LASER COMPONENTS

Digital Laser Driver with Communication via USB or RS-232

LASER COMPONENTS now offers a digital laser driver with a microcontroller for a selected laser module series. The new digital driver makes it possible to interface with the laser module using RS-232 or USB. Using digital communication, the laser module can be monitored and controlled. Even major operational settings such as output power and dimming, trigger, pulsing, and modulation can be programmed by the customer.

The monitoring features include the operating time of the system, the temperature inside the module, the laser diode current, and many more. These parameters help the customer detect aging of the laser module and consequently carry out proactive maintenance to prevent downtime of the production line.

The use of a microcontroller also ensures outstanding output power stability, as well as exceptional linearity in analog output power adjustment versus control voltage.

1. RS-232 Interface

1.1. Connection of Digital Lasers: The standard interface is an 8-pole cable.

Description	Comments (including maximum rating)	Cable color
V_{IN}	Operating voltage: 4.5 V (–10%) ≤ V_{IN} ≤ 30 V (+10%)	Red
V_{Dim}	Dimming voltage: 0 V (–0.5 V) ≤ V_{Dim} ≤ 5 V (+0.5 V)	White
$V_{Modulation}$	Modulation input (trigger): $V_{Modulation}$ is TTL Logic: 1 (high) ≙ +2 V to +5.3 V 0 (low) ≙ –0.3 V to 0.8 V The modulation input can be used for digital modulation with an internal trigger source as its output for synchronization purposes.	Green
RxD	RS-232	Yellow
TxD		Orange
C2CK	Internal use only	Blue
C2D		Brown
GND	Ground	Black

Table 1: Cable assignment / Connection of laser with RS-232

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1.2. Setting of the Serial Interface in the Terminal Program:

A driver does not have to be installed for the RS-232 interface.

Setting up serial port	
Port	COM
Baud rate	115200
Data	8 bit
Parity	none
Stop	1 bit
Flow Control	none

Table 2: Serial port

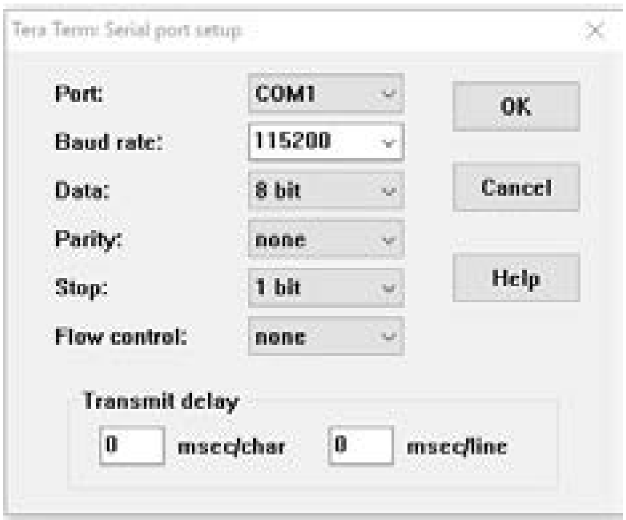

Figure 1: Example of Tera Term

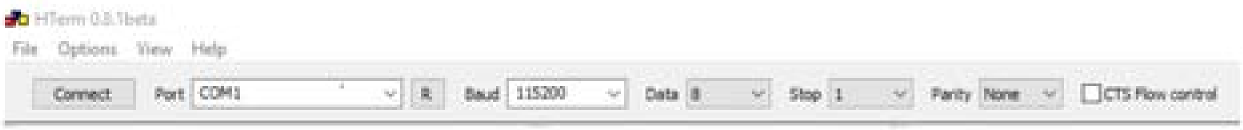

Figure 2: Example of HTerm

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1.3. Settings for Receiving and Sending Data:

Terminal Setup	
Receive	CR
Transmit	CR

Table 3: Setting for CR transmission

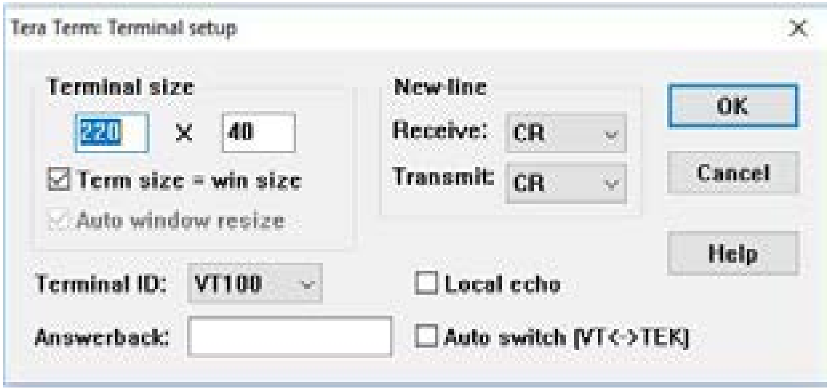

Figure 3: Example of Tera Term

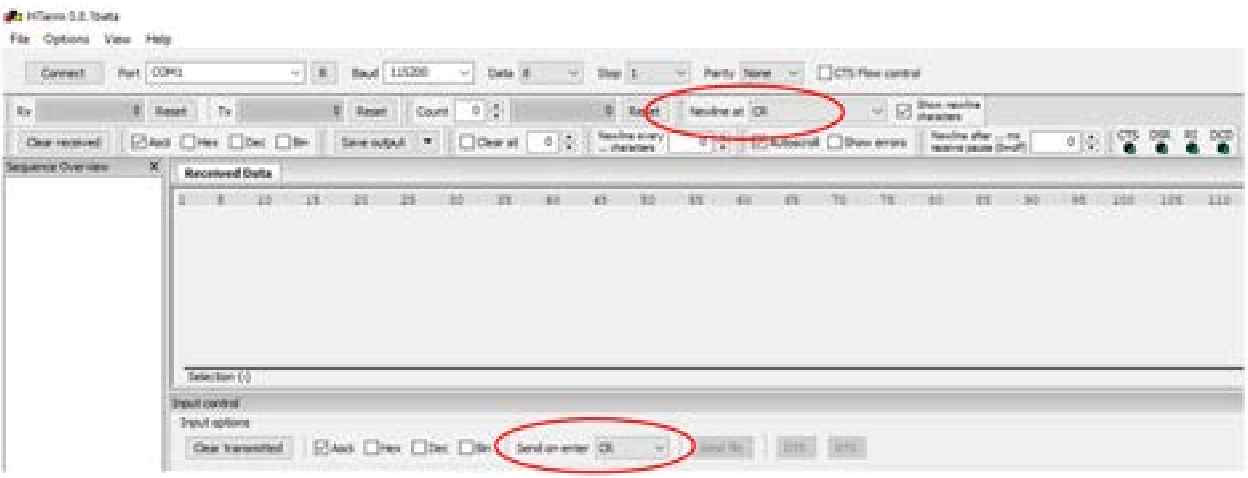

Figure 4: Example of HTerm

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After successful initialization of the serial interface, the module is started by applying the operating voltage V_{IN} and then signals via the COM port as follows:

```
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    Digital-Laser-Driver 2v1
```

