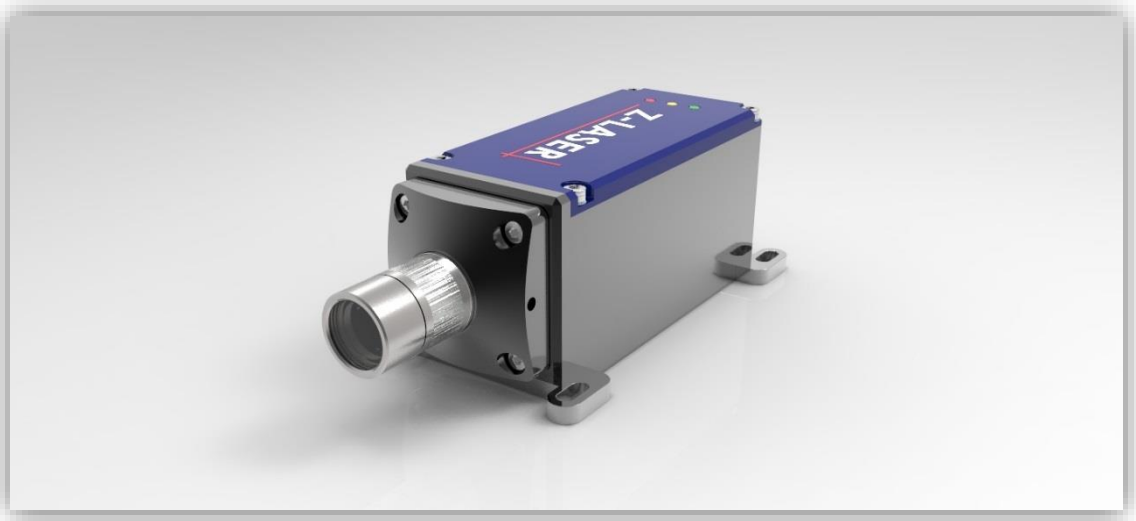
Z-LASER
Intelligent Solutions in Light



ADVANCED INFORMATION
Laser Operator's Manual
ZQ1

As a structured light, the laser source ZQ product family offers both high performance and outstanding beam properties. The newest developed ZQ1 improves the projection once more. The laser, along with intelligent surveillance functions, enables a high stability in performance and wavelength. Additionally, the user can configure and read a large amount of the laser's parameters through. The software also allows the laser line generator to be controlled remotely.

UI-ZL-150008-0.9-2017-09-13

Merzhauser Str. 134 ~ 79100 Freiburg ~ Tel.: +49-(0)761-29644-44 ~ Fax: +49-(0)761-29644-55
info@z-laser.de ~ www.z-laser.com

CAUTION NOTE

PLEASE READ THE ENTIRE MANUAL BEFORE ATTEMPTING TO OPERATE THIS PRODUCT.

OPERATING THIS PRODUCT USING PROCEDURES OTHER THAN THOSE SPECIFIED HEREIN MAY RESULT IN HAZARDOUS RADIATION EXPOSURE OR FAILURE.

AVOID EXPOSURE TO DIRECT OR SCATTERED RADIATION FROM THE LASER.

It is extremely important to follow laser safety rules and wear appropriate protective eyewear when working around these lasers. As a general rule, you should avoid eye or skin exposure to direct or scattered radiation from these lasers.

All laser safety-warning labels are provided on the Unit and comply with IEC 60825-1

This Product is in full compliance with the European IEC 60825-1 and the United States CDRH laser Safety Regulations.

CAUTION-

Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

Notice

Contents in this technical document can be changed without any notice due to the product modification. In the absence of confirmation by device specification sheets, Z-LASER takes no responsibility for any defects that may occur in equipment using any Z-LASER devices.

1. Introduction

The “ZQ1” laser module is a customized laser module for integration into industrial products. It is a very compact laser unit which includes the complete electronics as well. With up to 1.7 W output power it provides enough power for most machine vision applications. Due to the free focus functionality and an active temperature management the optical output performance in e.g. a line, is nearly perfect and does not alter over temperature changes. Read the following user instructions carefully to learn how to use and operate it as designed.

1.1 About this Document

This is a users’ manual in a preliminary version. Some descriptions of the ZQ1 product may not be clear enough or may suffer a lack of details. At the time this document was issued some properties and some product options were not yet released in their final form. Both, the description and the product itself keep evolving based on customer feedback and ongoing product improvement.

Please read chapter 11.3 “Errata” for non-compliances with to the specification.

