Z-LASER
Intelligent Solutions in Light

ADVANCED INFORMATION
Laser Operator's Manual
ZX

Revision	Date	Editor	Changes
0.1	16/05/25	CSCH	Initial Version
0.2	17/06/23	CSCH	Software manual merged
0.3	17/06/30	AS	Chapter “Create a serial connection” added
0.4	17/07/19	CSCH	General amendments
0.5	17/08/19	CSCH	General amendments
0.6		AS	Corrected CMD ID of SET_POWER_VALUE_IN_PERC
0.7	17/11/20	CSCH	General amendments
0.8	18/04/12	CSCH	Chapter 12 Declaration of Conformity updated
0.9	10/09/18	MTH	Chap. 3: more details, CMD-Version 0.3, Chap.5: Z-Remote 2.0, added Modulation Frequency to specs

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1 Introduction

The ZX is a customizable laser module especially designed for high demanding industrial applications, such as inspection, machine vision, sensing, medical technology, food industry or pinpoint laser positioning tasks. Its modular platform and compact design allow for the integration in a broad variety of industrial working environments.

1.1 About this Document

This is the user manual of the ZX laser module. It provides all necessary information to safely operate the laser system and to get full access to all available features of the product. Please carefully read the following instructions to learn how to use and operate the ZX laser module as intended.

CAUTION NOTE

Before initial commissioning please read the entire manual. Operating the product in a manner not specified in this document may lead to safety hazards and will void the product warranty.

Some descriptions of the ZX product may not be clear enough or may suffer from a lack of details. Both, the description and the product itself keep evolving based on customer feedback and ongoing product improvement.

1.2 Benefits of ZX Laser

- Modular platform – Choose your appropriate module:
  - Outer diameter: Ø20mm vs. Ø10mm
  - Wavelength: 405 nm…900 nm (other wavelengths upon request)
  - Output power: < 1mW…250mW
  - Projection I: line homogeneous, line Gaussian, DOE, dot, etc.
  - Projection II: ultra-sharp line vs. extended depth of focus
  - Electronics: integrated vs. separated
  - Connector: 5-pin M12-connector vs. cable
- reproducible projection properties due to automated production processes
- Industrial-rated stainless steel housing
- Ingress protection IP67
- externally focusable – no tools required
- integrated monitoring and modulation features

1.3 ZX product family at a glance

	ZX20	**ZX10**	**ZXS**
			
Housing	Ø 20 mm laser driver integrated	Ø 10 mm laser driver integrated	Ø20 mm / Ø10 mm (head) Ø17 mm (laser driver)
Wavelength	400…900 nm	600…900 nm	400…900 nm
Output power	1…250 mW	1…100 mW	1…250 mW (reduced @ ZXS10)
Projection	line (Gaussian, homogeneous), DOE, dot (circular, elliptical)	line (Gaussian, homogeneous), DOE, dot (circular, elliptical)	line (Gaussian, homogeneous), DOE, dot (circular, elliptical)
Focusability	optional (-F)	none	optional (-F)
Modulation Frequency	Up to 300 kHz (depends on wavelength)	Up to 1 MHz (depends on wavelength)	Up to 10 kHz (depends on wavelength)
Ingress protection	IP 67	IP 50	IP 67 (for ZXS20) IP 50 (for ZXS10)
Power supply	5-30 VDC (600…900 nm) 9-30 VDC (400…520 nm)	3,5…5,5 VDC	5-30 VDC (600…900 nm) 9-30 VDC (400…520 nm)
Electrical interface	M12, 5pin (refer to chapter 3.1)	Cable with open leads, 2pin	Cable with open leads, 6pin (refer to chapter 3.1)
Communication	UART, TWI	none	UART, TWI
Temperature termination	controlled by LDU	none	controlled by LDU
Modulation	analog / TTL	CW operation only	analog / TTL

Table 1: ZX product family at a glance

1.4 Upon Receiving the ZX-module

Upon receiving your delivery, please check the shipping box for visible damages. Immediately report such damages to your shipping company.
After unpacking please carefully check the laser product for potential damage. If you discover any damage please report immediately to Z-LASER. In the case of physical damage do not operate the product!

This shipment contains the following parts:

- ZX laser module with nameplate, laser class sticker and black vinyl protection cap.
- Quickstart guide and safety instructions with download link for the manual

Figure 1: scope of delivery - shipping box, ZX laser module & quickstart guide

If any of these components are missing, please contact Z-LASER and do not try to operate the product!

Save the shipping box and packing material for further shipping needs.

1.5 Handling of the product

The ZX module is an IP67 rated laser projector, nevertheless the ZX should be handled with care. Pay particular attention to the front protection glass.

IP67 (International protection class)

6 → Dust-tight. No ingress of dust, complete protection against contact.

7 → Immersion up to 1 m. Ingress of water in harmful quantity shall not be possible when the module is immersed in water under defined conditions of pressure and time (up to 1 m of submersion).

The driver electronics of the ZX module and the stainless steel housing provides active and passive protection against ESD, though reasonable handling is essential. Particular attention has to be paid to the correct electrical connection. Please see chapter 3.1 Electrical interfaces / Pinning for appropriate instructions.

Please contact the Z-LASER service department in case of uncertainties.

1.6 Operation requirements and specifications

Feature	Requirement	Comment
Operating Temperature	-10°C … +50°C (Case Temperature of the laser module)	**Attention: the LDU will switch off the laser when the temperature exceeds the specified limits**
Storage Temperature	-40°C - +85°C	Ambient temperature
Humidity	95% non-condensing	
Overall Power Dissipation	< 2.7 W	Worst case condition in CW mode. Depends on laser diode and operating voltage.
Supply Voltage (VCC)	5…30 VDC (for 600…900nm modules) 9…30 VDC (for 400…520nm modules)	
Max Operating Current	< 500 mA	
Max inrush current	up to 15A	at system start up
Maximum optical output power	up to 250 mW	Depends on laser diode.
Power stability	< ± 1% in steady state (1h, T=const.) < ± 3 % over entire temperature range	
Laser safety class	1, 1M, 2, 2M, 3R, 3B	Depends on module configuration. **Attention: reducing the intensity via Analog Modulation (Pin 4) does not change the laser class.**

Table 2: Operation requirements and specifications

NOTE

The laser driver unit (LDU) will stop laser emission, if the ZX module is operated outside the above specified temperature range. To restart laser emission the power supply has to switch off and back on again (power cycle).

2 Laser Safety

Your safety is of the highest importance to us. Please read and follow the following laser safety information before using this product.

Lasers are classified as 1, 1M, 2, 2M, 3R, 3B and 4 according to ISO EN 60825-1.

Class 3R, 3B and 4 lasers are not intended for use of uneducated people. The area in which they are operated must be restricted and marked according to laser safety guidelines. The operator of the laser system must provide trained personnel to supervise the observance of laser safety regulations. He must provide protection glasses and other safety prerequisites to the personnel. Generally the operator of the laser system takes full responsibility for the safe installation, marking, handling and operation of the laser.

CAUTION NOTE

The use of optical instruments with this product will increase eye hazard. Do not shine laser in the direction of other people or at reflective surfaces that might cause exposure to the human eye!

The laser radiation emitted from this unit may be harmful.
Always follow these precautions:

- Avoid direct exposure to the beam.
- Avoid looking at the beam directly.
- Don’t modify the laser product and operate it according to the user instructions
- Be aware of and follow the warnings on the safety labels
- To completely shut off power to the unit unplug the unit.
- Cover the output with the safety cap when the unit is operated outside its target system.

Review of reported incidents has demonstrated that accidental eye and skin exposures to laser radiation, and accidents related to the ancillary hazards of a laser or laser system, are most often associated with personnel involved with the use of these systems under the following conditions:

- Unanticipated eye exposure during alignment
- Misaligned optics and upwardly directed beams
- Available eye protection not used
- Equipment malfunction
- Improper methods of handling high voltage
- Intentional exposure of unprotected personnel
- Operators unfamiliar with laser equipment
- Lack of protection for ancillary hazards
- Improper restoration of equipment following service

These hazards can be avoided by a proper understanding of the equipment and by following safe procedures.

The German BGV B2 (Unfallverhütungsvorschrift “Laserstrahlung”) gives more information regarding safe operation of laser systems.

Equipment:
Test all lasers, delivery systems, and safety equipment prior to turning on the laser. Appropriate personal protective equipment such as appropriate laser protective eyewear should be worn during such tests. All safety procedures will be followed during service and demonstrations.

Eye Protection:
The greatest risk for personnel using lasers is eye injury to the cornea or retina from direct or reflected laser beams. Protective eyewear with adequate optical density (OD) at the particular wavelength in use must be clearly labelled and worn by all members of the operating team within the NHZ. It is recommended that built-in side shields be used to protect the eyes from tangential beams and scattered reflections. Safety eyewear labelled with the appropriate wavelength and optical density will be available at the entry where each door sign is posted.

Caution: Laser Safety Eyewear is not designed for looking directly at a laser beam.

Checks:
Check the power output of the laser frequently with an appropriate power meter, especially before beginning the procedure. Appropriate eyewear should be worn during such checks. The laser should be placed in a standby mode when not in use, to prevent inadvertent exposure to power/energy.

Electrical Hazards:
Use of any electrical system may give rise to electrical hazards; consequently, proper grounding and insulation are imperative. Protection against accidental contact with energized conductors by means of a barrier system is the primary methodology to prevent electric shock accidents with laser equipment. Additional electrical safety requirements are imposed upon laser devices, systems, and those who work with them, by the US Department of Labor, OSHA, the National Electrical Code (NFPA 70), and related state and local laws and regulations. These requirements govern equipment connection to the electrical utilization system, electrical protection parameters, and specific safety training. These requirements must be observed with all laser installations.
The following potential problems have frequently been identified during laser facility audits.

- Uncovered electrical terminals
- Improperly insulated electrical terminals
- Hidden “power-up” warning lights
- Lack of personnel trained in current cardiopulmonary resuscitation practices, or lack of refresher training
- “Buddy system” not being practiced during maintenance and service
- Non earth-grounded or improperly grounded laser equipment
- Non-adherence to the OSHA lock-out standard (29 CFR 1910.147)
- Excessive wires and cables on floor that create fall or slip hazards

Emergency Shutoff:
An emergency shutoff switch must be available to the operator or the assistant to rapidly shutdown the equipment. The interlock of the laser is intended to shut down laser power immediately

Controlled Area:
Authorized personnel, upon entry to an area where lasers are being used, should be provided with personal protective equipment (see Description of Facilities, above). Such controlled area should contain the NHZ, the extent of which is clearly delineated, and should be posted with appropriate laser warning signs specific to the wavelength being used (as described in ANSI Z136.3, Section 4.7). The laser should not be activated when it is necessary to open the door, if the Nominal Hazard Zone (NHZ) extends to the doorway.
Glass windows will be covered with shades or filters of appropriate optical density whenever a laser system is operational. No one will be allowed into a laser room unless properly authorized and protected.

Warning Signs:
Regulation Danger laser signs will be posted at eye level on all doors that access a room where Class 3b and/or Class 4 laser will be operated. These signs will state all required information as described in the ANSI Z136.1 standard, and will be removed when the laser is not in use.

Fire Hazards:
Class 4 laser systems represent a fire hazard. Enclosure of Class 4 laser beams can result in potential fire hazards if enclosure materials are likely to be exposed to irradiances exceeding 10 W/cm2 or beam powers exceeding 0.5 W. The use of flame retardant materials, as defined by the National Fire Protection Association (NFPA), should be encouraged.

Opaque laser barriers e.g., curtains, can be used to block the laser beam from exiting the work area during certain operations. While these barriers can be designed to offer a range of protection, they normally cannot withstand high irradiance levels for more than a few seconds without some damage, e.g., production of smoke, open fire, or penetration. Users of commercially available laser barriers should obtain appropriate fire prevention information from the manufacturer.

Operators of Class 4 lasers should be aware that unprotected wire insulation and plastic tubing can catch fire from intense reflected or scattered beams, particularly from lasers operating at invisible wavelengths.

Explosion Hazards:
High-pressure arc lamps, filament lamps, and capacitor banks in laser equipment shall be enclosed in housings, which can withstand the maximum explosive pressure resulting from component disintegration. The laser target and elements of the optical train which may shatter during laser operation shall also be enclosed or equivalently protected to prevent injury to operators and observers. Explosive reactions of chemical laser reactants or other laser gases may be a concern in some cases.

From the German BGV B2 (Unfallverhütungsvorschrift "Laserstrahlung"):
Lasereinrichtungen müssen entsprechend ihrer Klasse und Verwendung mit den für einen sicheren Betrieb erforderlichen Schutzeinrichtungen ausgerüstet sein (§4 Abs. 2). Diese Forderungen gelten als erfüllt, wenn:

- der Fernverriegelungsstecker eines Lasers der Klasse 3B oder 4 an einen Not-Aus-Schalter, einen Türkontakt oder an eine andere gleichwertige Einrichtung mit Schutzfunktion angeschlossen ist (§8 Abs. 4)
- Lasereinrichtungen der Klassen 2 für Unterrichtszwecke, 3R, 3B oder 4 bei Nichtbenutzung gegen unbefugten Gebrauch durch das Abnehmen des Schlüssels des Schlüsselschalters gesichert sind (§8 Abs. 4),
- Lasereinrichtungen der Klassen 3R, 3B oder 4 bei Nichtbenutzung durch die Verwendung der Strahldämpfungseinrichtungen gesichert sind (§8 Abs. 4).

Der Betrieb von Lasern der Klassen 3B oder 4 müssen dem zuständigen Unfallversicherungsträger und der für den Arbeitsschutz zuständigen Behörde vor der ersten Inbetriebnahme angezeigt werden (§5 Abs. 1).