1.4. Data Transmission via RS-232:

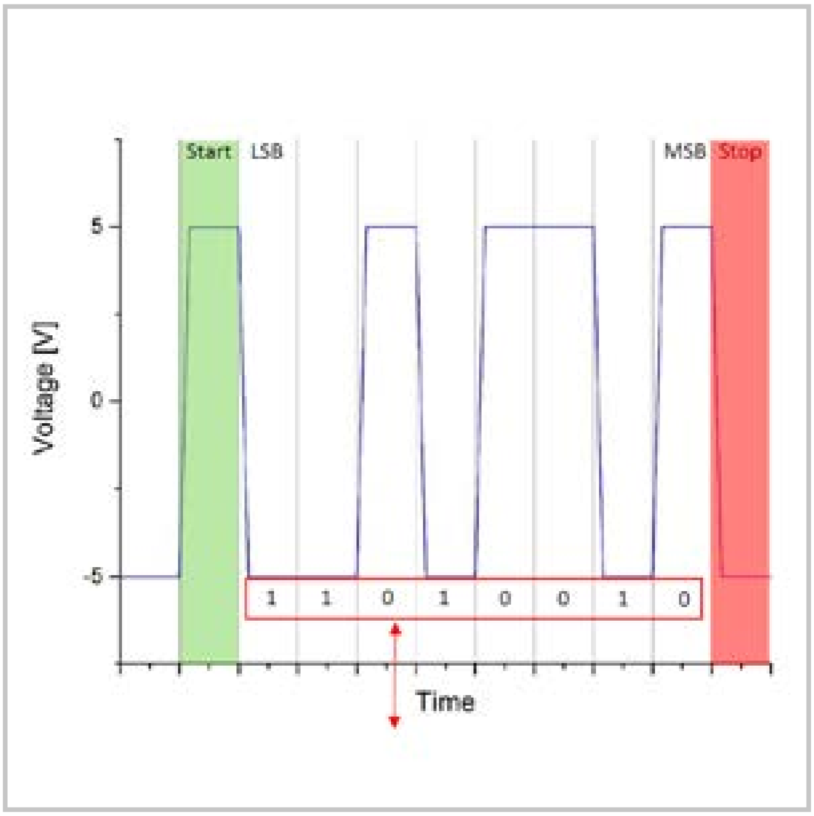

Figure 5: Transmitted byte: 0100 1011 (0x4B corresponds to ASCII: K)

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1.5. Commands

<table>
<tr><th>Command</th><th>Parameter</th><th>Description</th></tr>
<tr><td>trig</td><td>x</td><td>Digital modulation
This command determines at which modulation voltage the laser is active.
<table>
<tr><th>x</th><th>Mode</th></tr>
<tr><td>1</td><td>Low active</td></tr>
<tr><td>2</td><td>High active</td></tr>
</table>
It is important that:
1. The modulation input be set to GND via a pull-down resistor so that when the modulation voltage is not connected, the input is “low.” This results in the laser being active at the “low active” setting and inactive at the “high active” setting.
2. This setting affects the operation of the digital modulation with an internal trigger source (see “duty” command).

Chapter 2.6 describes digital modulation with external triggers in more detail.</td></tr>
<tr><td rowspan="2">dima</td><td rowspan="2">x y z</td><td>Analog Dimming
This command defines the voltage range for dimming with an external analog voltage V_{Dim}. The parameters x and y define the upper and lower voltage of the control range. The values of the parameters must be given in 1/10 V, which results, for example, in 10 $\triangleq$1.0 V. The following applies to x and y:
$x,y \in \mathbb{Z}, \{x,y \mid [0, 50]\}$
The parameter z for setting the active range. The following applies:
<table>
<tr><th>Z</th><th>Mode</th></tr>
<tr><td>1</td><td>Low active</td></tr>
<tr><td>2</td><td>High active</td></tr>
</table></td></tr>
<tr><td>Example “dima 50 0 1”
The laser is dimmable with an external voltage (V_{Dim}) in the range of 0.0 V to 5.0 V. Dimming is “low active”, i.e. at $V_{Dim} \geq 5.0$ V the laser is off, and at $U_{Dim} \leq 0.0$ V the laser lights up with maximum power. In the range of 5.0 V > U_{Dim} > 0.0 V, the power is dimmed linearly (see also chapter 2.7).</td></tr>
</table>

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<table>
<tr><th>Command</th><th>Parameter</th><th>Description</th></tr>
<tr><td rowspan="2">dimp</td><td rowspan="2">x</td><td>Digital Dimming
The output power of the laser is calculated according to:
$$P_{Opt} = P_{Opt\_max} \cdot \left(\frac{x}{1000}\right)$$
$$x \in \mathbb{Z}, \{x \mid [0,\ 1000]\}$$
Dimming is carried out by reducing the current flowing through the laser diode. This is <u>not</u> a reduction of the laser power with the help of pulse width modulation (PWM). The value that results from digital dimming is stored on the EEPROM.</td></tr>
<tr><td>Example:
"dimp 500" results in an optical output power which is half the maximum possible laser power (see also chapters 2.8 and 1).</td></tr>
<tr><td rowspan="2">duty</td><td rowspan="2">x y</td><td>Digital modulation with internal trigger:
With the "duty" command, the duty cycle for autonomous pulses and the trigger frequency can be defined. This special form of digital modulation is referred to as PWM.
The duty cycle is determined by the parameter x.
$$x \in \mathbb{Z}, \{x \mid [0,\ 100]\}$$
The frequency can be set by parameter y as follows:
<table><tr><th>Y</th><th>Frequency</th></tr><tr><td>1</td><td>382.8 kHz</td></tr><tr><td>2</td><td>95.7 kHz</td></tr><tr><td>4</td><td>31.9 kHz</td></tr></table>
With the command "duty 0" the internal trigger function is deactivated.</td></tr>
<tr><td>Example:
The command "duty 50 1" generates a duty cycle of 50% at a frequency of 382.8 kHz.
$$t_{ON} = t_{OFF} = 1.3\ \mu s.$$
(See also chapter 1.6.)</td></tr>
<tr><td>powL</td><td>-</td><td>Displays present laser power [mW].</td></tr>
<tr><td>mon1</td><td>-</td><td>Reflects present laser status using the following parameters:
- Supply voltage V_B [V]
- Internal voltage V_{CC} [V]
- Monitor current [µA]
- Laser diode current [mA]
Displays values continuously and can be terminated by pressing the 'esc' button.</td></tr>
<tr><td>temp</td><td>-</td><td>Displays present temperature in the laser module [°C].</td></tr>
<tr><td>time</td><td>-</td><td>Displays present laser runtime in days, hours, and minutes.</td></tr>
</table>

Command	Parameter	Description
lasc	-	Displays present current running through the laser diode [mA].
gmax	-	Displays the laser module's extreme values that occur during operation. The readout contains: - Maximum temperature in the laser module [°C] - Minimum temperature in the laser module [°C] - Maximum laser current [mA] - Maximum internal operational [V] - Maximum external supply voltage [V] - Maximum monitor diode current [uA]
IDLa	-	Displays the laser module's serial number and part number.