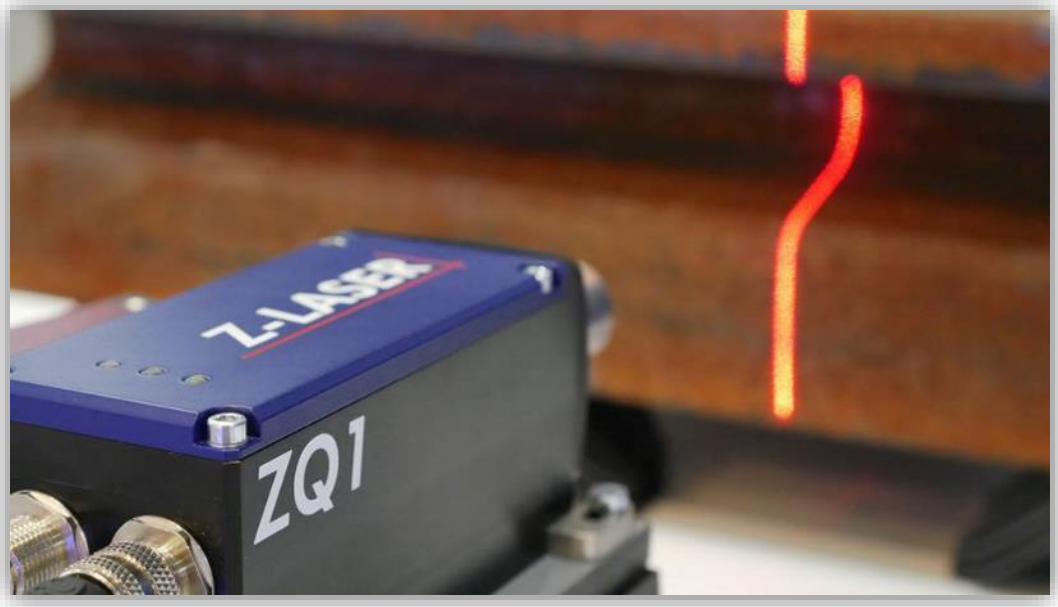
1.2 Application and Benefits of ZQ1 Laser

- High Power in a Compact Size
- Superior beam shaping
- Externally focusable

- High Pointing stability
- Integrated monitoring and modulation features
- Ingress Protection Marking → IP67

Applications

- Machine Vision
- Industrial Inspection
- Bio-medical



1.3 Upon Receiving the Delivery

Upon receiving this delivery, please carefully check the product for potential damage. If you discover any damage please report it immediately to Z-LASER. In the case of physical damage do not operate the product!

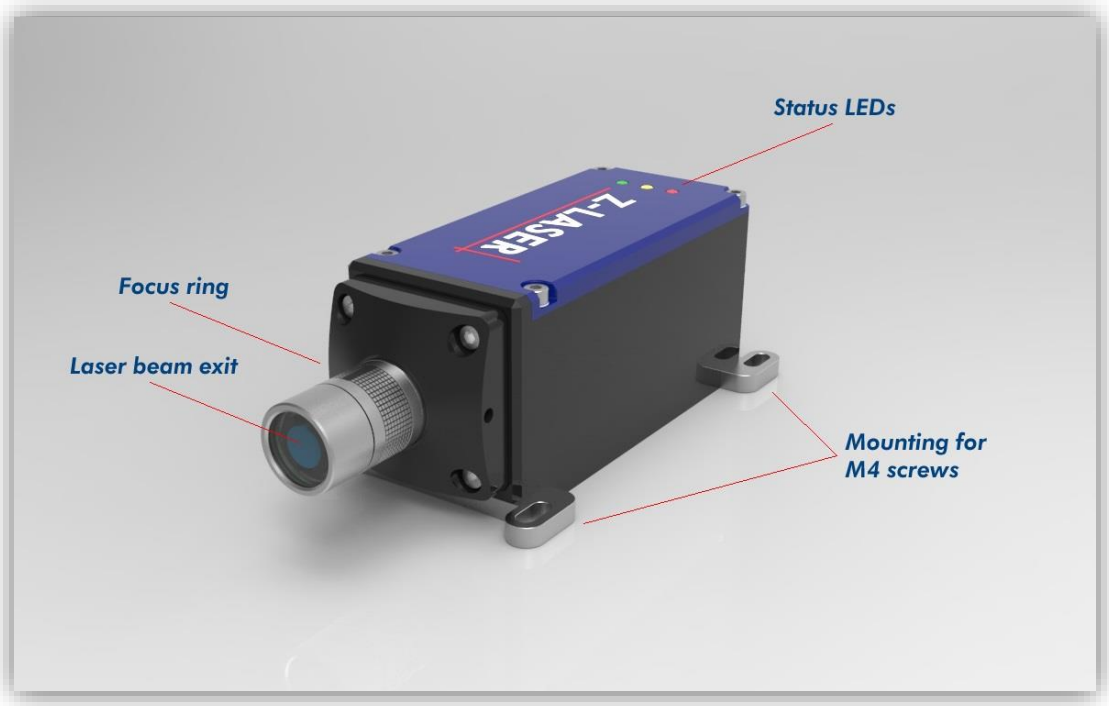
This shipment contains the following parts:

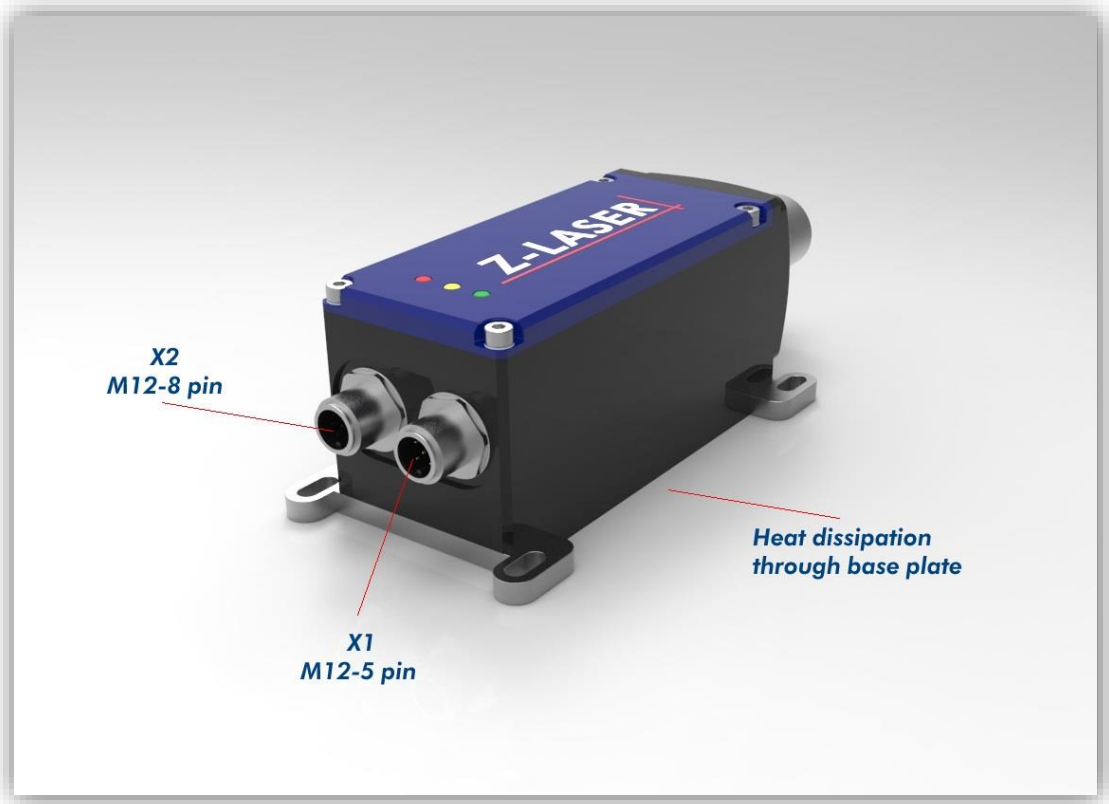
- ZQ1 laser module with attached laser safety sticker and vinyl protection cap.
- Quick start guide and safety instructions.
- USB Stick with quick start guide, user's manual, GUI Software installer.
- 2 meter power/control cable with 5-pin M12 connector.

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.

The “ZQ1” laser module is a customized laser module for integration into industrial products. Read the following user instructions carefully to learn how to use and operate it as designed. An active, or very good passive, cooling capability must be provided and attached to the marked cooling plane.





1.4 Handling of the product

The “ZQ1” module is an IP67 rated laser projector, nevertheless ZQ1 should be handled with care. Special attention is to be provided to the front protection glass. Prevent mechanical stress on the stainless steel optical head.

IP67 (Ingress Protection Marking according to ISO 20653 and DIN EN 60529)

6 → Dust tight. No ingress of dust; complete protection against contact (dust tight).

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

Notice:

If only the 5-pin M12 connector is used for operation, the supplied metal protective cap (IP67 rated) must be screwed onto the 8-pin M12 connector. Only then is the IP67 class guaranteed.