Der Unternehmer hat für den Betrieb von Lasereinrichtungen der Klassen 3B oder 4 Sachkundige als Laserschutzbeauftragte zu bestellen (§6 Abs. 1). Es wird empfohlen, diese mit Weisungsbefugnissen und Verantwortung auszustatten (§6 Abs. 2).

Der Unternehmer hat dafür zu sorgen, dass Versicherte, die Lasereinrichtungen der Klassen 2 bis 4 anwenden oder sich in Laserbereichen von Lasereinrichtungen der Klassen 3B oder 4 aufhalten, über das zu beachtende Verhalten mindestens einmal jährlich unterwiesen werden (§8 Abs. 3).

3 Operating the laser module

CAUTION NOTE

Please stick to the instructions given in this user manual when operating the ZX laser module. Operating the product in a manner not specified in this document may lead to safety hazards and will void the product warranty.

CAUTION NOTE

Laser emission of this product can cause serious damage to the human eye. Before operate the product consider the use of proper laser safety equipment such as laser safety glasses.

Protection cap:
Every ZX module is delivered with a protection cap which covers the laser beam exit. This cap protects the optical surface from being contaminated or damaged during transportation, storage or inactivity. Before starting laser emission the cap has to be removed from the module.

DO NOT USE the cap to block laser light. The cap can melt due to high power density of the laser beam.

Figure 2: protection cap

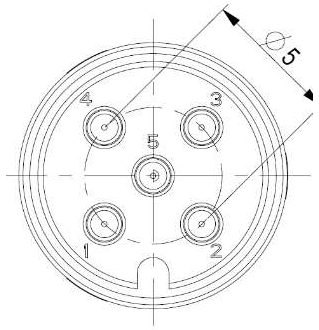
First steps to a basic operation of the laser module could be as follows:

i) Use the clamping area of your ZX20 module to mount it on a proper heatsink (for clamping area please see chapter 6 Drawings).
ii) Connect the ZX20 module as described in chapter 3.1 Electrical interfaces / Pinning
iii) Switch on the power supply. The green status LED turns ON after system start-up procedure.
iv) Connect Pin 2 (DIG) and apply appropriate TTL signal to the digital trigger input to start laser emission (orange LED turns ON).

3.1 Electrical interfaces / Pinning

The electrical interfacing of the ZX is represented by a 5-Pin M12 connector with A-Coding or a 6-pin cable with open leads. The factory-set default pin assignment is shown in Table 3.

While Pin 1 and Pin 3 are fixed and unchangeable, Pin 2, Pin 4 and Pin 5 can be assigned to various functions. Please see chapter 3.4.7 “SET_CONFIG_MODE” for detailed information on changing pin assignment and for how to get access to different operation modes. The default Config-Mode is “00”.



M12 5-Pin A-Coding Male Connector According to IEC 61076-2-101

Pin 1: **VCC**
Pin 2: **DIG** (Fail Out)
Pin 3: **GND**
Pin 4: **ANA** (RXD/ SCL)
Pin 5: **FAIL** (TXD/ SDA)

Pin 1 (brown) → **VCC**
Pin 2 (orange) → **DIG** (Fail Out)
Pin 3 (black) → **GND**
Pin 4 (yellow) → **ANA** (RXD/ SCL)
Pin 5 (green) → **FAIL** (TXD/ SDA))
Pin 6 (red) → **SHIELD**

Table 3: Pinning of the ZX laser module

VCC: voltage supply
DIG: digital modulation TTL (3.3…30 VDC for digital high, 0 VDC for digital low)
GND: ground
ANA: analog modulation: linearly adjust the optical output power between 10% (0 VDC) and 100% (2 VDC) of the nominal output power of the laser module
FAIL: fail out signal (will be actively pulled to GND if an error is present)
SHIELD: shielding pin, not connected to laser modules housing

Pin	Config Mode	Feature	Spec	Comment
1	ALL	**VCC**	5-30 VDC ± 10 % • Reverse polarity protected • Burst and surge protected	
2	00, 02, 03	**Digital Modulation (PWM)**	up to 500 kHz (depends on laser diode) PWM transmission error: < ± 2% @ 10 kHz < ± 5% @ 300 kHz PWM input, CMOS signaling: VIL_max: < +1.0 V VIH_min: > +2.3 V • Reverse polarity protected • Overvoltage protected up to 30 VDC	PWM transmission error: when a PWM signal at a 50% power level (duty cycle) is translated to a 45% laser power level – the transmission error is -10%. Typically the transmission error is caused by turn-on-delays of the laser diode.
	06, 07	*Fail Out*	*3.3V CMOS output (active low)*	*Signal pulled to GND if an error is present*
3	ALL	**GND**	Common ground	System Ground, please ensure proper connection to ground signal of your power supply
4	00,	**Analog Modulation**	Real time analog power control input • Linear range: 10%...100% of nominal laser power. • Resolution: 100µW • Response Time: 100ms • Input range: 0.0…2.0 V • Reverse polarity protected • Overvoltage protected up to 30 VDC • Internal pull-up resistor leads to 100% of rated laser output power if left open	rated laser output power: Maximum laser output power that can be emitted by one laser module. This value is calibrated at Z-Laser.
	02, 06	*UART RXD*	*3.3V Communication Signal*	*Laser Data Input*
	03, 07	*TWI SCL*	*3.3V Communication Signal*	*Serial Clock*
5	00,	**Fail Out**	3.3V CMOS output (active low)	Signal pulled to GND if an error is present
	02, 06	*UART TXD*	*3.3V Communication Signal*	*Laser Data Output*
	03, 07	*TWI SDA*	*3.3V Communication Signal*	*Serial Data*

Table 4: electrical interfaces

CAUTION NOTE

The analog modulation input (default Pin 4) has an internal pull-up resistor. This leads to 100% of rated laser output power if the pin is not driven by an external source. As a consequence the laser emits with 100% of rated laser output power, if the analog modulation input is directly connected to the digital modulation input.

CAUTION NOTE

Reducing the intensity via analog modulation (default Pin 4) does not have an impact on the laser class.

3.2 Power supply

The ZX module can be supplied by 5…30 VDC (for 600…900nm modules) or 9…30 VDC (for 400…520nm modules), respectively. The ZX will automatically transform the input into a proper internal voltage level for the particular operating condition.

The supply input on Pin 1 is protected against reverse polarity and transient over voltages.

There is no ON-switch and shutter. Once supply voltage is applied, the module starts powering up. During start-up procedure self-testing routines verify the safety architecture and integrity of the entire system. After completion of these tests, laser emission starts by applying a TTL Trigger signal on Pin 2. A simple way to permanently operate the module in Continuous Wave (CW) mode is to short-cut Pin 2 with the voltage supply (Pin 1).

System integrity tests are only conducted after power cycling the ZX laser module. To prevent undetected accumulations of failures, the module should be power cycled on a regular base, e.g. once every 24h. An integrated ON-time counter can be read out via TWI telegrams (see chapter 3.4.6) or the GUI (see chapter 5) and indicates the time passed by since the last system integrity test.

3.3 Focus adjustment

You can adjust the focus position of every focusable ZX module without any tools by turning the knurling wheel. In order to prevent unintentional shift of focus, the rotation of the wheel is mechanically impeded and you may need a bit of force to move it.

The focus position can be set to larger distance by turning the knurling wheel clockwise, by turning the wheel counterclockwise you can focus the laser beam to shorter distance.

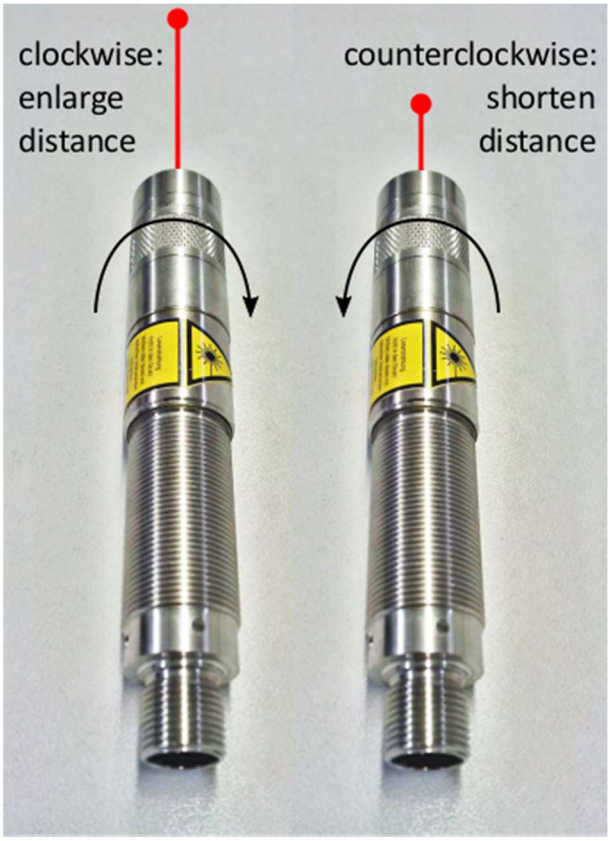


Figure 3: focus adjustment

3.4 Serial Interface

The ZX-H module can be controlled by user commands being transmitted via a serial interface. Two transmission standards are supported on dedicated IO-Pins, UART and TWI. The user can operate one of each at a time. When the TWI interface is used, external pull-up resistors must be implemented. Note: not all implemented telegrams are documented due to low relevance to customer use cases. A full documentation is available on request. Please contact Z-LASER.

3.4.1 UART Interface

- Up to 19 200 Baud
- No parity
- 1 Stop bit
- 8 Data bits
- Half duplex communication
- Voltage Level **3.3V**
- ASCII data format

Every Sequence (read and write) must be terminated by a Line Feed character (0x0A = "\n" = LF)

The ASCII representation of the UART-frames is identical to the hexadecimal representation of the TWI-frames. Even the device-ID must be transmitted when UART is used; see light green telegram byte for TWI transmissions below. So the given documentation refers to TWI but is valid for UART communication as well.

Example:
Documentation of the TWI telegram that reads the ZX Firmware Version

WR-Device-ID	CMD (0xF0)	Hi-Byte CRC	Lo-Byte CRC

RD-Device-ID	System Status	Major Version	Minor Version	Build	Hi-Byte CRC	Lo-Byte CRC

The corresponding TWI telegram in **hexadecimal** representation:

TWI write frame ->	88 F0 0E EF	length: 4 Bytes
TWI read frame ->	00 03 00 05 8D 35	length: 6 Bytes

The corresponding UART telegram in **ASCII** representation:

UART request telegram ->	88F00EEF<LF>	length: 9 Bytes
UART receive telegram->	000300058D35<LF>	length: 13 Bytes

The length of the UART frame is always calculated as: (length of TWI frame) * 2 + termination character.

CRC (CCIT format) is calculated from the command and data frame without the TWI-address. See details in next subchapter.

3.4.2 TWI Interface

The TWI communication interface is operated via SCL and SDA (Pin 4 and Pin 5) according to standardized physical TWI protocol definition up to 100 Kbit/s. No pull-up resistors are implemented for both wires; this must be done on the host side. A proper GND reference of the applied signals has to be ensured. Signal-GND (Pin 3) can be used for this.
Please refer to the original Philips specification that can be found at this URL:

http://cache.nxp.com/documents/user_manual/UM10204.pdf

NOTE

Please pay attention to the following deviations from the original Philips I²C specification:

- Max high level output voltage 3.3V
- 1 mA current sink capacity
- Pull-Up resistors must be chosen in accordance with the current sink specification

Feature	Reference
The default device-ID of the laser module is 0x88 (WR). It can be permanently re-programmed however (see below, always depicted in light green)	
Standard TWI telegrams are supported; every TWI telegram contains a write transmission and one or more read transmission of a defined length. The write transmission contains the write-device-ID and 3 or more data bytes. At least a Command byte and two CRC bytes for the telegram are transmitted. Optionally a data payload of one or more bytes can be inserted. The subsequent read transmission(s) contain the read-device-ID, a data payload of one or more data bytes and two CRC bytes for the telegram. Every read transmission has a predefined number of bytes - for every SET command the read transmission contains the system status which indicates the success of the transmitted write telegram. For write telegrams the read transmission can be repeated multiple times until the status indicates a successful completion of the command processing (busy bit = 0) For read telegrams that cannot provide instantaneous data to return, the read transmission does not contain data payloads else then the system status followed by the CRC (data byte count = 0). To provide the expected transmission length, fill bytes are appended. This is indicated to the TWI host by an active “busy” flag in the system status byte (Bit 0 = 1). The read transmission can be repeated multiple times until the busy bit is reset (Bit 0 = 0) and valid data bytes are returned. Other circumstances where no data is returned: Error flag (bit 1 = 1) – e.g. the command byte has not been interpreted correctly NACK flag (bit 3 = 1) – e.g. premature new command received when previous command has not yet been executed successfully. WR-Device-ID | CMD Byte | Data Byte 0….N | Hi-Byte CRC | Lo-Byte CRC RD-Device-ID | System Status | Data Byte 0….N | Hi-Byte CRC | Lo-Byte CRC | Fill Byte 0….N Typical data payload configurations for write transmissions are as follows: for simple commands — no Byte for parameter settings — Parameter for parameter settings — Parameter-Hi | Parameter-Lo for parameter settings — Parameter-1 | Parameter-2 | Parameter-3 | Parameter-4	

The CRC calculation is based on the following polynomial:

x^16 +x^12 + x^5 + 1 (0x1021) -> CRC-CCITT

Initial Value = 0xFFFF (direct)
Final XOR Value = 0
Reverse Data Bytes = No
Reverse CRC results = No

(note that x^16 is added to indicate the MSB of the polynomial, only 16 LSB's are used for the calculation)
The CRC-Checksum refers to the entire telegram except the TWI-device-ID.
A simple CRC calculator is given here:
https://www.lammertbies.nl/comm/info/crc-calculation.html

Example:
Get_Firmware_Version command:

WR-Device-ID	CMD-ID	Hi-Byte CRC	Lo-Byte CRC
0x88	**0xF0**	**0x0E**	**0xEF**

RD-Device-ID	System Status	Major Version	Minor Version	Build	Hi-Byte CRC	Lo-Byte CRC
0x89	**0x00**	**0x03**	**0x00**	**0x05**	**0x8D**	**0x35**

Not used for CRC
input bytes
calculated CRC check sum

3.4.3 Create a serial connection

The easiest way to control a ZX module with a PC is the corresponding Graphical User Interface (GUI) provided by Z-LASER.
But you can also use a standard command line interface to create a serial connection. For modules that are already in a Configuration Mode that allows serial communication, steps 1-3 can be skipped.