Table 4: RS-232 commands

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1.6. Digital Modulation with External Trigger

The "trig x" command is used to set the operating mode of the digital modulation. There are two operating modes:

x	Mode
1	Low active
2	High active

Table 5: Operating modes of the digital modulation

The TTL logic for digital modulation with an external trigger source of $V_{Modulation}$ is as follows:

$V_{Modulation}$	State
–0.3 V bis +0.8 V	Low
2.0 bis 5.3 V	High

Table 6: Definition of state of logic

The output of the laser corresponds as follows:

$V_{Modulation}$	State	Laser	
		Low active	High active
–0.3 V to +0.8 V	Low	on	off
2.0 to 5.3 V	High	off	on

Table 7: Definition of state of laser

For voltages of 0.8 V < $V_{Modulation}$ < 2.0 V, the state of the laser is not defined.
The frequency and duty cycle are determined by the external modulation voltage $V_{Modulation}$.

In order to obtain reasonable pulses, the following values should be taken into account:

- Maximum frequency f_{Max} = 3 MHz
- Minimum pulse width t_{ON_min} = 200 ns

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1.7. Analog Dimming with External Dimming Voltage

The command "dima x y z" defines the analog dimming function. The parameters x and y define the upper and lower voltage limits within which the output power of the laser is changed linearly. The parameter z defines at which of the two limits the laser either no longer emits or emits at full power.

The functionality is to be shown on the basis of four examples:

- Examples 1 and 2:

  - Example 1: dima 50 0 1
    - "dima" stands for "analog dimming"
    - "50" stands for the upper voltage limit 50/10 V = 5.0 V at which the laser should be off.
    - "0" stands for the lower voltage limit 0/10 V = 0.0 V at which the laser is at full power.
    - "1" stands for dimming mode; "1" ≙ "low active".

V_{Dim} [V]	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
P_{Opt} [mW]	20.0	18.1	16.1	14	12	9.9	7.8	5.7	3.6	1.4	0.0

Table 8: Measured values for analog dimming ("low active")

  - Example 2: dima 50 0 2
    - "dima" stands for "analog dimming"
    - "50" stands for the upper voltage limit 50/10 V = 5.0 V at which the laser is at full power.
    - "0" stands for the lower voltage limit 0/10 V = 0.0 V at which the laser should be off.
    - "2" stands for dimming mode; "2" ≙ "high active".

V_{Dim} [V]	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
P_{Opt} [mW]	0.0	1.5	3.7	5.8	8.0	9.9	12.2	14.2	16.2	18.0	20.0

Table 9: Analog dimming ("high active")

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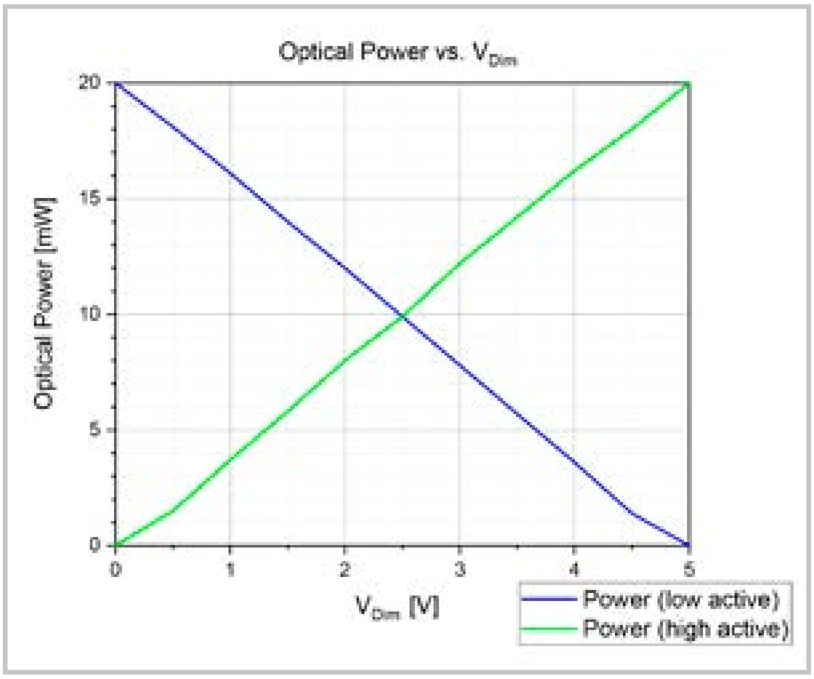

Figure 6: Analog dimming

- Examples 3 and 4:

  - Example 3: dima 40 20 1
    - "dima" stands for "analog dimming"
    - "40" stands for the upper voltage limit 40/10 V = 4.0 V at which the laser should be off.
    - "20" stands for the lower voltage limit 20/10 V = 2.0 V at which the laser is at full power.
    - "1" stands for dimming mode; "1" ≙ "low active".

V_{Dim} [V]	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
P_{Opt} [mW]	20.0	20.0	20.0	20.0	20.0	15.3	10.2	4.7	0.0	0.0	0.0

Table 10: Measured values for analog dimming ("low active")

  - Example 4: dima 40 20 2
    - "dima" stands for "analog dimming"
    - "40" stands for the upper voltage limit 40/10 V = 4.0 V at which the laser is at full power.
    - "20" stands for the lower voltage limit 20/10 V = 2.0 V at which the laser should be off.
    - "2" stands for dimming mode; "2" ≙ "high active".