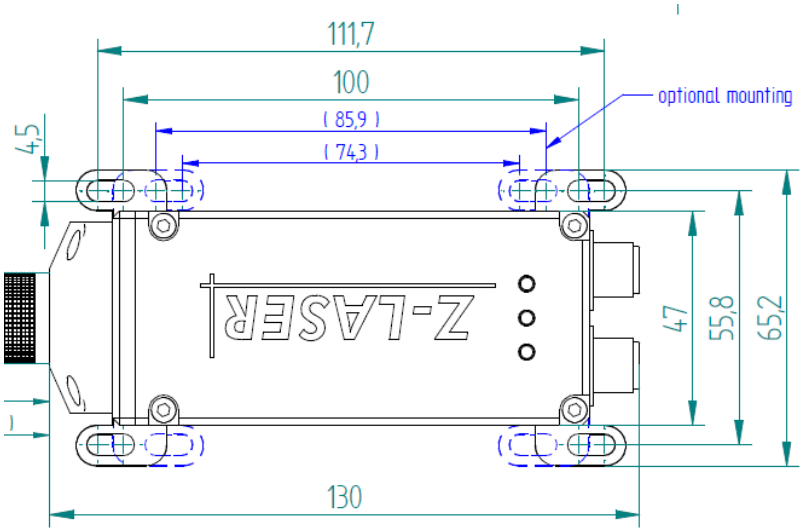
The control electronics of the “ZQ1” module and the metal housing provides active and passive protection against ESD but proper handling is essential. Care must be taken regarding the correct electrical connection; the instruction for correct electrical connection is found in section 3 “Operating the laser module”.

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

1.5 Assembly

The “ZQ1” module should be operated with sufficient cooling capabilities. While it is possible to power up the module and transmit various serial communication telegrams without any special cooling, it is strongly recommended not to switch on the laser sources without a sufficient active or passive cooling system attached to the cooling plane (Take care for sufficient heat conductivity of the mounting).

The ZQ1 laser module can be attached to a heat sink flexible. The two removable fixing tabs can be easily attached by the user for a several different configuration.



Electrical power supply and operation control signaling must be provided according to instructions given in this document.

Please do not disassemble the ZQ1 laser module.

1.6 System

The core component of ZQ1 is the laser driver unit (LDU) with integrated micro controller (MCU), TEC controller and a laser diode. The LDU provides various user interfaces.

Feature	Requirement	Comment	Reference
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	< 40 W	Worst case condition in CW mode. Depending on laser diode and operating voltage.	
Supply Voltage (VCC)	12 … 24 VDC		
Max Operating Current	< 4.0 A		
Maximum power	Up to 900 mW (405 nm) Up to 1300 mW (450 nm) Up to 700 mW (520 nm) Up to 550 mW (640 nm) Up to 400 mW (670 nm) Up to 1700 mW (808 nm)	Depending on Laser diode, please contact Z-LASER	
Power stability	< ± 1% in steady state (1h, T=const) < ± 2.5 % over entire temperature range < ± 10% over entire lifetime	Depending on Laser Diode	
Laser safety class	3B or 4	Depending on laser diode and projection. **Attention: reducing the intensity via Analog Modulation (X2.4) does not change**	

		the laser classification	
MTTF (constant operation)	>10000 hours @ 25 °C diode case	Limited by the laser diode.	

1.6.1 Laser Driver Unit (LDU)

The laser driver unit incorporates the core functionality and the main intelligence of the laser system. It is built on a single PCB that beside the laser driver provides also Peltier cooling controllers (TEC). Two serial two-wire communication interfaces (TWI) are provided (RS232 and I2C slave interface).

1.6.2 User Interface

The LDU has two external connectors, X1 and X2.

2. Optics

A wide range of laser types at many different wavelengths and laser power levels are available for ZQ1. Some major configurations are documented here; custom configurations are available on request.

2.1 Point laser

On request. Not for all Wavelength and power available.

2.1.1 Elliptical point

On request.