Example:

1. Send "SET_USER_PASSWD" command repeatedly via preferred communication protocol (UART or TWI). The time between each command should not exceed more than 50ms. Other ways the short timeslot during power up where the laser module checks the TWI and the UART Interface for incoming command could be missed.

2. Switch on power supply to laser module

3. As soon as you get a valid answer for "SET_USER_PASSWD" command send the "SET_CONFIG_MODE" Command to set the module in a mode that supports communication (e.g. "UART_Com_Dig_In"-Mode = 2).

4. To change e.g. the optical output power to 50% you have to send the "SET_POWER_VALUE_IN_PERC" command.

   Communication Sequence (UART):

[TX - Set User Password] - 88 f5 55 73 65 72 ef 21 <LF>
[Addr | CmdID | Password | CRC16 | Linefeed]

[TX - Set User Password] - 88 f5 55 73 65 72 ef 21 <LF>
…
…
…
[switch power supply on]

[TX - Set User Password] - 88 f5 55 73 65 72 ef 21 <LF>

[TX - Set User Password] - 88 f5 55 73 65 72 ef 21 <LF>
…
…
…
[TX - Set User Password] - 88 f5 55 73 65 72 ef 21 <LF>
[RX - valid response] - 00 e1 f0 <LF>
[Status Byte | CRC16 | Linefeed]

[TX - Set Config Mode] - 88 17 02 a7 a9 <LF>
[Addr | CmdID | ConfigMode | CRC16 | Linefeed]
[RX – valid response] - 00 e1 f0 <LF>
[Status Byte | CRC16 | Linefeed]

[TX – Set Power Value In Perc] - 88 4f 32 16 ec <LF>
[Addr | CmdID | PowerValue | CRC16 | Linefeed]
[RX – valid response] - 00 e1 f0 <LF>
[Status Byte | CRC16 | Linefeed]

3.4.4 Command Overview

Command-Set-Version: 0.3

CMD ID (dec)	CMD ID (hex)	Cmd Name	Description
18	0x12	Get_Current	reads the laser current as unsigned integer value. Note: this command returns the total laser current (bias current plus operating current)
20	0x14	Get_Mode	reads hardware modes of the LDU's.
22	0x16	Get_Config_Mode	reads current configuration mode.
23	0x17	Set_Config_Mode	Select a configuration mode.
34	0x22	Get_LD_Lifetime	reads the laser diodes accumulated operating hours as unsigned integer value (2 bytes) in hours and minutes
64	0x40	Get_LD_Temp	reads the laser temperature as unsigned integer value (2 bytes) in °C/100
65	0x41	Set_Laser_On	Enable Laser Diode
67	0x43	Set_Laser_Off	Disable Laser Diode
69	0x45	Set_Laser_On_Off	Toggle Laser Diode Status
70	0x46	Get_Laser_On_Off	Reads Status: 1: Laser On; 0: Laser Off
78	0x4E	Get_Power_Val_In_Perc	Reads Power Value in Percent (Hex-Value)
79	0x4F	Set_Power_Val_In_Perc	Writes Power Value in Percent (Hex-Value)
84	0x54	Get_Min_Warn_Temp	reads the lower temperature limit that triggers a temperature warning as signed character in °C
86	0x56	Get_Max_Warn_Temp	reads the upper temperature limit that triggers a temperature warning as signed character in °C
88	0x58	Get_Min_Shtdwn_Temp	reads the lower temperature limit that triggers a temperature error as signed character in °C. This error results in a shutdown of the laser diode.
90	0x5A	Get_Max_Shtdwn_Temp	reads the upper temperature limit that triggers a temperature error as signed character in °C. This error results in a shutdown of the laser diode.
96	0x60	Get_Status	reads all pending errors and warnings
102	0x66	Get_Analog_Mod_On_Off	returns the status of the analog power modulation. (unsigned character: 0 = analog modulation off, 1 = analog modulation on)
103	0x67	Set_Analog_Mod_On_Off	activates the analog power modulation
104	0x68	Get_Digital_Mod_On_Off	returns the status of the digital modulation. (unsigned character: 0 = digital modulation off, 1 = digital modulation on)
105	0x69	Set_Digital_Mod_On_Off	activates the digital modulation
109	0x6D	Set_Revert_Pow_Factor	Sets the optical output power to 100% and saves it as default value. A power cycle is necessary to apply these changes.
120	0x78	Get_Module_Total_OnTime	reads the laser modules total operating time after the first power-on as unsigned integer value (2 bytes) in hours and minutes
126	0x7E	Get_Cal_Laser	reads the calibrated output power in 1/100mW as unsigned integer and the wavelength in nm as unsigned integer
144	0x90	Get_Max_Sys_Power	reads maximal electrical power consumption of the Laser System
158	0x9E	Get_Weighted_Lifetime	reads weighted lifetime in hours and as percentage of estimated lifetime

164	0xA4	Get_Part_Number	reads the part number of the LDU by 9 ASCII bytes (0x30…0x39).
166	0xA6	Get_Power_Out_Abs	reads the maximal output power (@100% value) in 1/100mW as unsigned integer value.
170	0xAA	Get_Min_Power	reads the minimum adjustable power limit as percentage and absolute value
186	0xBA	Get_Manufacturer_ID	reads manufacturer-ID as ASCII
196	0xC4	Get_Percent_Power_Limit	reads the user defined percent power limits (max and min).
240	0xF0	Get_FW_Version	reads the firmware version as unsigned integer value (3 bytes)
242	0xF2	Get_Serial	get the serial number of LDU
244	0xF4	Get_Cmd_Set_Version	reads the command-set version as unsigned integer value (2 bytes)
245	0xF5	Set_User_Password	sets user password to enable critical configuration procedures (laser operation).
247	0xF7	Set_Default_Pow_Val	save the current power value as startup default
252	0xFC	Get_TWI_Addr	reads the TWI-Address of the device for serial communication
253	0xFD	Set_TWI_Addr	writes the TWI-Address of the device for serial communication

3.4.5 System Status Byte

The Status Byte consists of 8 Status-Flags and is transmitted with each communication answer.

Position	Flag	Description
Bit 0	BUSY	Timing Problem: Laser was not ready to process command. Wait until Busy Flag LOW and repeat the command.
Bit 1	CRC_ERROR	The Laser module received a wrong CRC with the current command
Bit 2	PASSWORD_ERROR	Wrong Service or User Password was sent
Bit 3	TELEGRAM_ERROR	NACK: Command not acknowledged; unknown command was sent
Bit 4	WARNING	One or more warnings are signaled. The Laser diode can still be active. The green LED is blinking slowly
Bit 5	ERROR	One or more errors are signaled. The Laser diode is off. The green LED is blinking fast.
Bit 6	PASSWORD_SET	A valid Service or User Password was sent.
Bit 7	NO_DATA	No valid data is transmitted by the laser. Repeat read command

The regular Status Byte answer to a respond should be 0x00 (standard) or 0x40 (password was set).

Example: A received Status Byte of 0x91 indicates, that the communication interface was BUSY, NO DATA was transmitted and the system signals a WARNING.

3.4.6 List of read telegrams

Command-Set-Version: 0.3

<table>
<tr><th>Feature</th><th>Password protection</th></tr>
<tr><td>GET_LASER_CURRENT - reads the laser current as unsigned integer value (2 bytes) in mA. Note: this command returns the total laser current (bias current plus operating current)

<table>
<tr><td>WR-Device-ID</td><td>CMD (0x12)</td><td>Hi-Byte CRC</td><td>Lo-Byte CRC</td></tr>
<tr><td>RD-Device-ID</td><td>System Status</td><td>Current Hi-Byte</td><td>Current Lo-Byte</td><td>Hi-Byte CRC</td><td>Lo-Byte CRC</td></tr>
</table>
(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)</td><td>no protection</td></tr>
<tr><td>GET_MODE - reads the hardware mode of the LDU (unsigned character).

<table>
<tr><td>WR-Device-ID</td><td>CMD (0x14)</td><td>Hi-Byte CRC</td><td>Lo-Byte CRC</td></tr>
<tr><td>RD-Device-ID</td><td>System Status</td><td>Mode-Byte</td><td>Hi-Byte CRC</td><td>Lo-Byte CRC</td></tr>
</table>
(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)

Bits of the mode Byte
<table>
<tr><td>Bit 0</td><td>Enable on/off the digital modulation control input (1 == on).
Effective only in configuration modes with digital modulation.</td></tr>
<tr><td>Bit 1</td><td>Reserved for future use</td></tr>
<tr><td>Bit 2</td><td>Enable on/off the analog modulation control input (1 == on).
Effective only in configuration modes with analog modulation.</td></tr>
<tr><td>Bit 3</td><td>Reserved for future use</td></tr>
<tr><td>Bit 4</td><td>Enable on/off the fail out signal (1 == on).
Effective only in configuration modes with fail out.</td></tr>
<tr><td>Bit 5</td><td>Reserved for future use</td></tr>
<tr><td>Bit 6</td><td>Reserved for future use</td></tr>
<tr><td>Bit 7</td><td>Reserved for future use</td></tr>
</table></td><td>no protection</td></tr>
<tr><td>GET_CONFIG_MODE - reads the current Configuration Mode as unsigned character.

<table>
<tr><td>WR-Device-ID</td><td>CMD (0x16)</td><td>Hi-Byte CRC</td><td>Lo-Byte CRC</td></tr>
<tr><td>RD-Device-ID</td><td>System Status</td><td>Config. Mode</td><td>Hi-Byte CRC</td><td>Lo-Byte CRC</td></tr>
</table>
(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)</td><td>no protection</td></tr>
</table>

GET_LD_LIFETIME - reads the laser diodes accumulated operating hours as unsigned integer value (2 bytes) in hours

WR-Device-ID	CMD (0x22)	Hi-Byte CRC	Lo-Byte CRC

RD-Device-ID	System Status	Hours HiByte	Hours LoByte	Minutes	Hi-Byte CRC	Lo-Byte CRC

(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)

no protection

GET_LD_TEMP - reads the laser temperature as unsigned integer value (2 bytes) in °C/100

WR-Device-ID	CMD (0x40)	Hi-Byte CRC	Lo-Byte CRC

RD-Device-ID	System Status	Temp Hi-Byte	Temp Lo-Byte	Hi-Byte CRC	Lo-Byte CRC

(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)

no protection

GET_LASER_ON_OFF - reads laser diode status (unsigned character – single byte).
1: Laser On; 0: Laser Off

WR-Device-ID	CMD (0x46)	Hi-Byte CRC	Lo-Byte CRC

RD-Device-ID	System Status	Laser Status	Hi-Byte CRC	Lo-Byte CRC

(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)

no protection

GET_POWER_VAL_IN_PERC - reads the current laser power as percentage (unsigned character – single byte) of nominal laser power

WR-Device-ID	CMD (0x4E)	Hi-Byte CRC	Lo-Byte CRC

RD-Device-ID	System Status	Power Value	Hi-Byte CRC	Lo-Byte CRC

(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)

This command returns the programmed laser power. This command does not advise if the laser is switched on or off.

no protection

GET_MIN_WARN_TEMP - reads the lower temperature limit that triggers a temperature warning as signed character in °C

WR-Device-ID	CMD (0x54)	Hi-Byte CRC	Lo-Byte CRC

RD-Device-ID	System Status	Temp. Limit	Hi-Byte CRC	Lo-Byte CRC

(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)

no protection

GET_MAX_WARN_TEMP - reads the upper temperature limit that triggers a temperature warning as signed character in °C

no protection

WR-Device-ID	CMD (0x56)	Hi-Byte CRC	Lo-Byte CRC	
RD-Device-ID	System Status	Temp. Limit	Hi-Byte CRC	Lo-Byte CRC

(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)

GET_MIN_SHTDWN_TEMP - reads the lower temperature limit that triggers a temperature error as signed character in °C. This error results in a shutdown of the laser diode.

no protection

WR-Device-ID	CMD (0x58)	Hi-Byte CRC	Lo-Byte CRC	
RD-Device-ID	System Status	Temp. Limit	Hi-Byte CRC	Lo-Byte CRC

(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)

GET_MAX_SHTDWN_TEMP - reads the upper temperature limit that triggers a temperature error as signed character in °C. This error results in a shutdown of the laser diode.

no protection

WR-Device-ID	CMD (0x5A)	Hi-Byte CRC	Lo-Byte CRC	
RD-Device-ID	System Status	Temp. Limit	Hi-Byte CRC	Lo-Byte CRC

(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)

GET_STATUS – reads the module status byte. The module status indicates the status of a LDU module after the previous write transmission.

no protection

WR-Device-ID	CMD (0x60)	Hi-Byte CRC	Lo-Byte CRC			
RD-Device-ID	System Status	don't care	4 Error Bytes	4 Warn. Bytes	Hi-Byte CRC	Lo-Byte CRC

(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)

