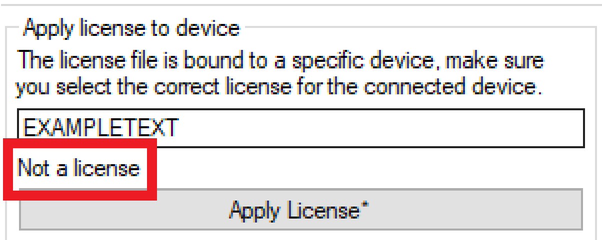


Figure 41. A text which does not form a valid license was loaded onto the device

12.1 LPC Feature Unlock Migration

The light power control (LPC) feature can be loaded via a software license. Please note that not all devices are eligible for this software license. Older devices without the -LPC? product string require a hardware upgrade before the LPC feature can be used. Devices which were bought with the LPC option before software licenses were introduced are eligible for a free license. Please contact Meerstetter Engineering support@meerstetter.ch if you bought your device with the LPC option and wish to use a firmware version greater or equal to 2.20.

13 Special Functions

13.1 Parameter Handling

13.1.1 Settings Dump (.mepar File) with the Service Software

In cases where many or all settings of a LDD-130x device are to be changed from a host software or a host microcontroller, a settings dump function is available. This generates a file which can be dumped to a LDD-130x using third party host systems.

- Every parameter which is labeled with “New”, that contains information will be stored in the .mepar file.
- In the “Maintenance” tab click “Create File” in the box “Create *.mepar file (for Settings Dump)”.

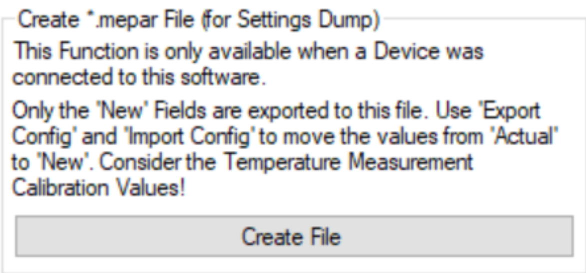


Figure 42. Settings Dump.

- For every parameter stored in the .mepar file, a line contains the parameter string that is specific to function, firmware and device type.
- Using the MeCom communication protocol, the .mepar file can be sent 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 the Service Software to a device.
- Copy a line from the file and paste it in the field. Click “Send String”.

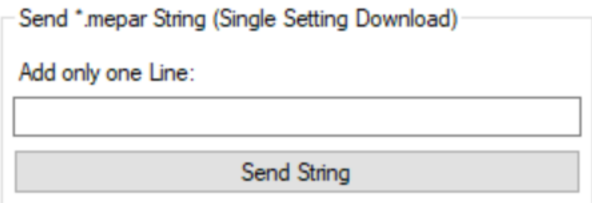


Figure 43. Single Setting Download.

14 Troubleshooting and Errors

14.1 Quick Reference

Table 10. Typical Problems

Problems	Possible Reason	Possible Solution
The Service Software is not starting	The Service Software does not work with 64-bit versions of Microsoft Visual C++ 2015 Redistributable Package	Make sure that the correct version (32-bit) of Microsoft Visual C++ 2015 Redistributable Package is installed.
The output is suddenly switched off	An error happened.	Check the error message in the "Monitor" tab.
The firmware is too old	The firmware is too old to connect to the Service Software.	Please update the firmware as described in 2.3 Firmware Updates .
Error 105 shows up while the output current is rising.	1303: The input voltage is insufficient to reach the voltage necessary to drive the set current. 1301: Possibly Hardware Damage	Check if the voltage requirements on the datasheet are respected and ensure that the output power of your supply is sufficient to avoid voltage drops.
Error 103	• The input voltage is insufficient. • The PID controller is set up too aggressively or incorrectly	
Error 102	Load with too low compliance voltage is used or short-circuit at output.	Check Load for short-circuit or load with higher compliance voltage.

14.2 Error Numbers, Instances and Parameters

- Error Numbers from 1 through 99, excluding 30 through 39, designate error conditions that are universal across the whole range of Meerstetter TEC Controllers and laser diode drivers.
  Error numbers starting from 100 designate conditions that are specific to LDD-130x devices (see tables below).
- Error Instance can designate the involved instance of a functionality or be useful information for Meerstetter Engineering technical support.
- Error Parameters are additional information to help Meerstetter Engineering technical support in the processes of error diagnosis or remote debugging.