2.1.2 Centric point

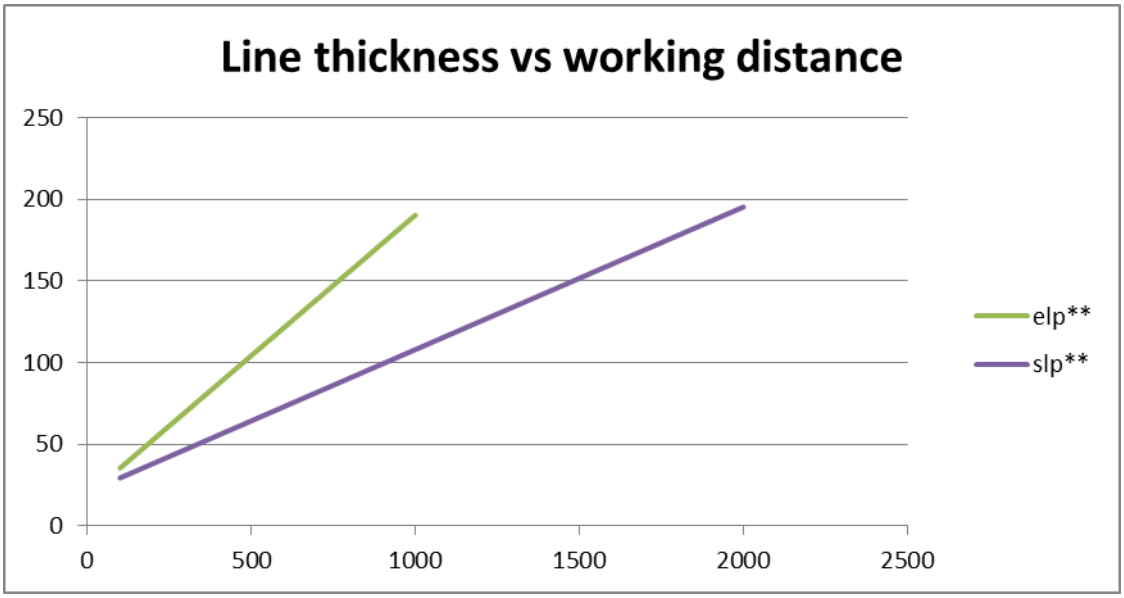
On request.

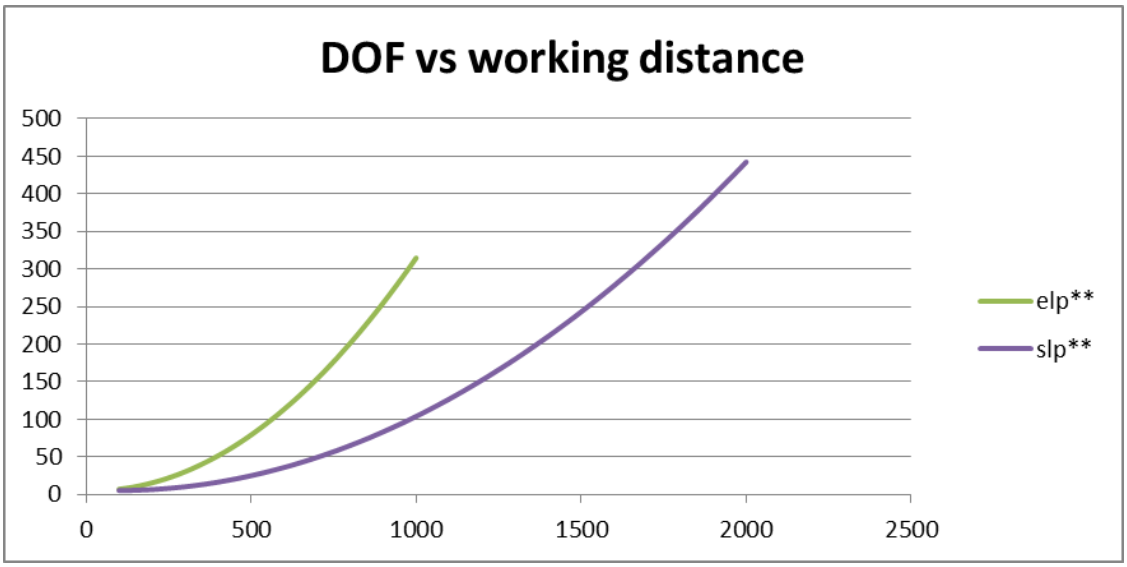
2.2 Line generator

Wavelength (nm)	Focusing options and constant		DOF options and constant	
	elp**	slp**	elp**	slp**
450	0,90	1,03	1,03	1,78
638	0,98	0,90	0,90	0,98
670	1,00	1,00	1,00	1,00
808	1,16	1,14	1,14	1,24

- slp** = standard line Powell; standard setup with medium line width and depth of focus

- elp** = extended line Powell; lines with advanced depth of focus and thicker lines





The graphs above show the values for line width and depth of focus of a 670 nm laser. To get the values for a different wavelength the factor from the table has to be multiplied by the values from the graphs.