Error Codes (MSB first) - can't be reset during runtime

Bit 0	ERROR_FLASH_CHECK
Bit 1	ERROR_EEPROM_CHECK
Bit 2	ERROR_RAM_CHECK
Bit 3	ERROR_BOOT_CHECK
Bit 4	ERROR_WRONG_INPUT_VOLTAGE
Bit 5	ERROR_VLD_LEVEL_CHECK
Bit 6	ERROR_SYNCRONISATION_CHECK
Bit 7	ERROR_COMPARATOR_CHECK
Bit 8	ERROR_VIN_OUT_OF_RANGE

Bit 9	ERROR_TWI	
Bit 10	ERROR_UART	
Bit 11	ERROR_HEARTBEAT_MISSING (MMCU-SMCU crosscheck)	
Bit 12	ERROR_MISSING_CALIB	
Bit 13	ERROR_OVER_CURRENT	
Bit 14	ERROR_UNDER_CURRENT	
Bit 15	ERROR_LD_NTC	
Bit 16	ERROR_LD_OVERTEMP	
Bit 17	ERROR_LD_UNDERTEMP	
Bit 18	ERROR_MEMORY_FAIL	
Bit 19	ERROR_EXTRAPOLATION_RANGE	
Bit 20	ERROR_P_SET	
Bit 21	ERROR_CALIBRATION_TABLE	
Bit 22	ERROR_TABLE_INDICES_FAIL	
Bit 23	ERROR_OPERATION_CURRENT_FAIL	
Bit 24	ERROR_INTERPOLATION_TABLE	
Bit 25	ERROR_SMCU_CALIBRATION	
Bit 26	ERROR_PERIPHERAL_CHECK	
Bit 27	ERROR_CMD_EXECUTION	
Bit 28	ERROR_BYPASS_TRANSISTOR	
Warning Codes		
Bit 0	WARNING_LD_NTC_PROBLEM	
Bit 1	WARNING_LD_OVERTEMP	
Bit 2	WARNING_LD_UNDERTEMP	
Bit 3	WARNING_LD_SMALL_POWER_FACTOR	
Bit 4	WARNING_LD_BIG_POWER_FACTOR	
Bit 5	WARNING_CANT_SET_POWER_FACTOR	
Bit 6	WARNING_WRONG_COMMAND	
Bit 7	WARNING_COMMAND_VALUE_OUT_OF_RANGE	
Bit 8	WARNING_ACCESS_VIOLATION	
Bit 9	WARNING_CAN_NOT_SET_RUNNING_MODE	
Bit 10	WARNING_OVER_24_HOURS_ONTIME	
Bit 11	WARNING_EXTRAPOLATION	
Bit 12	WARNING_CAL_T_MIN_MAX_LIMIT	
Bit 13	WARNING_END_Of_LIFE	

GET_ANALOG_MOD_ON_OFF - returns the status of the analog power modulation. (unsigned character: 0 = analog modulation off, 1 = analog modulation on).

no protection

WR-Device-ID	CMD (0x66)	Hi-Byte CRC	Lo-Byte CRC	
RD-Device-ID	System Status	Analog Mod.	Hi-Byte CRC	Lo-Byte CRC

(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)

GET_DIGITAL_MOD_ON_OFF - returns the status of the digital modulation. (unsigned character: 0 = digital modulation off, 1 = digital modulation on).

no protection

WR-Device-ID	CMD (0x68)	Hi-Byte CRC	Lo-Byte CRC	
RD-Device-ID	System Status	DIgital Mod.	Hi-Byte CRC	Lo-Byte CRC

(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)

GET_MODULE_TOTAL_ONTIME - reads the laser modules total operating time after the first power-on as unsigned integer value (2 bytes) in hours.

no protection

WR-Device-ID	CMD (0x78)	Hi-Byte CRC	Lo-Byte CRC			
RD-Device-ID	System Status	Hours HiByte	Hours LoByte	Minutes	Hi-Byte CRC	Lo-Byte CRC

(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)

GET_CALIBRATED_LASER - reads the calibrated laser power in 0.01 mW steps as unsigned integer and wavelength in nm as unsigned integer. This command returns the 100% nominal laser power at the end of the output as well as its wavelength.

no protection

WR-Device-ID	CMD (0x7E)	Hi-Byte CRC	Lo-Byte CRC	
RD-Device-ID	System Status	Power Value Hi	Power Value Lo	Wavelength-Hi
	Wavelength-Lo	Hi-Byte CRC	Lo-Byte CRC	

(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)

GET_MAX_SYST_POWER – reads the maximal electrical Power consumption if the System in Watt (1 byte, hex).

no protection

WR-Device-ID	CMD (0x90)	Hi-Byte CRC	Lo-Byte CRC	
RD-Device-ID	System Status	el. Power [W]	Hi-Byte CRC	Lo-Byte CRC

(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)

GET_WEIGHTED_LIFETIME – reads weigthed lifetime in hours and as percentage of estimated lifetime.

no protection

WR-Device-ID	CMD (0x9E)	0x01	Hi-Byte CRC	Lo-Byte CRC			
RD-Device-ID	System Status	HiByte Hours	LoByte Hours	0	Percentage	HiByte CRC	LoByte CRC

(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)

GET_PART_NO – reads the part number of the LDU by 9 ASCII bytes (0x30…0x39). — no protection

WR-Device-ID	CMD (0xA4)	0x01	Hi-Byte CRC	Lo-Byte CRC

RD-Device-ID	System Status	ASCII Digit 9	…	ASCII Digit 0	Hi-Byte CRC	Lo-Byte CRC

(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)

GET_POWER_OUT_ABS – reads the absolute optical output power of the LDU in 0.01mW steps as unsigned. — no protection

WR-Device-ID	CMD (0xA6)	Hi-Byte CRC	Lo-Byte CRC

RD-Device-ID	System Status	Power Value Hi	Power Val Lo	Hi-Byte CRC	Lo-Byte CRC

(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)

GET_MANUFACTURER_ID – reads the Manufacturer ID of the LDU by 9 ASCII bytes (0x30…0x39). — no protection

WR-Device-ID	CMD (0xBA)	Hi-Byte CRC	Lo-Byte CRC

RD-Device-ID	System Status	ASCII Digit 9	…	ASCII Digit 0	Hi-Byte CRC	Lo-Byte CRC

(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)

GET_PERCENTAGE_POWER_LIMIT – reads the user defined percent power limits — no protection

WR-Device-ID	CMD (0xC4)	Hi-Byte CRC	Lo-Byte CRC

RD-Device-ID	System Status	Max Perc Limit	Min Perc Limit	Hi-Byte CRC	Lo-Byte CRC

(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)

GET_POWER_OUT_ABS – reads the absolute optical output power of the LDU in 0.01mW steps as unsigned. — no protection

WR-Device-ID	CMD (0xA6)	Hi-Byte CRC	Lo-Byte CRC

RD-Device-ID	System Status	Power Value Hi	Power Val Lo	Hi-Byte CRC	Lo-Byte CRC

(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)

GET_FW_VERSION - reads the firmware version as unsigned integer value (3 bytes) — no protection

WR-Device-ID	CMD (0xF0)	Hi-Byte CRC	Lo-Byte CRC

RD-Device-ID	System Status	Major Version	Minor Version	Build	Hi-Byte CRC	Lo-Byte CRC

(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)

GET_SERIAL_NO - get the serial number of LDU by 10 ASCII bytes (0x30…0x39).

no protection

WR-Device-ID	CMD (0xF2)	Hi-Byte CRC	Lo-Byte CRC

RD-Device-ID	System Status	ASCII Digit 9	…	ASCII Digit 0	Hi-Byte CRC	Lo-Byte CRC

(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)

GET_CMD_SET_VERSION - reads the command-set version as unsigned integer value (2 bytes)

no protection

WR-Device-ID	CMD (0xF4)	Hi-Byte CRC	Lo-Byte CRC

RD-Device-ID	System Status	Major Version	Minor Version	Hi-Byte CRC	Lo-Byte CRC

(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)

GET_TWI_ADDRESS - reads the TWI-Address of the device for serial communication.

no protection

WR-Device-ID	CMD (0xFC)	Hi-Byte CRC	Lo-Byte CRC

RD-Device-ID	System Status	TWI-Address	Hi-Byte CRC	Lo-Byte CRC

(Status followed by CRC and trailing fill bytes when data can not be returned instantaneously)

3.4.7 List of write telegrams

Command-Set-Version: 0.3

Feature		Reference
SET_CONFIG_MODE - selects a configuration for the connector pins. If a device is set to a configuration mode without an active communication interface the following sequence has to be sent repeatedly during start up to switch to a new configuration mode: Set_User_Password (0xF5) Set_Configuration_Mode (0x17) As soon as you get a valid answer for both commands, the new configuration mode is active. WR-Device-ID | CMD (0x17) | Config. Mode | Hi-Byte CRC | Lo-Byte CRC RD-Device-ID | Status Byte | Hi-Byte CRC | Lo-Byte CRC (RD transmission can be repeated) **Digital Modulation Input:** PWM input , TTL **Analog Modulation Input:** analog power input **Fail Output:** Active low signal that statically indicates all detected error conditions **Fail Input:** Sets the ZX into failure state. The laser is switched off. A power cycle is required to leave this failure state. **SCL**: Serial Clock Line of TWI interface **SDA:** Serial Data Line of TWI interface **TX:** Transmit Data of UART interface **RX:** Receive Data of UART interface Config. Modes:		User PW protected
0x00	**Modulation_Fail_Out** Pin 1: VCC Pin 2: Digital Modulation Input Pin 3: GND Pin 4: Analog Modulation Input Pin 5: Fail Output	
0x01	**N/A**	
0x02	**UART_Com_Dig_In** Pin 1: VCC Pin 2: Digital Modulation Input Pin 3: GND Pin 4: RX Pin 5: TX	
0x03	**TWI_Com_Dig_In** Pin 1: VCC Pin 2: Digital Modulation Input Pin 3: GND Pin 4: SCL Pin 5: SDA	

0x04	**N/A**	
0x05	**N/A**	
0x06	**UART_Com_Fail_Out** Pin 1: VCC Pin 2: Fail Output Pin 3: GND Pin 4: RX Pin 5: TX	
0x07	**TWI_Com_Fail_Out** Pin 1: VCC Pin 2: Fail Output Pin 3: GND Pin 4: SCL Pin 5: SDA	

SET_LASER_ON – activates the laser emitting. In case of activated analog or digital modulation the corresponding modulation signals has to be additionally applied for emitting.

no protection

WR-Device-ID	CMD (0x41)	Hi-Byte CRC	Lo-Byte CRC
RD-Device-ID	System Status	Hi-Byte CRC	Lo-Byte CRC

This setting cannot be stored permanently; it will turn back to the default value after the next power cycle.

SET_LASER_OFF – deactivates the laser emitting. In case of activated analog or digital modulation the corresponding modulation signals are ignored.

no protection

WR-Device-ID	CMD (0x43)	Hi-Byte CRC	Lo-Byte CRC
RD-Device-ID	System Status	Hi-Byte CRC	Lo-Byte CRC

This setting cannot be stored permanently; it will turn back to the default value after the next power cycle.

SET_LASER_ON_OFF – toggles between SET_LASER_ON and SET_LASER_OFF.

no protection

WR-Device-ID	CMD (0x45)	Hi-Byte CRC	Lo-Byte CRC
RD-Device-ID	System Status	Hi-Byte CRC	Lo-Byte CRC

This setting cannot be stored permanently; it will turn back to the default value after the next power cycle.

SET_POWER_VALUE_IN_PERC - programs the optical output power value as percentage (unsigned character – single byte) of nominal laser power. This Command will be ignored in case of activated Analog Modulation.

no protection

WR-Device-ID	CMD (0x4F)	Power Value	Hi-Byte CRC	Lo-Byte CRC
RD-Device-ID	Hi-Byte CRC	Lo-Byte CRC	(RD transmission can be repeated)	

With SET_DEFAULT_POW_VAL the programmed setting is written to non-volatile memory and stays valid after next power cycle.

Attention: reducing the laser intensity via SET_POWER_VALUE command does not change the laser classification

SET_MIN_WARN_TEMP - programs the lower temperature limit that triggers a temperature warning as signed character in °C

User PW protected

WR-Device-ID	CMD (0x55)	Temp. Limit	Hi-Byte CRC	Lo-Byte CRC
RD-Device-ID	System Status	Hi-Byte CRC	Lo-Byte CRC	(RD transmission can be repeated)

SET_MAX_WARN_TEMP - programs the upper temperature limit that triggers a temperature warning as signed character in °C

User PW protected

WR-Device-ID	CMD (0x57)	Temp. Limit	Hi-Byte CRC	Lo-Byte CRC
RD-Device-ID	System Status	Hi-Byte CRC	Lo-Byte CRC	(RD transmission can be repeated)

SET_ANALOG_MOD_ON_OFF - programs the status of the analog power modulation. (unsigned character: 0 = analog modulation off, 1 = analog modulation on).

User PW protected

WR-Device-ID	CMD (0x67)	Analog Mod.	Hi-Byte CRC	Lo-Byte CRC
RD-Device-ID	System Status	Hi-Byte CRC	Lo-Byte CRC	(RD transmission can be repeated)

SET_DIGITAL_MOD_ON_OFF - programs the status of the digital power modulation. (unsigned character: 0 = digital modulation off, 1 = digital modulation on).

User PW protected

WR-Device-ID	CMD (0x69)	Digital Mod.	Hi-Byte CRC	Lo-Byte CRC
RD-Device-ID	System Status	Hi-Byte CRC	Lo-Byte CRC	(RD transmission can be repeated)

SET_REVERT_POW_FACTOR – Sets the optical output power to 100% and saves it as default value. A power cycle is necessary to apply these changes.