V_{Dim} [V]	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
P_{Opt} [mW]	0.0	0.0	0.0	0.0	0.0	4.4	10.1	15.3	20.0	20.0	20.0

Table 11: Analog dimming ("high active")

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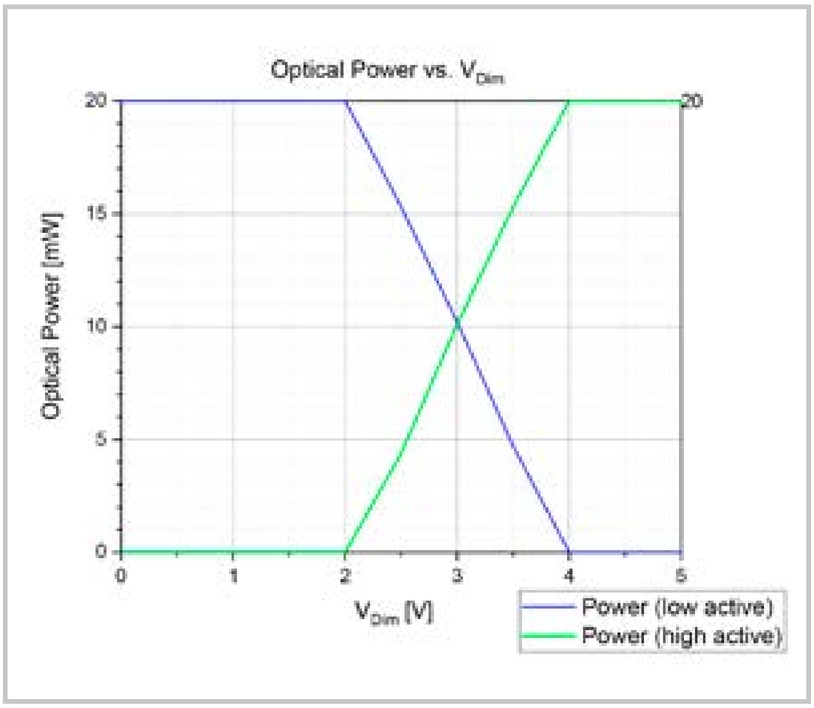

Figure 7: Analog dimming

1.8. Digital Dimming

Digital dimming via the command "dimp x" works in the same way as a laser with a USB interface. Therefore, please refer to chapter 2.5

1.9. Digitale Modulation with an Internal Trigger Source

Digital modulation with an internal trigger source via the command "duty x y" corresponds to the digital modulation of a laser with a USB interface. Therefore, please refer to chapter 2.6 for detailed information on operation and setting options.

In addition, the $V_{Modulation}$ connection on the laser with an RS-232 interface allows the internal trigger signal to be tapped for synchronization purposes.

<u>Important:</u>
The trigger voltage should be tapped via a high-impedance termination (e.g., 1 MΩ).
When terminated with 1 MΩ, the amplitude of the trigger signal is approximately 4.7 V.

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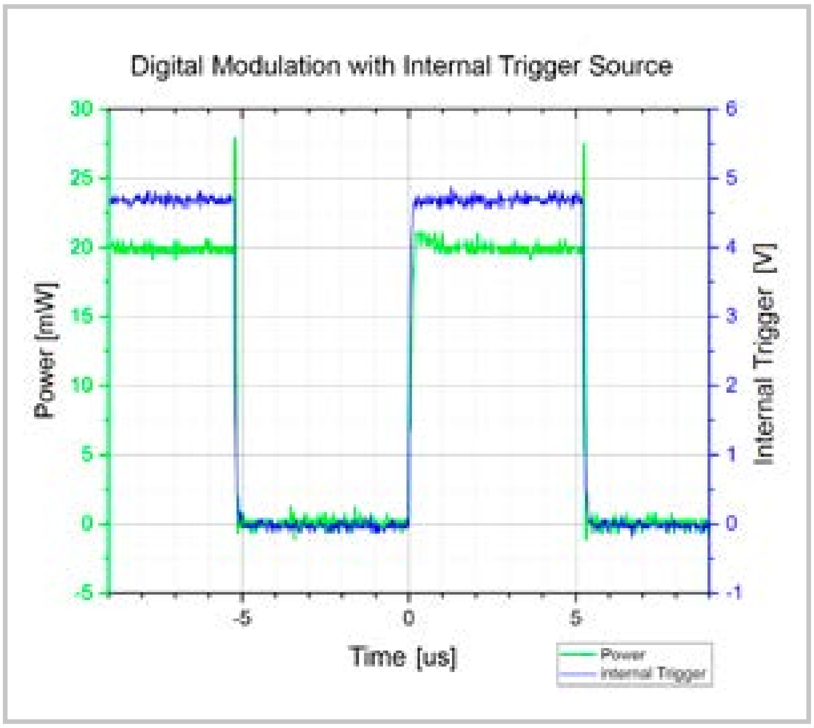

Figure 8: Digital modulation "duty 50 2": f = 95.7 kHz; duty = 50%; t_{Delay} = 20 ns

1.10. Combination Options

The possibilities of combining modulation with dimming are shown below:

Modulation with	Dimming
External source	analog (dima)
	digital (dimp)
Internal trigger source (duty)	analog (dima)
	digital (dimp)

Table 12: Analog dimming ("high active")

<u>Important:</u>
Only one type of modulation and only one type of dimming can be active at any one time.

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2. USB Interface

2.1. Description of the Interface

In contrast to a laser with an RS-232 interface, a laser with a USB interface has only one USB type A connector with four pins.

PIN	Signal	Description
1	V_{BUS}	+5 V supply voltage
2	D-	Data USB 2.0, differential pair -/+
3	D+	
4	GND	Mass

Table 13: PIN assignment of USB 2.0 type A connector

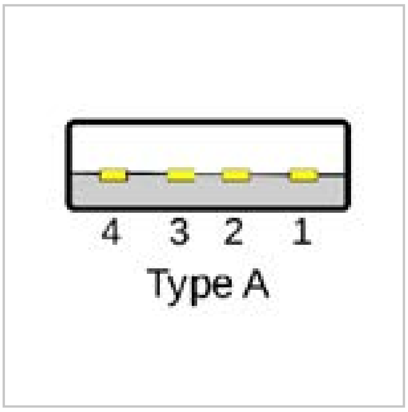

Figure 9:
USB 2.0 type A connector

The driver for the USB interface is automatically searched for by the operating system (e.g., Windows) and then installed. This happens as soon as the module is connected to the USB interface of the computer or a hub connected to the computer. If this is not the case, the driver can be downloaded under the following link and installed manually:

Driver software: http://www.ftdichip.com/Products/ICs/FT231X.html

After successful installation, a new COM port is listed in the device manager. Communication with the laser can take place via this serial interface.