Example: 670 nm laser focused at 1 m working distance: line width approx. 110 µm; Depth of focus approx. 105 mm (@ slp** optic, values from the graphs)

Calculated: 450 nm laser focused at 1m working distance: line width ca. 110 µm x 1.03 = 113 µm; Depth of focus approx. 105 mm x 1.78 = 187 mm

*Values in the graphs for homogenous line profiles.

Note: The line parameter depend from the output power.

2.2.1 Standard line generator

Standard line Powell: standard setup with medium line width and depth of focus.

2.2.2 Extended line generator

Extended line Powell: lines with advanced depth of focus and thicker lines.

Note: 90° fan angle is with -elp configuration not available.

2.2.3 Fine line generator

On request.

2.3 Pattern generator (DOE)

On request.

3. Operating the laser module

The “ZQ1” module is shipped with a pre-set optical output power for each sub module. The pre-set power values are regarded the maximum power values – or 100% of the optical output values that can be gained from each module.

Please be certain that before operating the laser module you have taken all aspects of laser safety into consideration. (Refer to Chapter 12 of the user`s manual). Keep the safety cap closed at the laser output or mount it in fixed position in front of a photo detector. Make sure that no human being is accidentally exposed to laser radiation.

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

1. Be certain that the “ZQ1” laser module is assembled correctly and mounted on a proper heat sink. Mounting must be flat and air gaps should be avoided by using heat sink compound.
2. Prepare a proper cabling for X1 and X2, refer to chapter 3.2 of the user’s manual for details
3. Connect a 12-24 VDC power supply to the X1 connector. Be sure it can source more than 40 Watt.
4. Connect X1.2 and apply appropriate signals (TTL Level, protected up to 24VDC) to the digital trigger input to switch the laser on (green LED starts blinking).
5. By default is System Enable not active. If activated from user please connect additionally short X2.6 and X2.8 to switch the laser light on.

Protection cap:

The cap serves to protect the laser during transportation, storage or inactivity. To remove or put the cap just pull or slide it. There can be a depression, which inhibit the procedure, in this case you can add a twist movement.

DO NOT USE the cap to block laser light. Heated plastic could contaminate the optical components. With damage to the cap, an uncontrolled laser light emission take place.

3.1 Power supply

The “ZQ1” Laser module can be supplied by 12-24 VDC. The Supply input on X1 is protected against excessive inrush currents, reverse polarity and transient over voltages.

There is no ON-switch and shutter. When supply voltage is applied, the module starts powering up and self-testing the entire system and verifying the safety architecture. After the warm-up stage (<3min) the laser starts to emit (if TTL Trigger Signal is applied).

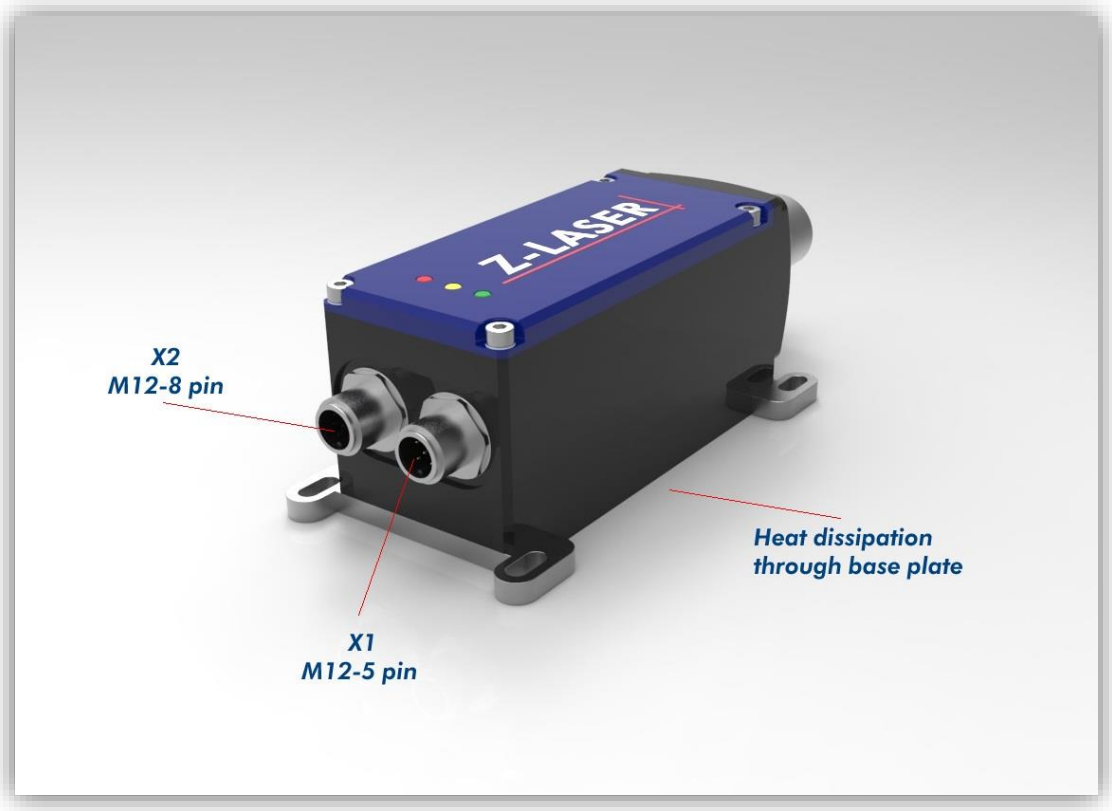
System integrity tests are only conducted after powering up the “ZQ1” laser module. To prevent undetected accumulations of failures, the module should be power cycled on a regular base, e.g. once every 24h. An integrated ON-time counter can be read out via TWI telegrams or the GUI and indicates the time passed by since the last system integrity test.