User PW protected

WR-Device-ID	CMD (0x6D)	Hi-Byte CRC	Lo-Byte CRC
RD-Device-ID	System Status	Hi-Byte CRC	Lo-Byte CRC

(RD transmission can be repeated)

SET_DEFAULT_POW_VAL – writes the programmed power value setting to non-volatile memory that it stays valid after next power cycles.

User PW protected

WR-Device-ID	CMD (0xF7)	Hi-Byte CRC	Lo-Byte CRC
RD-Device-ID	System Status	Hi-Byte CRC	Lo-Byte CRC

(RD transmission can be repeated)

SET_TWI_ADDR – sets a new device ID for TWI and UART interface.

User PW protected

WR-Device-ID	CMD (0xFD)	Device ID	Hi-Byte CRC	Lo-Byte CRC
RD-Device-ID	System Status	Hi-Byte CRC	Lo-Byte CRC	

(RD transmission can be repeated)

3.4.8 Communication Procedures

After every write telegram (SET_*) it is necessary to wait until the command has been completely executed. No write telegram will be processed until the execution of a previous one has been completed.
The regular read transmission of a write telegram returns the system status. If the status indicates a “busy” (Bit 0 = 1) then the write telegram has not yet been completed. The TWI host can then repeat this read transmission multiple times until the “busy” flag indicates the completion (Bit 0 = 0).
All subsequent TWI telegrams are discarded before the busy bit is reset. The returned status indicates a discarded telegram with a “NACK” flag (Bit 3 = 1). Upon receiving a “NACK” status of a telegram, the TWI host should repeat the complete first write telegram to confirm the successful completion.
Some read telegrams cannot provide instantaneous return data. The read transmission indicates this with a “busy” flag (Bit 0 = 1) in the system status. In this case, no data payload is returned, instead the CRC-TGM is appended as well as the respective number of fill bytes.
The TWI host can repeat the read transmission multiple times until the busy flag is reset (Bit 0 = 0) and valid data are returned. A premature TWI telegram is discarded and its read transmission returns a “NACK” flag in the system status. To receive the previously requested data, the TWI host must repeat the completed first read telegram.

3.5 How to control the laser

The driver electronics of the “ZX” laser module has a digital control interface; it can statically be controlled via TWI or UART.
Attention: reducing the laser intensity via TWI or UART telegrams does not change the laser classification.

3.5.1 Static laser output power via TWI or UART

The laser output power of the “ZX” module can be controlled statically via TWI or UART telegrams. The user has to take care in understanding how the laser power is controlled in principle.
The laser power cannot be adjusted directly since there is no calibrated measurement implemented for the “laser power out of the laser diode”. Instead the laser power is controlled by adjusting the laser current. Keeping the laser current under control is the most reliable way to prevent mode hopping and to provide low noise in the laser light.
The calibration of the output power of the entire laser module is done during a multi-dimensional calibration procedure in the manufacturing process. The maximum laser power is referred to as 100%. The laser control system preserves this nominal power throughout the entire lifetime and the entire specified temperature range. The user can set the output power individually linearly between ~10% and 100%. The target percentage is set via TWI or UART telegram (see chapter 3.4.7) or via the analog modulation (pin 4 in Modulation_Fail_Out or Modulation_Fail_In Configuration Mode). The control system preserves the user set power value over the temperature range and lifetime.

3.6 LED status indication

Note: the LED's are placed close to the connector at the back end of the laser module.

LED Indication

- ➔ Laser ON Indication (laser emits)
- ➔ Ready Status; Blink Codes Indication for different warning/failure identification.

Behavior	Meaning
Green LED blinks fast (10Hz): 	System Startup
Green LED permanently ON 	Ready Status. No pending errors or warnings. Laser is ready to emit.
Orange LED permanently ON 	Laser emits. No pending errors or warnings.
Green LED blinks with long pulses,  Pulse 1 Pulse 2 Pulse n laser off Warning Blink Code n, laser off	Laser is ready to emit. One or more warnings pending. The number of green blinking pulses corresponds with warning code. If there are more than one warning pending, only the first warning that occurred is displayed. Warning Blink Codes:
	1: Not Used
	2: over/under temperature warning
	3: Not Used
	4: wrong power value
	5: cannot set power factor
	6: wrong command
	7: command value out of range
	8: warning access violation
	9: over 24 hours on time
	10: Not Used
Green LED blinks with long pulses, orange LED is on during two blink sequences  Pulse 1 Pulse 2 Pulse n laser emits Warning Blink Code n, laser emits	Laser emits. One or more warnings pending. The number of green blinking pulses corresponds with warning code. The orange blinking pulse signalizes the emitting laser. If there are more than one warning pending, only the first warning that occurred is displayed. Warning Blink Codes see table above.
Green LED blinks with short pulses	Laser can't emit due to one or more pending errors. The number of green blinking pulses

 Pulse 1 Pulse 2 ... Pulse n Error Blink Code n	corresponds with error code. If there are more than one error pending, only the first that occurred is displayed. Error Blink Codes:
	1: Not Used
	2: over/under temperature shutdown
	3: wrong Vin voltage
	4: internal error
	5: internal error
	6: NTC damaged
	7: internal error
	8: operation current fail
	9: over/under LD current
	10: internal error
	11: comparator check fails
	12: peripheral check
	13: heartbeat missing
	14: Vld Level check fails
	15: Not Used
	16: safety hardware fails
Alternate blinking of green and orange LEDs 	Fatal Error. Hardware defect.
Alternate double blinking of green and orange LEDs 	Fatal Error. Flash memory defect.

4 System Safety functions

The ZX laser driver unit (LDU) features HW and SW functions to support a fail-safe laser system. The software of the main microcontroller unit (MMCU) has no capability to switch on the laser on its own. A secondary microcontroller unit (SMCU) verifies every important process related to the laser emission and releases it. All diagnosis and security resources operate independently from the main laser driver circuit. Time critical security features are built by fast-acting discrete electronic circuits.

Optional configurations require a user password to be transmitted via TWI or UART in order to operate the laser; these cannot be switched on without using a host computer system.

4.1 Diagnosis and security functions

Feature
Independent Hardware resources for main functions and surveillance tasks. The main MCU (MMCU) runs with a voltage supply VCC_M which is derived from the primary power supply. The voltage supply for the MMCU can be shut down by the SMCU. The surveillance MCU (SMCU) operates from independent supply voltage VCC_S which is derived from the primary power supply. It supervises critical tasks performed by the MMCU.
Redundant sensors for laser system parameters Each laser includes two redundant sensors. The first sensor is operated by a first reference voltage and is used by the MMCU. The second sensor is operated by a second reference voltage and is used by the SMCU. The reference voltages are independent from each other. The sensor operated by the SMCU is used only for plausibility checks of all derived system settings. The SMCU verifies the measurements and acts in case of malfunctions.
Functional safety of method to control the laser power DAC-1 generates an accurate Laser Current for the laser diode and is operated by the MMCU. DAC-2 generates a maximum current level for a permanent current surveillance and is operated by the SMCU. The threshold current level set by the DAC-2 is dynamically calculated using sensor measurements. An over-current event activates the current bypass block in less than 1 µs. (FTT/FTZ) The laser diode is thus effectively bypassed. Both, the MMCU and the SMCU monitor the over current event. Upon an over current event a system wide shut down is initiated by either the MMCU or the SMCU (Reaction time < 10 ms). The laser will enter an error state.
Power up checks of the MMCU and the SMCU

Safety surveillance functions are tested to ensure that no single failures are accumulated. In every system startup the following functions are self-tested as well as typical failure conditions.

RAM test, ROM test, EEPROM test of SMCU and MMCU
Power Domain test of MMCU and SMCU
Test of bypass devices
Test of power supply voltages
Tests of reference voltages
Tests of sensor devices
MMCU and SMCU setup the system for a new laser current

Attention: In case of a failure it might not be possible to conduct any subsequent procedure in the planned way! Only the system shutdown is ensured because both MCU's are controlling each other.

Permanent monitoring of the MCU's sanity

To prevent an undetected accumulation of faults both MCU's conduct a permanent cross check (Heartbeat check). The MMC's send alternating tokens every 10 milliseconds to each other. After 10 missing tokens either MCU assumes that the counterpart is unavailable and shuts down the entire system (ERROR Bit 13)

Independent methods of laser power shut-down

Ordinary functional switch via digital modulation control (ZX Connector Pin 2). This switch must be released by MMCU and SMCU to take effect.

System shut-down by the SMCU via an independent laser power supply switch. In an emergency state the SMCU can disable the laser diode's current supply.

Over current shut-down via laser current bypass switch (LD Bypass). This is a very fast switch that bypasses the laser diode in an emergency state. Every over current event will alert both MCU's and a system shut-down will be carried out by the SMCU or the MMCU.

MFDT (multi-failure detection time, German: „Mehrfehler-Erkennungszeit" MFEZ)
System sanity checks are conducted with every power cycle. Thus the maximum MFDT is defined as longest on-time of the LDU. 24 hours after a power cycle a warning will be issued and a new self-test will be requested. (Warning Bit 10, warning LED code 9)

FTT (failure tolerance time, German: „Fehlertoleranz-Zeit" – FTZ)
A potentially harmful laser power must be detected and prevented within less than 1µs.
SFTY: A laser power that leaves the range of +/- 20% of the pre-set power value must be detected and prevented within 10 ms.

5 Using the Z-Remote Software to operate the laser module

5.1 Introduction

Z-Remote is a software that enables the communication between a laser module and a PC via UART connection. This software helps you to understand the principal communication with a ZX module and allows you to control and configure it.

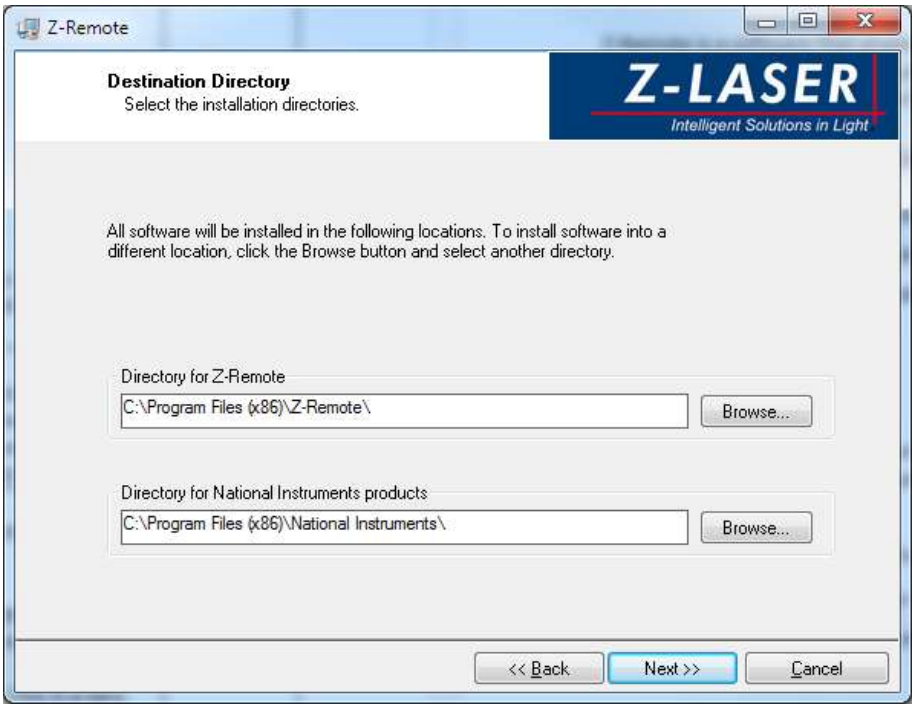
5.2 Supported Operating Systems

Windows 10	(32-Bit Edition / 64-Bit Edition)
Windows 8	(32-Bit Edition / 64-Bit Edition)
Windows 7	(32-Bit Edition / 64-Bit Edition)

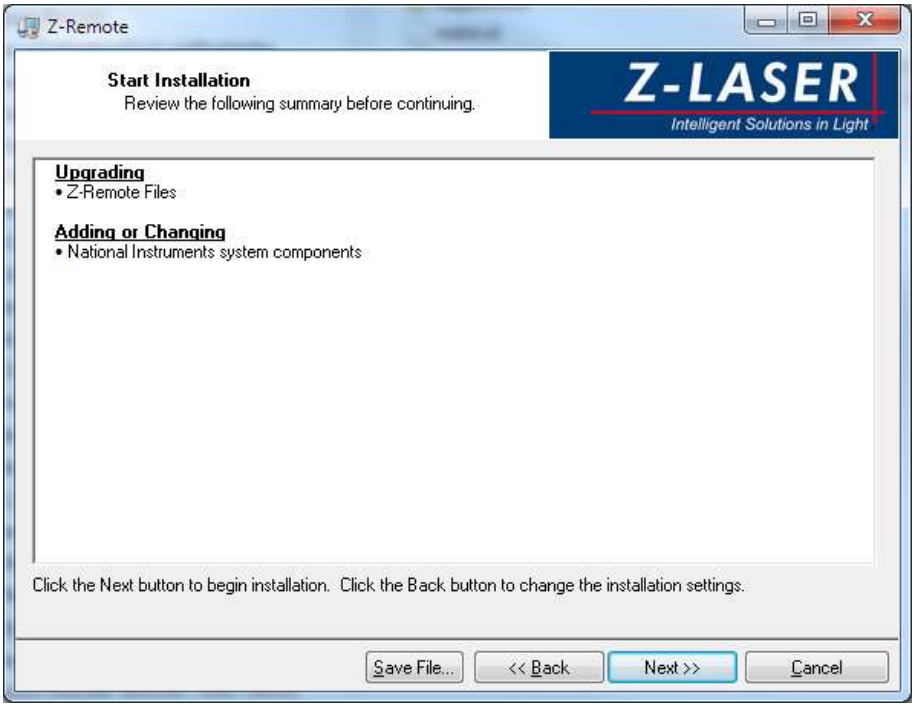
5.3 Installation

This section explains the procedure to install Z-Remote. Follow the steps described below when ZFSM Remote is not installed at your PC.