14.2.1 Error Numbers 1 – 99 (universal)

Table 11. Processor Errors

#	Description	Error Condition
1-10 13-15	MCU system malfunction	-

Table 12. HMI Errors

#	Description	Error Condition
11	Emergency stop was triggered by LTR-1200	-
12	LTR-1200 HMI regularly sends ‘free’ signals to all rack-internal devices such that they can activate their output stages (if enabled)	No signal received for more than one second

Table 13. Parameter System Errors

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

Table 14. Power Supply Errors

#	Description	Error Condition
30	Input voltage net too low	< 10.5 V
31	Input voltage net too high	> 63 V (for HW version ≥ v1.20) > 55 V (for HW version < v1.20)
32	Internal 12 V power net too low	< 10.7 V
33	Internal 12 V power net too high	> 13.5 V
34	Internal 5 V power net too low	< 4.7 V
35	Internal 5 V power net too high	> 5.25 V
36	Internal 3.3 V power net too low	< 3.1 V
37	Internal 3.3 V power net too high	> 3.5 V
38	Internal −5 V power net too low	< −6 V
39	Internal −5 V power net too high	> −4 V

Table 15. Flash Memory Errors

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

Table 16. Communication Error

#	Description	Error Condition
53	UART send buffer overflow error	-
54	CANopen internal error	-

Table 17. Device Temperature and Hardware Errors

#	Description	Error Condition
60	Device running too hot	See datasheet.
61	Communication error with I/O hardware during factory test	-

14.2.2Error Numbers 100 - ... (specific to LDD-130x devices)

Table 18. Power Output Errors

#	Description	Error Condition
100	Output overcurrent	> “Current Error Threshold”
101	Output overvoltage	> “Voltage Error Threshold”
102	PID lower limit error	Too long in lower limitation (0, 0.1 % margin) and Output current > 0.05 A
103	PID upper limit error	Too long in upper limitation (0.96, 0.1 % margin)
104	Fast switchoff output overcurrent error	Device overcurrent
105	Input overcurrent	> 57 A, > 500 ms
110	Interlock error	Interlock low If you are not using the interlock connector, this function can be disabled via the DIP switch.

Table 19. Current Measurement Errors

#	Description	Error Condition
120	Phase current measurement offset too high.	-
121	Phase current measurement offset too low.	-

Table 20. Internal Power Stage Errors

#	Description	Error Condition
130	Excessive phase asymmetry	-
131	Measured and calculated output currents too different	-

Table 21. External Temperature Measurement Errors

#	Description	Error Condition
140	12bit ADC raw value below safety margin	< 40 (1%)
141	12bit ADC raw value above safety margin	> 4050 (99%)
142	Measured temperature too low	< “Lower Error Threshold”
143	Measured temperature too high	> “Upper Error Threshold”

Table 22. Load-Characterization Errors

#	Description	Error Condition
150	Auto-characterization failed: Could not reach the target current in the given time frame.	-
151	Auto-characterization failed: The output must be enabled.	-
152	Auto-characterization failed: Modeling Enable must be turned off.	-
153	Auto-characterization failed: Upper end of the modeling range must be higher than the lower end.	-
154	Auto-characterization failed: Invalid characterization, try using a larger modeling range.	-

Table 23. Feature Unlock Errors

#	Description	Error Condition
160	LPC feature locked: Load a valid license or disable LPC.	-
161	Feedforward feature locked: Load a valid license or disable the feedforward.	-

Table 24. Fan Control Errors

#	Description	Error Condition
175	The fan does not reach the desired rotation speed.	Fan PWM Signal is 100% and the reached Speed is < 60% of the nominal speed for 12 s
176	The fan does not rotate.	Fan Speed = 0 and PWM Level > 35% for 10 s

Table 25. Various Errors

#	Description	Error Condition
183	No package has been received within the specified Watchdog timeout time	-
188	Reset required	Some essential settings are only applied during startup. Please reset the device.

A Change History

Date of change	Version	Changed/ Approved	Change / Reason
20 December 2021	A	RS/HS	• Initial Release
1 April 2022	B	HS/PV	• Error 102 edited • Describe temperature correction function
29 August 2022	C	CU/RS	• Describe the theory of light power control • Light Measurement edited
6 September 2022	D	CU/RS	• Chapter 3, 4 and 5 edited (add auxiliary pictures, detailed text descriptions) • Chapter 6, 7 and 8 edited (auxiliary pictures added)
23 September 2022	E	ML/CU	• Add CANopen to the overview picture • Add Capture 2.2.3 CANopen
15 March 2023		CU/RS	• Document and firmware version updated • Picture of the CANOpen interface added • Picture of the power controller settings updated and the unit of the PID Kp value corrected in chapter 4 • Error condition of the error number 31 corrected to 63V for the newer HW versions • Quick References restored because confused information was included • Pictures new updated
25 June 2024	F	SC/RS	• Add: Signal Generator section • Add: Lookup Table section • Mod: GPIO function list updated • Add: Cooling Fans section • Mod: removed all mentions of volatile parameters
16 October 2024	G	SC/RS	• Removed all mentions of the GPIO option for the Output Enable. • Removed “static” terminology where it no longer applies.
27 February 2024	H	SC/RS	• Add: Feedforward/Load Modeling section • Add: Feature Unlock section • Upd: Error List