It is not recommended to disconnect the supply voltage from a running system, uncompleted TWI transmissions might lead to undefined settings.

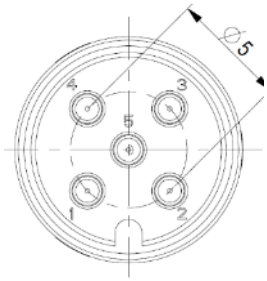
A controlled power-down procedure initiated by the appropriate TWI command ensures that all important settings and parameters are stored in a safe way within the non-volatile memory. The laser sources and all other system resources are powered down in a way that prevents intermediate light emission or storing of energy in capacitors and inductors.

3.2 Electrical interfaces

ZQ1 has two electrical interfaces (X1 and X2). Basically for simple operation is enough to connect X1. To use the full functionality however, both must be used at the same time. Both electrical interfaces are as M12 industrial standard male connects implemented. X1 is a 5-Pin M12 with A-Coding and X2 is an 8-Pin M12 with A-Coding.

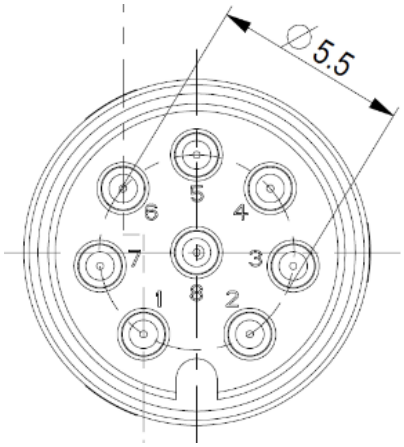


M12 industrial standard connectors at the ZQ1.

Feature	Reference
X1 (5-Pin M12 A-Coding): The pin assignment on the X1 matches the other Z-LASER products with M12 Connector and provide the power supply, TTL Trigger, Analog Intensity control Pin and additional Fail-Out Output.  **M12 5-Pin A-Coding Male Connector** **According to IEC 61076-2-101** X1.1 VCC (12-24 VDC) X1.2 Digital-Modulation (TTL signaling level related to Signal-GND) X1.3 GND X1.4 Analog Modulation (0-2V signaling level related to Signal-GND) X1.5 Fail Out Attention: the “analog modulation” input has an internal pullup resistor. This leads to 100% of nominal laser power if the pin is not driven by an external source. As a side effect the laser is on with 100% of nominal laser power if the analog modulation input is directly connected to the digital modulation input.	

Attention: reducing the intensity via Analog Modulation (X2.4) does not change the laser classification. Reducing the intensity via Analog Modulation (X2.4) effect the intensity distribution along the line. For more Information please refer to …. X1 makes the "ZQ1" pin compatible to Z-Laser's ZM18 and ZM12 models. Please take attention of the power rating of the power supply.			
Feature	**Spec**	**Comment**	**Reference**
VCC X1.1	12-24 VDC ± 10 % With Inrush current limiter and reverse polarity protection. Standard burst and surge protected.		
Digital Modulation (PWM) X1.2	< 200 kHz (without overshot) PWM transmission error < ± 2% @ 10 kHz < ± 5% @ 100 kHz PWM input with programmable polarity, TTL signaling: VIL_max: < +1.2 Volt VIH_min: > +2.8 Volt Reverse polarity protected Overvoltage protected up to 30 V	„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.	
GND X1.3	Common ground	System Ground, please maintain proper connectivity	
Analogue Modulation X1.4	Real time analog power control input Linear range: 10%...100% of nominal laser power. 1% correspond to circa 10mW optical power. Resolution: < 10µW Response Time < 100ms	"nominal" laser power adjusted by customer or absolute maximum power that has been calibrated at Z-Laser **Attention: reducing the intensity via**	