1. Download the Z-Remote from Z-Laser homepage.
2. Double-click "`Z-Remote-Installer\Volume\setup.exe`"
3. You can select the folder you want to install Z-Remote. Click **Next>>**

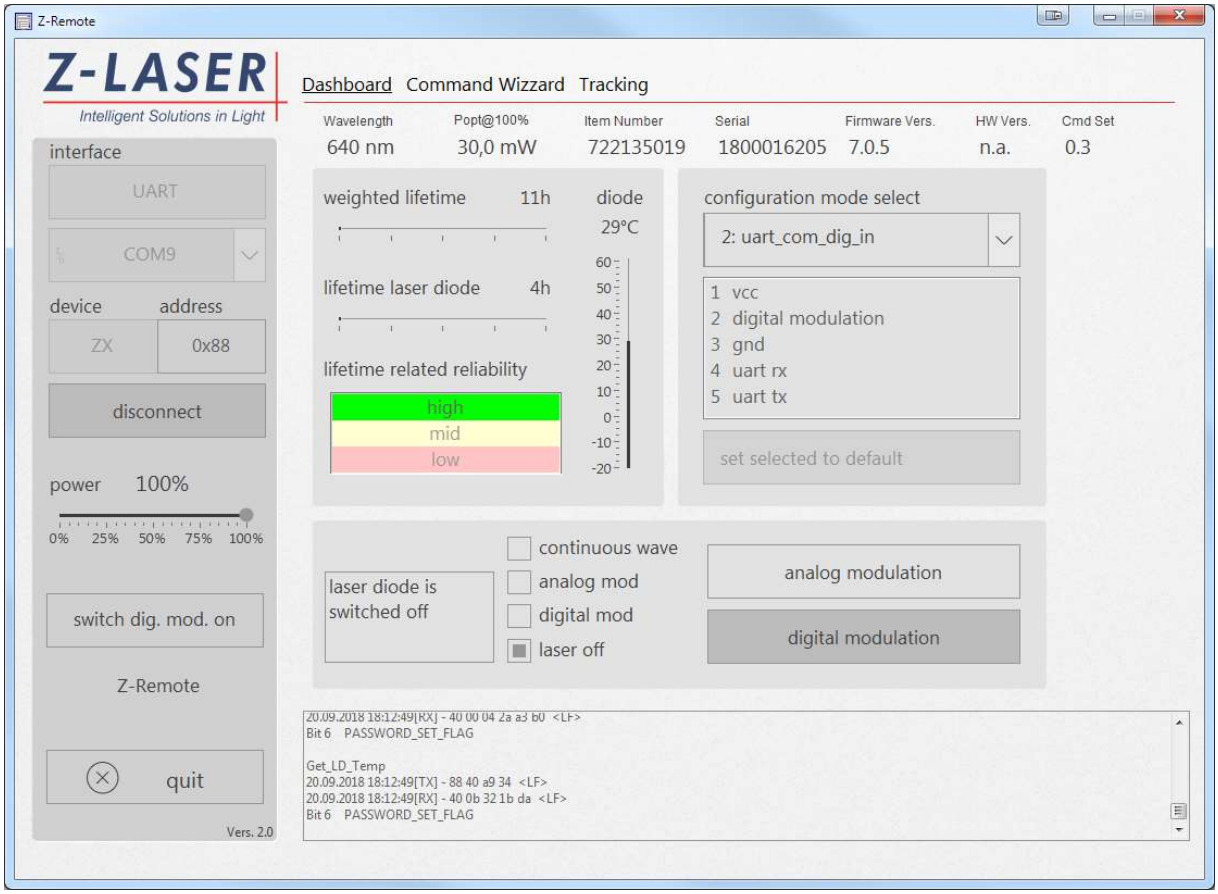


4. The following window gives you a summary of the parts to be installed. Click the **Next>>** button to start the installation process. This can take several minutes.

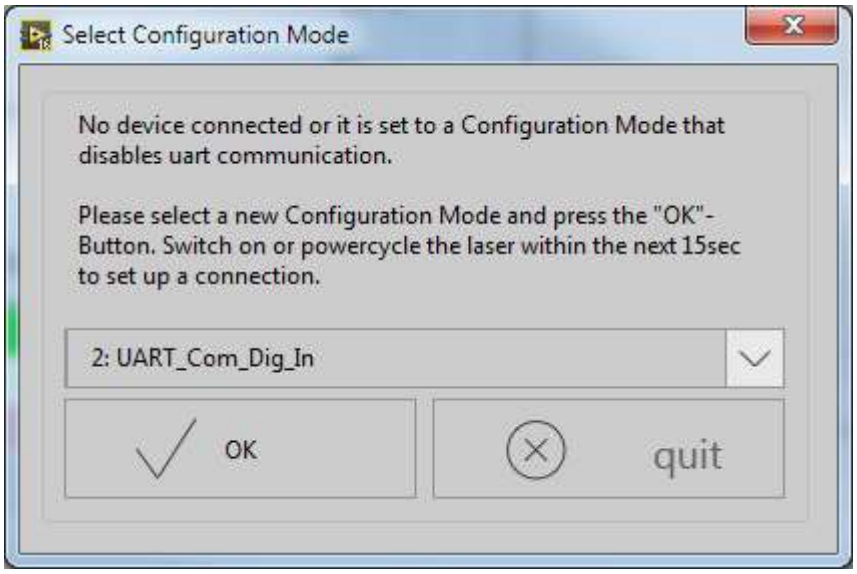


5. Installation Completed. Please restart your Computer to finish this installation.

5.4 Start Z-Remote

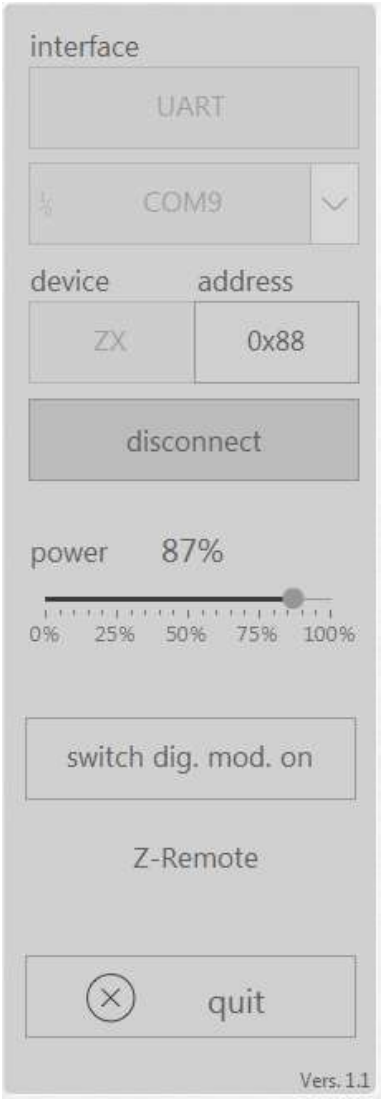


1. Connect the ZX module with your PC and start Z-Remote (see 3.1).
2. Use the pull-down menus in the interface section to select the communication protocol (e.g. UART) and the corresponding COM Port assigned to the ZX module.
3. Select the device type you want to control (ZX).
4. Select the device address. The default address is 0x88 for TWI and UART connections.
5. Press “connect” button.
6. A dialog window appears. Select a Configuration Mode for the following session. Please note that the selected configuration mode supports the required protocol (e.g. Mode 2 for UART communication).



7. Press “OK” button.
8. Switch on or power cycle the ZX module within the next 15 sec to set up a connection.

5.5 Control elements of remote section



5.5.1 Interface

Use both controls to select a communication protocol and the COM port assigned to the ZX module.

5.5.2 Device Control

Use this control to select between different laser models.

5.5.3 Address Control

Use this control to set the device address. Default value for UART and TWI communication: 0x88

5.5.4 Connect Button

Use this button to connect/disconnect the laser module.

5.5.5 Optical Power Control

This item controls the optical output power. You can enter a new value by writing it into the control or by moving the slider. The output power is set as percentage of the nominal output power.

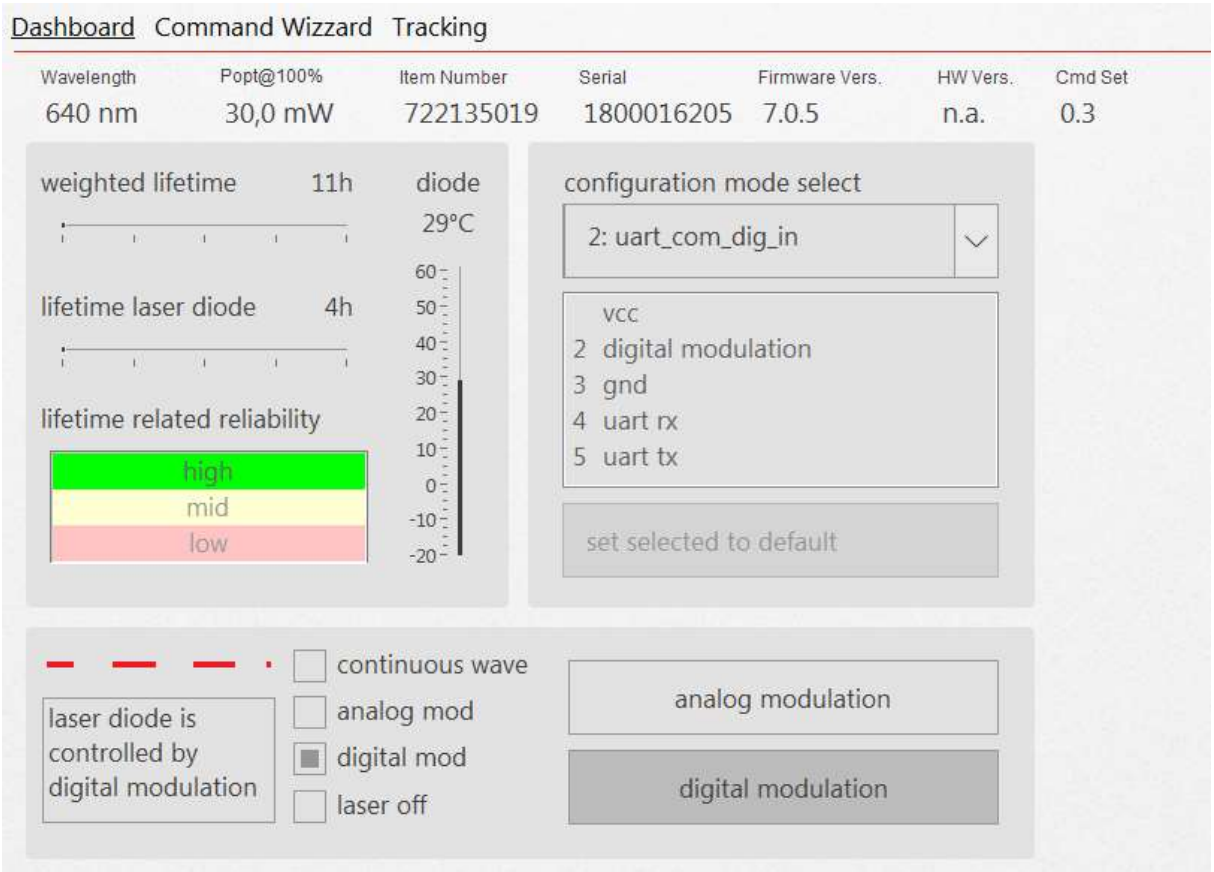
5.5.6 Laser on Button

Use this button to toggle between laser off and the selected laser modulation (digital modulation, analog modulation or continuous wave).

5.5.7 Quit Button

This button closes Z-Remote software

5.6 Dashboard Tab



5.6.1 Wavelength Indicator

This display indicates the laser wavelength [nm] of the connected ZX module.

5.6.2 Popt@100% Indicator

This display indicates the nominal optical output power [mW] with the power control set to 100%.

5.6.3 Item Number Indicator

This display indicates the Item Number of the connected ZX module.

5.6.4 Serial Number Indicator

This display indicates the Serial Number of the connected ZX module.

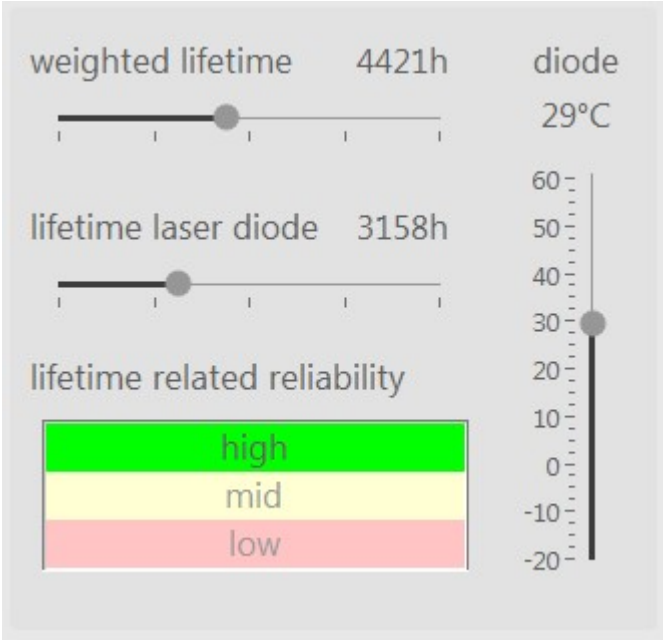
5.6.5 Firmware Vers. Indicator

This display indicates the Firmware Version of the connected ZX module.