2.2. Setting up the Interface in the Terminal Program:

Serial port settings	
Port	COM
Baud rate	115200
Data	8 bit
Parity	None
Stop	1 bit
Flow Control	None

Table 14: Serial port

10/18 / V01 / IF / manuals/laser-modules/digital-laser-driver

2.2.1. Example of Tera Term:

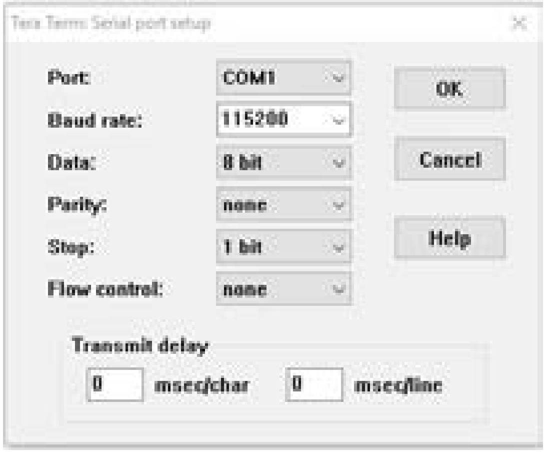

Figure 10: Example of Tera Term

2.2.2. Example of HTerm:

Figure 11: Example of HTerm

2.3. Settings for Receiving and Sending Data:

Terminal Setup	
Receive	CR
Transmit	CR

Table 15: Setting for CR transmission

2.3.1. Example of Tera Term:

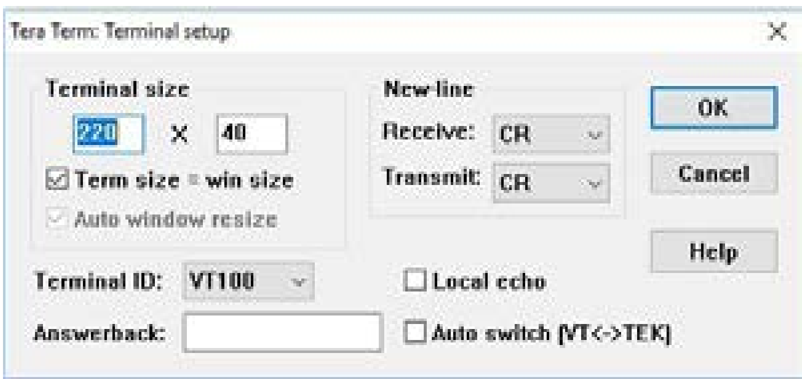

Figure 12: Example of HTerm

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2.3.2. Example of HTerm:

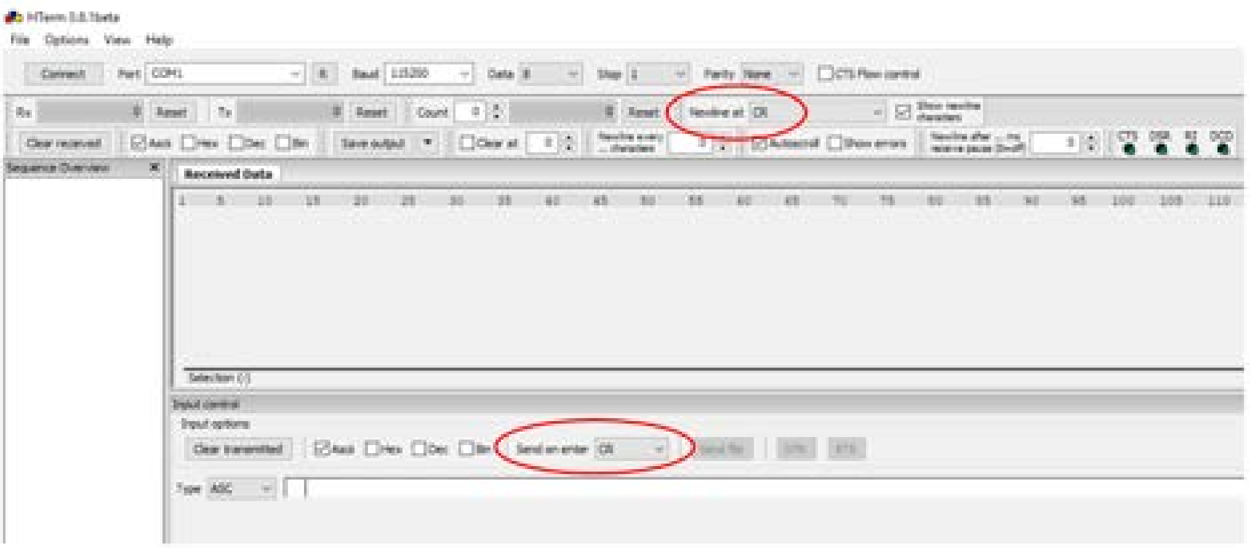

Figure 13: Example of HTerm

2.4. Commands:

Command	Parameter	Description
dimp	x	Digital Dimming The output power of the laser is calculated according to: $P_{Opt} = P_{Opt\_max} \cdot \left(\frac{x}{1000}\right)$ $x \in \mathbb{Z}, \{x \mid [0,\ 1000]\}$ Dimming is carried out by reducing the current flowing through the laser diode. This is <u>not</u> a reduction of the laser power with the help of pulse width modulation (PWM). The value that results from digital dimming is stored on the EEPROM.
		Example: "dimp 500" results in an optical output power which is half the maximum possible laser power (see also chapter 1.5)

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<table>
<tr><th>Command</th><th>Parameter</th><th>Description</th></tr>
<tr><td rowspan="2">duty</td><td rowspan="2">x y</td><td>Autonomous Pulses:
With the “duty” command, the duty cycle for autonomous pulses and the trigger frequency can be defined. This special form of digital modulation is referred to as PWM.
The duty cycle is determined by the parameter x.
$x \in \mathbb{Z}, \{x \mid [0, 100]\}$
The frequency can be set up by parameter y as follows:
<table>
<tr><th>y</th><th>Frequency</th></tr>
<tr><td>1</td><td>382,8 kHz</td></tr>
<tr><td>2</td><td>95,7 kHz</td></tr>
<tr><td>4</td><td>31,9 kHz</td></tr>
</table>
With the command “duty 0” the internal trigger function is deactivated.</td></tr>
<tr><td>Example:
The command “duty 50 1” generates a duty cycle of 50% at a frequency of 382.8 kHz.
$t_{ON} = t_{OFF} = 1.3$ µs.
(See also chapter 2.6.)</td></tr>
<tr><td>powL</td><td>-</td><td>Displays present laser power [mW].</td></tr>
<tr><td>mon1</td><td>-</td><td>Reflects present laser status using the following parameters:
- Supply voltage V_B [V]
- Internal voltage V_{CC} [V]
- Monitor current [µA]
- Laser diode current [mA]
Displays values continuously and can be terminated by pressing the ‘esc’ button</td></tr>
<tr><td>temp</td><td>-</td><td>Displays present temperature in the laser module [°C].</td></tr>
<tr><td>time</td><td>-</td><td>Displays present laser runtime in days, hours, and minutes.</td></tr>
<tr><td>lasc</td><td>-</td><td>Displays present current running through the laser diode [mA].</td></tr>
<tr><td>gmax</td><td>-</td><td>Displays the laser module’s extreme values that occur during operation.
The readout contains:
- Maximum temperature in the laser module [°C]
- Minimum temperature in the laser module [°C]
- Maximum laser current [mA]
- Maximum internal operational voltage [V]
- Maximum external supply voltage [V]
- Maximum monitor diode current [uA]</td></tr>
<tr><td>IDLa</td><td>-</td><td>Displays the laser module’s serial number and part number.</td></tr>
</table>

Table 16: USB commands

10/18 / V01 / IF / manuals/laser-modules/digital-laser-driver

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2.5. Digital Dimming

The laser power of the laser module can be adjusted with the help of the command "dimp x." PWM is not used for this purpose. Rather, the power is regulated by the current of the laser diode.

The output power of the laser is calculated according to:

$$P_{Opt} = P_{Opt\_max} \cdot \left(\frac{x}{1000}\right)$$

Example:
A laser with P_{Opt_max} = 20 mW receives the command "dimp 500," which results in the reduced output power P_{Opt} as follows:

$$P_{Opt} = P_{Opt\_max} \cdot \left(\frac{x}{1000}\right) = 20\ \text{mW} \cdot \left(\frac{500}{1000}\right) = 10\ \text{mW}$$

For a laser with P_{Opt_max} = 20 mW, the measured power was assigned to each control command "dimp x" (see Table 17) and then the course of the power over x graphically displayed (see Figure 14).

x	P_{Opt} [mW]	x	P_{Opt} [mW]	x	P_{Opt} [mW]	x	P_{Opt} [mW]
0	0.0	300	5.9	600	12.0	900	18.0
20	0.1	320	6.3	620	12.4	920	18.4
40	0.3	340	6.7	640	12.8	940	18.8
60	0.7	360	7.1	660	13.2	960	19.2
80	1.2	380	7.5	680	13.6	980	19.6
100	1.6	400	7.9	700	14.0	1000	20.0
120	2.0	420	8.4	720	14.4		
140	2.4	440	8.8	740	14.8		
160	2.8	460	9.2	760	15.2		
180	3.3	480	9.6	780	15.6		
200	3.7	500	10.0	800	16.0		
220	4.2	520	10.4	820	16.4		
240	4.6	540	10.8	840	16.8		
260	5.0	560	11.2	860	17.2		
280	5.4	580	11.6	880	17.6		

Table 17: Digital dimming

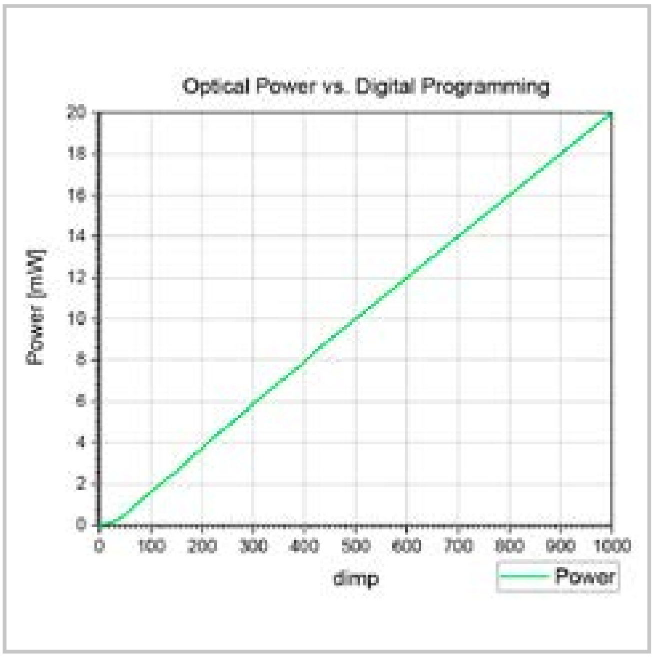

Figure 14: Linearity of digital dimming

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2.6. Digital Modulation

The digital modulation of the USB laser is a PWM with its own trigger source.

The command "duty x y" defines both the duty cycle and the frequency. The parameter x stands for the value of the duty cycle [%], and the parameter y stands for the frequency. There are three frequencies that can be selected with y.

y	Frequency
1	382.8 kHz
2	95.7 kHz
4	31.9 kHz

Table 18: Frequencies of the internal trigger source

Example: duty 50 2
The duty cycle is set to 50% and the trigger frequency to 95.7 kHz. A fast PIN diode displays the emitted laser power as voltage on an scilloscope (see Figure 15).

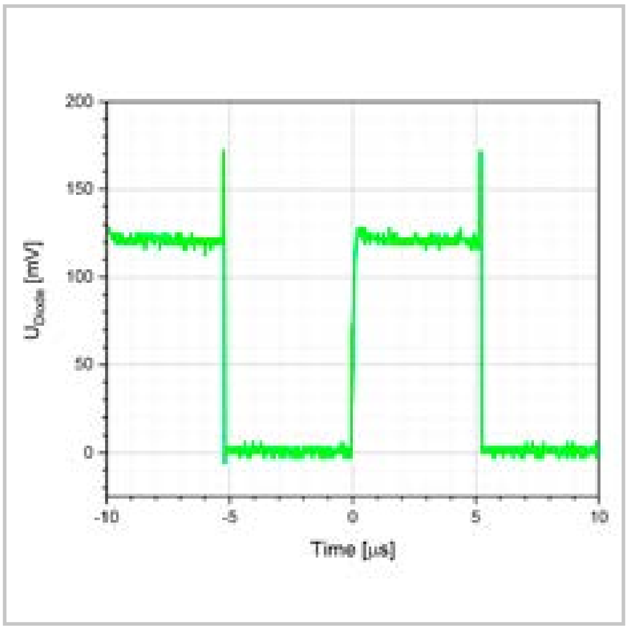

Figure 15: Duty cycle: 50% at f = 95.7 kHz

<u>Important:</u>
The command "duty 0" deactivates the digital modulation with an internal trigger source. This is also the switch-on state of the laser. This means that if the supply voltage is interrupted and reapplied, the digital modulation with an internal trigger source is deactivated.