5.6.6 HW Vers. Indicator

This display indicates the Hardware Version of the connected Laser. Please note, not all types laser support this functionality.

5.7 Lifetime Section



5.7.1 Weighted Lifetime Indicator

This display indicates the weighted lifetime in hours.

5.7.2 Lifetime Laser Diode Indicator

This display indicates the accumulated operating hours of the laser diode.

5.7.3 Diode Temperature Indicator

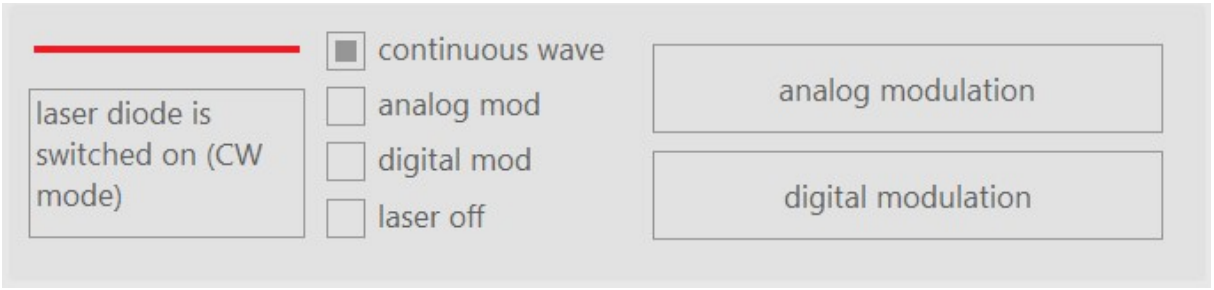
This display indicates the current laser diode temperature [°C].

5.7.4 Lifetime Related Reliability Indicator

This display indicates the weighted lifetime related reliability.

5.8 Modulation Section

This section indicates and describes and controls the laser modulation.



5.8.1 Modulation Indicator

This display indicates and describes the current laser modulation setting.

- Continuous wave: The laser module emits continuously
- Analog modulation: the optical output power is controlled with Pin 4 (analog modulation).
  Please note: This feature is only available in configuration modes 0 and 1.
- Digital modulation: switch the laser on and off with Pin 2(digital modulation).
  Please note: This feature is only available in configuration modes 0, 1, 2 and 3.
- Laser off: The laser module doesn't emit.

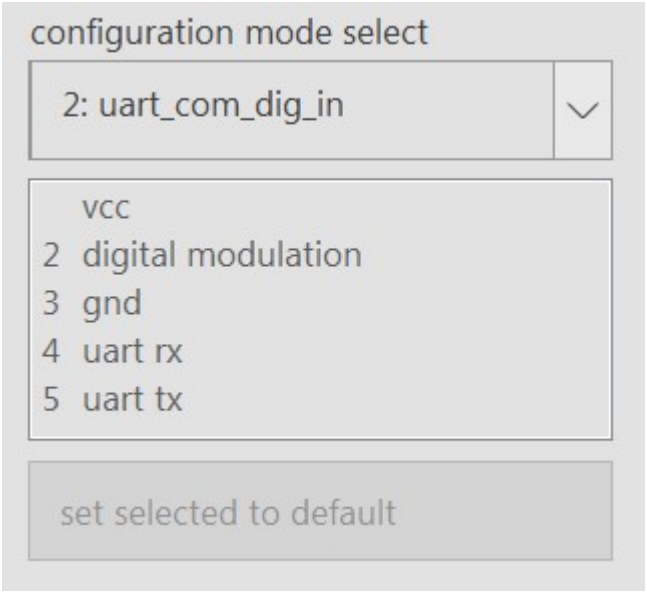
5.8.2 Analog Modulation Button

Press this button to activate analog modulation.

5.8.3 Digital Modulation

Press this button to activate digital modulation.

5.9 Configuration Mode Select Section



5.9.1 Configuration Modes Select Control

Use this control to select one of the available Configuration Modes.

5.9.2 Configuration Mode Description

This item shows the pin configuration of the selected configuration mode.

5.9.3 Set Selected To Default Button

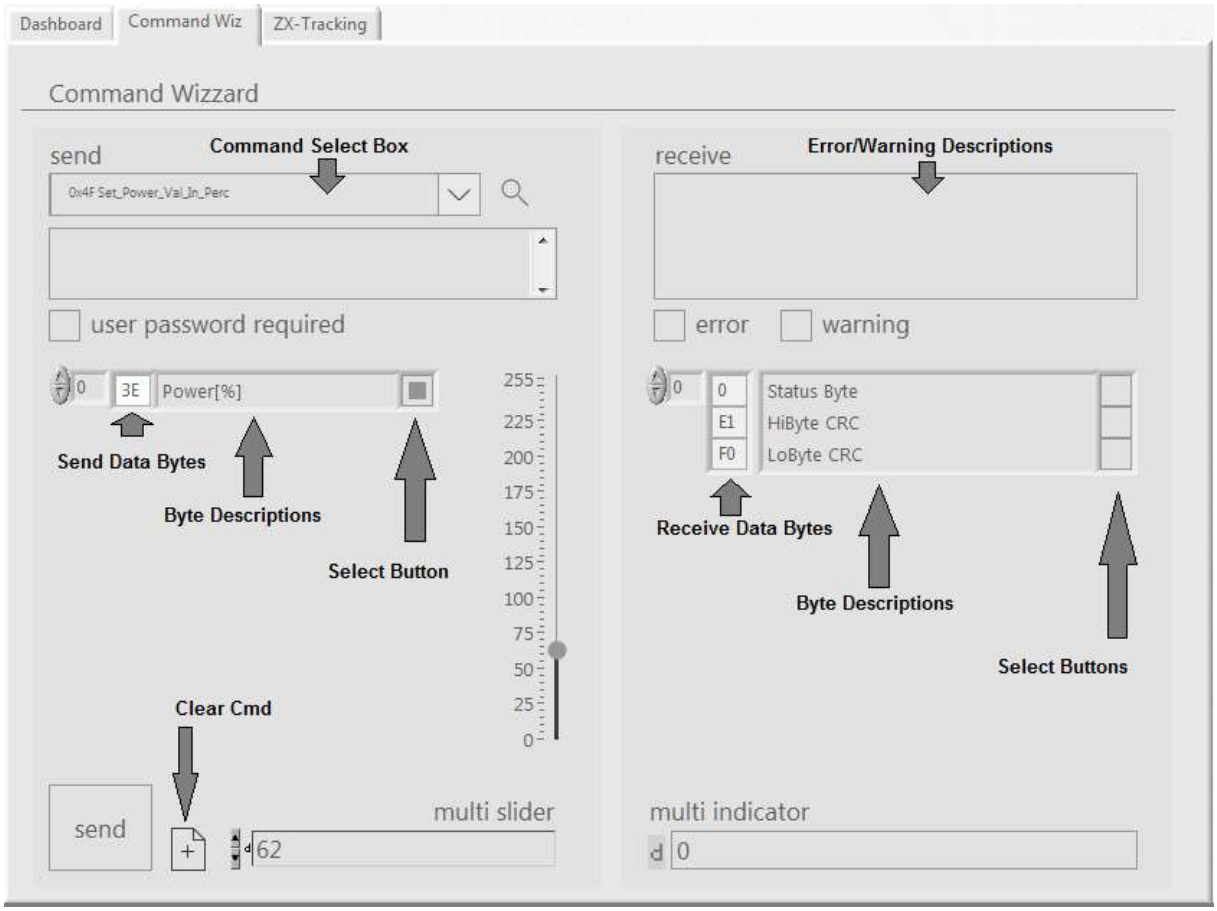
Use this button to set the selected configuration mode as default mode for connected ZX module.

5.10 Communication Log Window

Displays a history of all sent and received command with a time stamp. All commands are displayed as hexadecimal values.

5.11 Command Wizard Tab

By using the Command Wizard you can build all available commands manually. This Wizard can help you to develop own communication interfaces for ZX modules. It gives you a short description of every byte used in command or receive frames. The required CRC bytes are calculated automatically.



5.11.1 Command Select Box

Select a command you want to create manually. Based on this selection the corresponding byte descriptions and frame dimensions are set below.

5.11.2 Search Button

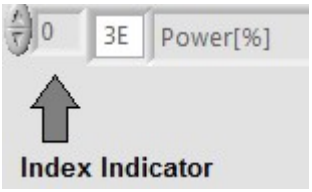
Press this button to search for a certain command.

5.11.3 Command Description Box

This item displays a short description of the selected command.

5.11.4 Send Data Bytes

Array with all data bytes required for selected command. The number of displayed bytes is related to the selected command. If a command contains more than ten data bytes it can't be displayed in total. In this case you have to adjust the array index to access a specific data byte.



5.11.5 Byte Descriptions (Send Section)

Short descriptions for every data byte.

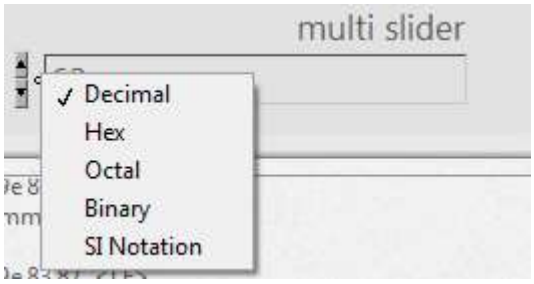
5.11.6 Select Buttons (Send Section)

You can assign every single data byte to the Multi Slider by pressing the corresponding Select Button.

5.11.7 Multi Slider

Use the Multi Slider to display and adjust the values of assigned data bytes. If more than one byte is assigned, all bytes are joint to a single value (Big-Endian).

An additional input box at the bottom of the slider allows you to display or adjust the assigned data bytes in different numeral systems (e.g. hexadecimal or decimal). Click on the radix at the left side to change the numeral system:



5.11.8 Send Button

Press this button to send the command. The Communication Window below shows the sent command in total.

The received response command is displayed in the Receive Section at the right side immediately.

5.11.9 Clear Cmd Button

Click this button to clear all data bytes.

5.11.10 Error Indicator

Signaling ZX errors decoded in status byte of response command.

5.11.11 Warning Indicator

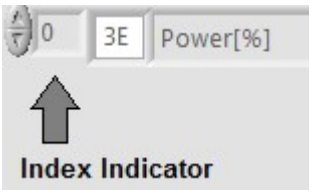
Signaling ZX warnings decoded in status byte of response command.

5.11.12 Error/Warning Description

Short description of errors and warnings decoded in status byte.

5.11.13 Receive Data Bytes (Receive Section)

Array showing all data bytes of the response command. The number of displayed bytes is related to the sent command. If a response command consists of more than ten bytes it can't be displayed in total. In this case you have to adjust the array index to access a specific data byte:



5.11.14 Byte Descriptions (Receive Section)

Short descriptions for every data byte.

5.11.15 Select Buttons

You can assign every single data byte to the Multi Indicator by setting the corresponding select button.

5.12 ZX-Tracking Tab

5.12.1 Start Button (laser diode current section)

This button activates the tracking of the laser diode current. Toggle this button to reset the corresponding diagram.

5.12.2 Laser Diode Current Diagram

This diagram shows the progress of laser diode current.

5.12.3 Sample Time Controls

Use this control to adjust the sample time of the corresponding tracking value.

5.12.4 Start Button (temperature section)

This button activates the tracking of the laser diode temperature. Toggle this button to reset the corresponding diagram.

5.12.5 Laser Diode Temperature Diagram

This diagram shows the progress of laser diode temperature.

6 Drawings

6.1 ZX20 (fixed focus)

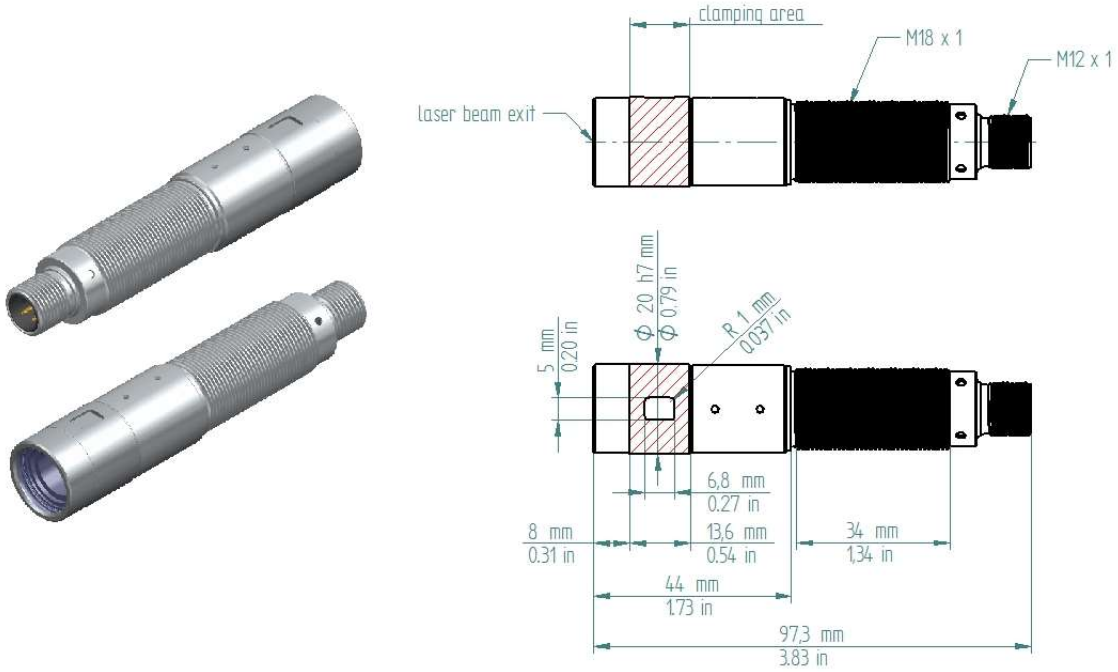


Figure 4: ZX20 (fixed focus)