2.7. Combination of Digital Dimming and Modulation

The two power setting options (1.6 and 1.7) can also be combined. With the command "dimp," the pulse power of the PWM can be adjusted. Thus, not only can the duty cycle and frequency be variably adjusted but the pulse power as well.

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3. Example for Operation of the Laser via USB

Retrieval of information on the current state of the laser via “mon1”:

```
(C)2018 Laser Components GmbH
    Digital-Laser-Driver 2v1

>mon1
```

Input is confirmed via “Enter.” The response is continuous output as in the following:

```
(C)2018 Laser Components GmbH
    Digital-Laser-Driver 2v1

 Supply Voltage: 11.934V, Internal Voltage:  7.91V, Monitor Current:    0 uA, Laser Current:  184 mA
```

With “Esc”, the output is interrupted, and further commands can be entered.
For example, the type of modulation can be changed from “low active” to “high active” with the command “trig 2”.

```
(C)2018 Laser Components GmbH
    Digital-Laser-Driver 2v1

 Supply Voltage: 11.934V, Internal Voltage:  7.91V, Monitor Current:    0 uA, Laser Current:  184 mA

 trig2
```

Input is confirmed again via “Enter”. The following response is produced:

```
(C)2018 Laser Components GmbH
    Digital-Laser-Driver 2v1

 Supply Voltage: 11.934V, Internal Voltage:  7.91V, Monitor Current:    0 uA, Laser Current:  184 mA

  Trigger high aktiv!
```

The running time of the laser can also be retrieved. However, this does not refer to the duration the laser is emitting but rather to the duration the laser is connected to the supply voltage.

For the time query, it is only necessary to enter the “time” command.

```
time
```

After completing the task by pressing “Enter”, you obtain the following response:

```
>        0 d     0 h    39 min
```


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4. Behavior of the Laser When Switching the Supply Voltage VB On and Off

The switch-on and switch-off behavior was investigated using a laser with a wavelength of λ = 520 nm and an optical output power of P_{OUT} = 20 mW.

4.1. Switch-on Behavior

The laser requires a certain amount of time to connect to the supply voltage until the laser emits the desired power. For VB = +12 V, this is shown in Figure 16:

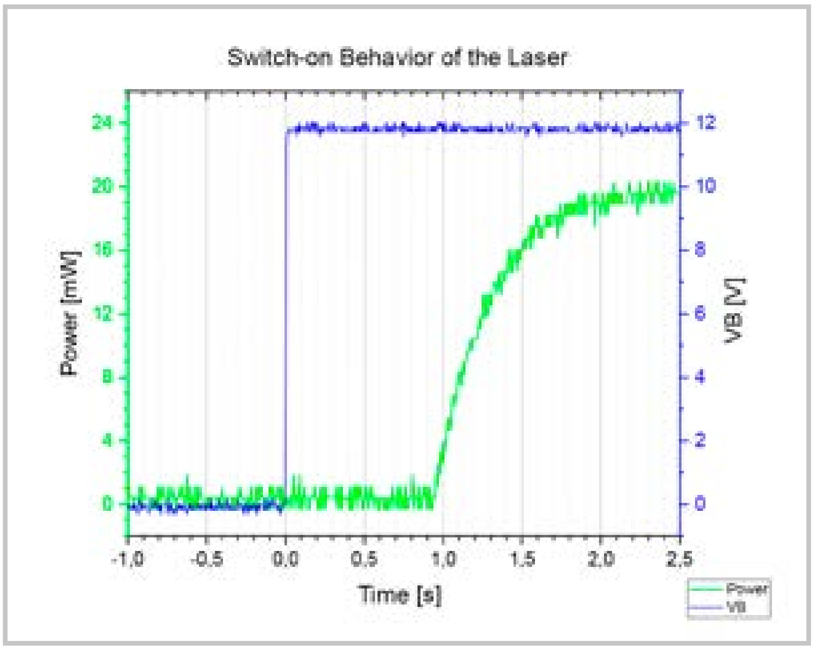

Figure 16: Switch-on behavior at +12 V

The first 900 ms (t_{Start}) require the firmware and electronics to be ready for operation. The laser power is then set. In contrast to digital modulation, further capacitances are charged, which results in a relatively long rise time of 530 ms.

In total, there is a delay time of t_{Delay} = 1.175 s. Delay, in this case, refers to the timespan between 50% VB and 50% laser power.

Further investigations with other voltage values for VB show that both t_{start} and t_{delay} are constant and thus independent of VB. Only the rise time of VB can influence t_{delay} in this case.

4.2. Switch-off Behavior

It is crucial to differentiate between two situations regarding the switch-off behavior.

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4.2.1. Switching from VB to GND

When switching the voltage from VB to GND, the following behavior is exhibited (see Figure 17):

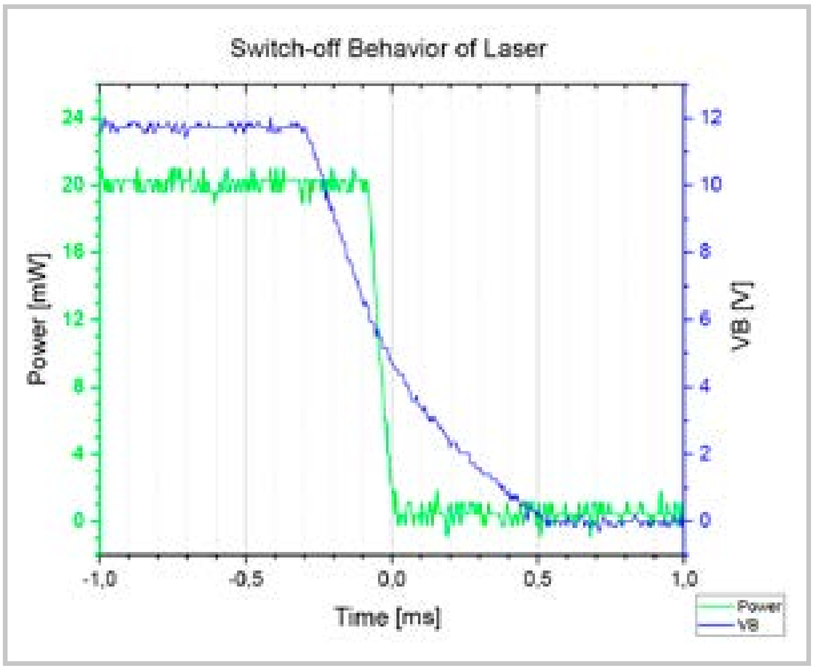

Figure 17:
Time from the beginning of switching VB to achieving the "laser is off" state (switch-off time)

The switch-off time depends on the original value of the voltage VB; however, this correlation is not linear.

VB	Switch-off time
+12 V	310 µs
+20 V	590 µs
+30 V	590 µs

Table 19: Laser switch-off time when VB goes to 0 V

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4.2.2. Interruption of VB

If the supply voltage is interrupted, the switch-off behavior changes. Since the large capacitances of the input filter can no longer be discharged via VB = 0 V, the laser emits an afterglow (see Figure 18).

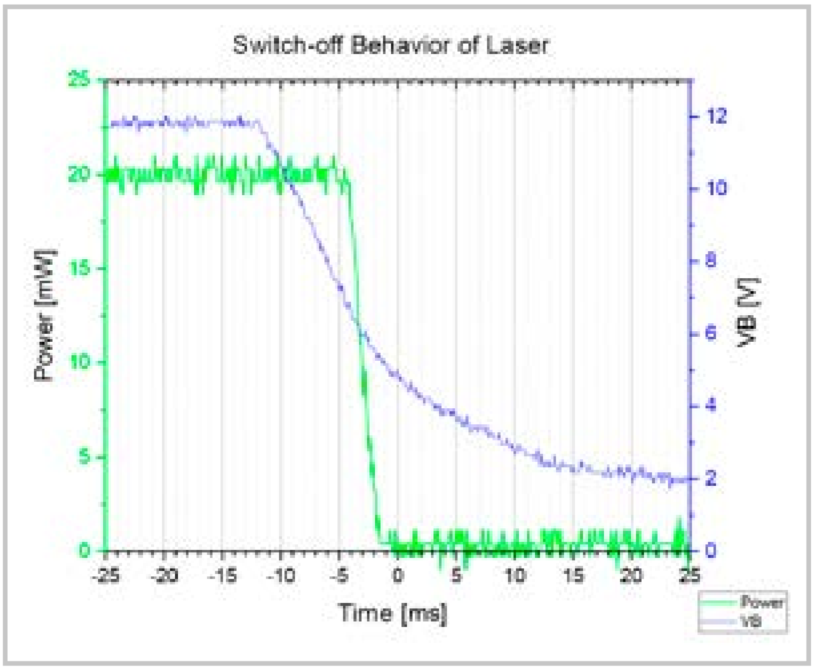

Figure 18: Switch-off time in case of interruption of VB = +12 V

The switch-off time in this case also depends on the original value of the voltage VB.

VB	Switch-off time
+9 V	5.8 ms
+12V	10.4 ms
+15 V	15.4 ms
+24 V	33.6 ms
+30 V	46 ms

Table 20: Laser switch-off time when VB is interrupted

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5. Power Stability at Constant Ambient Temperature

The power stability of the digital laser at room temperature (ϑ = +25 ± 3 °C) is better than a deviation of ±0.5% (see Figure 19).

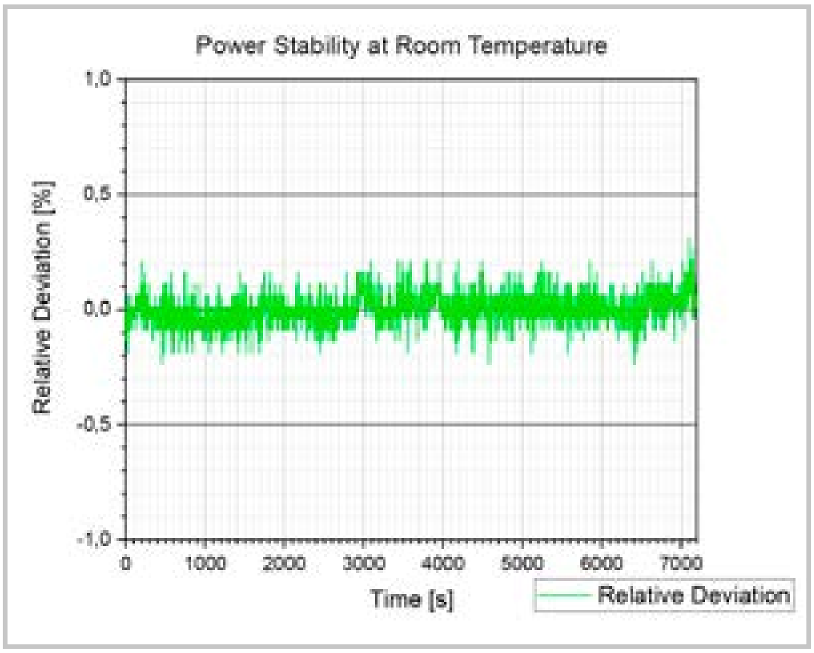

Figure 19: Stability at ϑ = 25 °C

Target value	Average value $P_{Opt\_Average}$	Minimum of e_{rel}	Maximum of e_{rel}
20 mW	19.9675 mW	-0.24%	+0.31%

Table 21: Data on stability

6. Housing Dimensions

When using the digital laser driver, the housing dimensions of the different FLEXPOINT® laser module series may change to the values listed in the chart below.

FP-DOT / FP-DOE laser

Communication	Housing size (length x diameter)
RS-232	67 mm x 11.5 mm
USB	67 mm x 11.5 mm

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FP-DOT / FP-DOE laser 19 mm ruggedized housing

Communication	Housing size (length x diameter)
RS-232	77 mm x19 mm
USB	68 mm x 19 mm

FP-line laser

Communication	Housing size (length x diameter)
RS-232	67 mm x 11.5 mm
USB	67 mm x 11.5 mm

FFP-line laser 19 mm ruggedized housing

Communication	Housing size (length x diameter)
RS-232	86 mm x 19 mm
USB	77 mm x 19 mm

FP-MVmicro

Communication	Housing size (length x diameter)
RS-232	98.6 mm x 19 mm
USB	98.6 mm x 19 mm

ILM12F

Communication	Housing size (length x diameter)
RS-232	68 mm x M12
USB	68 mm x M12

FP-HD laser

Communication	Housing size (length x diameter)
RS-232	98.6 mm x 19 mm
USB	98.6 mm x 19 mm

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FP-MVstereo

Communication	Housing size (length x diameter)
RS-232	98.6 mm x 19 mm
USB	98.6 mm x 19 mm

FP-MVfiber (FP-FCL)

Communication	Housing size (length x diameter)
RS-232	74 mm x 19 mm
USB	74 mm x 19 mm

7. Indication in Part Name

FLEXPOINT® laser modules with a digital laser driver inside will indicate "DIG" in the part name.

Example: FP-MVmicro-**DIG**-660-10-30-F-RS-232

or

FP-MVmicro-**DIG**-660-10-30-F-USB

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