6.2 ZX20-F (focusable)

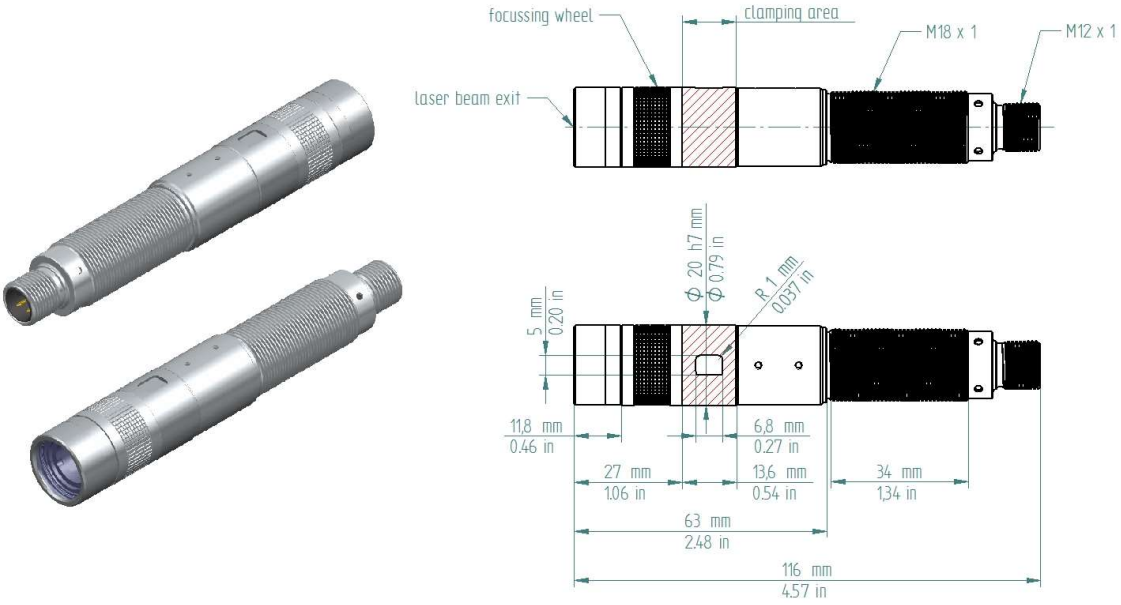


Figure 5: ZX20-F (focusable)

6.3 ZXS20 (separated electronics, fixed focus)

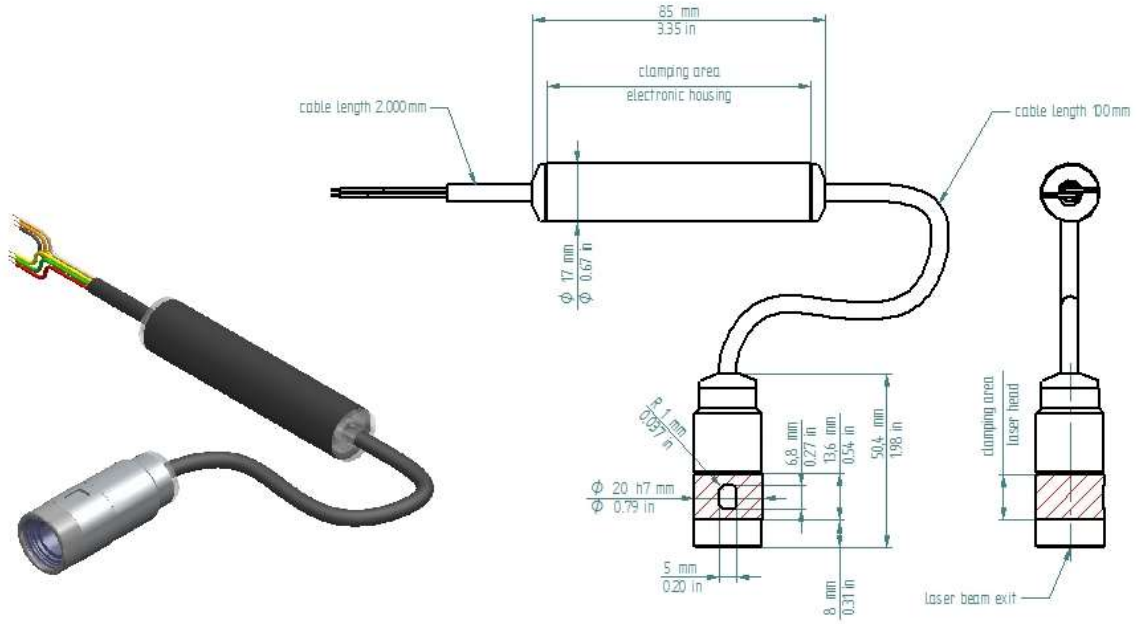


Figure 6: ZXS20 (separated electronics, fixed focus)

6.4 ZXS20-F (separated electronics, focusable)

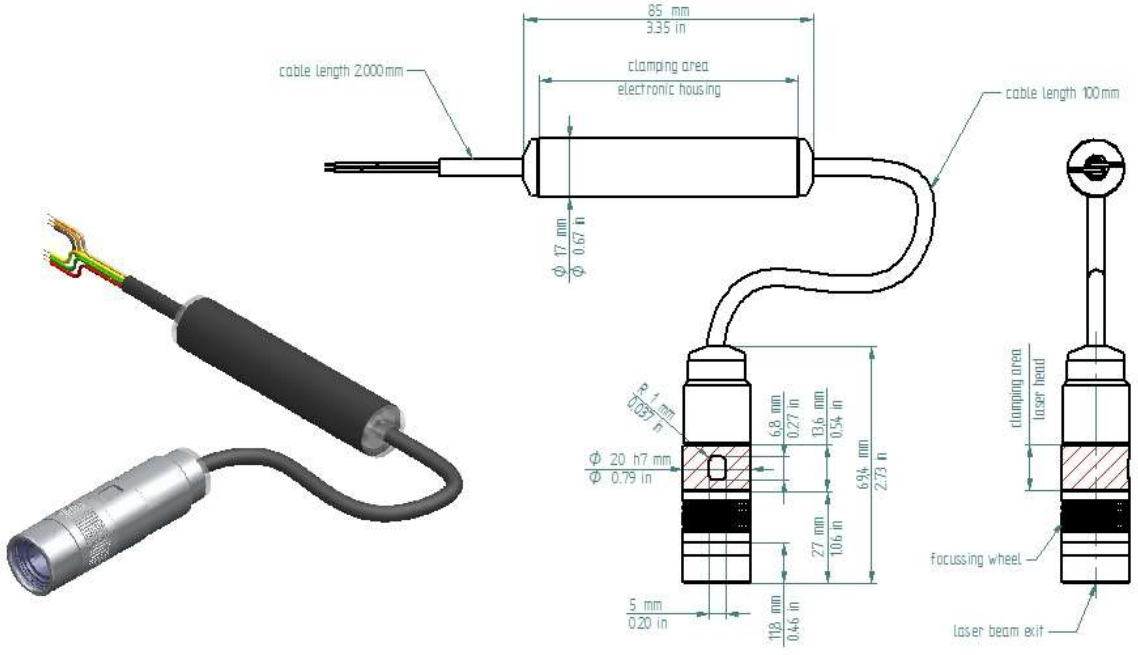


Figure 7: ZXS20-F (separated electronics, focusable)

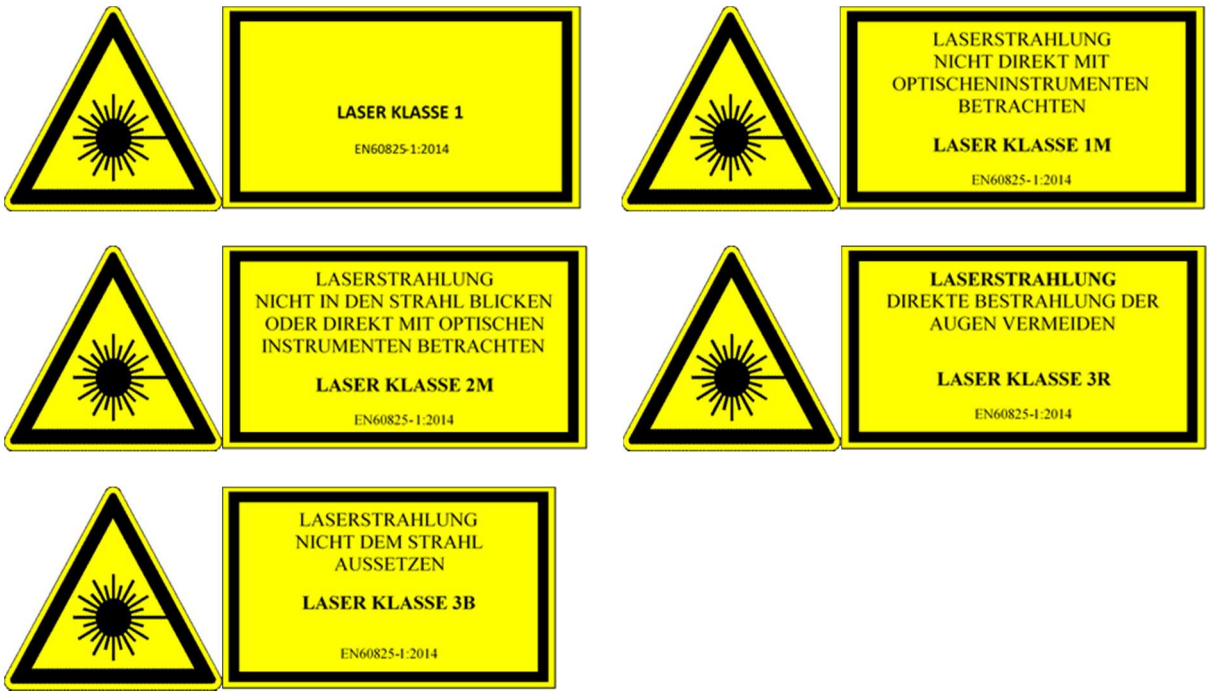
7 Product Labelling

The ZX laser module is labelled with a nameplate and a laser class sticker. If one of these labels is missing, do not operate the laser.

Nameplate (example):
The ZX nameplate contains the Z-LASER product code (first row), part number, serial number as well as company information and CE-label.

Figure 8: ZX nameplate

Laser class label:



Z-Laser declares the conformity to a laser safety class according to EN ISO 60825-1 only for the complete product entity. Whenever this entity is changed the laser safety class is voided.

8 Product Warranty

Z-LASER guarantees its ZX products to be free of material and workmanship defects for two year from the date of shipment or 10,000 hours of operation (depending on the model), whichever comes first. This warranty is in lieu of all other guarantees expressed or implied and does not cover incidental or consequential loss.

Any modification of the product voids the warranty. Moreover it will bear the risk of changing the laser class of the product (Refer to Chapter 2 Laser Safety).

9 Service

No special service measures have to be taken to preserve the specified functionality. The degradation with aging of the laser diode can be compensated for by adjusting the laser current statically or dynamically. The laser modules are shipped with enough headroom for an operating time of at least 10,000 hours.
Z-Laser can guarantee a MTTF of at least 10,000 hours for the ZX laser module when operated within the specified temperature limits. Most likely the MTTF is significantly higher.
The accumulated ON-time of the laser is tracked by the microprocessor and is shown in the GUI (refer to chapter 5) or can be read via a TWI telegram (refer to chapter 3.4.6). Other parameters can be read that give an indication of module aging as well (laser current needed to yield a certain optical output power). Thus it can be decided when a spare unit needs to be provided or when the target system needs service.

10 In the case of a damage

The ZX laser module is considered damaged when it has any visible damage to optical surfaces or electrical contacts, the optical output does not emit light, the LEDs indicate errors after self-test procedures or light intensity can obviously not be controlled as expected.

Please contact Z-LASER Service.

When calling Z-LASER, please provide the following information to the customer care representative:

- Your Contact Information
- Serial number or original order number
- Description of problem (i.e., hardware or software)

Please ask for a RMA Tracking No. before returning the laser module.

11 Disposal

The ZX laser product is an electronic device that must not be disposed via ordinary waste bins. The product must be disposed according to EU directive WEEE 2002/96/EG.

12 Declaration of Conformity

Conformity to EMC standards refers only to complete ZX modules and does not include customer cabling.

Name/Product: ZX

ZX

meets the requirements of the directives 2014/30/EU and 2011/65/EU.

The product is RoHS compliant and free of silicone.

The following standards were applied:

EN 60825-1:2014
EN 13849-1:2016-6
EN 61000-6-4:2011-9
EN 61000-6-2:2005

CE

Product „ZX“

Manufactured by

Z-Laser Optoelektronik GmbH
Merzhauserstr. 134
D-79100 Freiburg

Complies to:

2014/30/EU	EMC guideline
2011/65/EU	RoHS guideline

13 Glossary

ADC: Analog to Digital Converter

DAC: Digital to Analog Converter

CW: Continuous wave

GUI: Graphical user interface, represented by the “Z-Remote” Software

LCByp: Laser Current Bypass, safety switch to test the system integrity and shut down the laser current in case of emergency

LCsw: Laser current main switch

LD: Laser Diode

LDU: Laser Driver Unit

MCU: Micro Controller Unit (main unit)

MMCU: Main Micro Controller Unit (functional unit)

SFTY: specification item related to a safety critical laser product

TWI: Two Wire Interface, refers to serial user communication interface (I2C or RS232)