	Usable input range **0.0 …. 2.0 Volt** Reverse polarity protected Overvoltage protected up to 30 V Internal Pullup Resistor leads to 100% of nominal laser power if undriven Reducing the intensity via Analog Modulation (X2.4) effect the intensity distribution along the line. For more Information please refer to Chapter 11.2	**Analog Modulation (X1.4) does not change the laser classification**	
Fail Out X1.5	Open drain OUTPUT with integrated 47 kΩ pull-up resistor to the external VCC level (12-24VDC)	Active low signal that statically indicates all detected warning conditions as well as “system startup” status	

Feature	Reference
X2 (8-Pin M12 A-Coding): The X2 connector provides two pins for RS-232 communication, two pins for I²C, Fail Out Pin and GND Pin .X2 provides System Enable control pins (IN and OUT) as well.  **M12 8-Pin A-Coding Male Connector According to IEC 61076-2-101** X2.1 Rx-D (RS-232 wire - non isolated signal related to GND) X2.2 Tx-D (RS-232 wire - non isolated signal related to GND) X2.3 SCL Slave I²C X2.4 SDA Slave I²C X2.5 Fail Out X2.6 System Enable OUT	

X2.7 GND X2.8 System Enable IN	

Feature	Spec	Comment	Reference
Rx-D X2.1	Active state: +3V…+15V Inactive state: -3V…-15V	ANSI/EIA/TIA-232-F-1997	
Tx-D X2.2	Active state: +3V…+15V Inactive state: -3V…-15V	ANSI/EIA/TIA-232-F-1997	
SCL X2.3	3.3 Volt signal level (5V compatible)	No internal pullup resistor	
SDA X2.4	3.3 Volt signal level (5V compatible)	No internal pullup resistor	
Fail Out X2.5	Open drain OUTPUT with integrated 47 kΩ pull-up resistor to the external VCC level (12-24VDC)	Active low signal that statically indicates all detected warning conditions as well as “system startup” status	
System Enable OUT X2.6	No external signal required. If System Enabled is activated by the user (GUI or command), System Enable In and Out need to be shorted with each other for the laser to emit. Can be used as hardware interlock.	No laser operation is possible without an enabled system (system enable is by factory default disabled).	
V- X2.7	GND	System Ground, please maintain proper connectivity	
System Enable IN X2.8	No external signal required. If System Enabled is activated by the user (GUI or command), System Enable In and Out need to be shorted with each other for the laser to emit. Can be used as hardware interlock	No laser operation is possible without an enabled system (system enable is by factory default disabled).	

3.3 Serial Interface

The ZQ1 module can be controlled by user commands being transmitted via a serial interface (TWI). Two transmission standards are supported on dedicated IO-Pins on X2, RS232 and I²C. When the I²C interface is used, external pull-up resistors must be implemented.

3.3.1 RS232 Interface

- Up to 19 200 Baud
- No parity
- 1 Stop bit
- 8 Data bits
- Half duplex communication

Every Sequence (read and write transmissions) must be terminated by an inactive phase of at least 2 ms and a successful transmission of the respective response by ZQ1.

The serial interface protocol for RS232 telegrams is completely identical to I2C-telegrams. However no device-ID byte is transmitted when RS232 is used; see light green telegram byte for I2C transmissions below. So the given documentation refers to I2C but is valid for RS232 as well.

3.3.2 I2C Interface

The I2C communication interface is operated via SDA and SCL (X2.4 and X2.3) according to standardized physical I2C 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 (X2.7) can be used for this.

Please refer to the original Philips specification that can be found at this URL:

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

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 I2C Telegrams are supported; every I2C telegram contains a write transmission and one or more read transmission of a defined length. **Write transmission** The write transmission contains the write-device-ID (WR-Device-ID), a command ID (CMD-ID) and a 16-bit CRC checksum Telegram (CRC TGM). Optionally a data payload of one or more bytes can be inserted. **Example:** WR-Device-ID | CMD Byte | Data Byte 0....N | CRC-TGM Hi | CRC-TGM Lo **Read transmission** The subsequent read transmission(s) contain the read-device-ID, a data payload of one or more data bytes and a 16-bit CRC checksum Telegram 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 I2C 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.

Example:

RD-Device-ID	System Status	Data Byte 0....N	CRC-TGM Hi	CRC-TGM Lo

System Status Byte

Bit-defines for Status Byte	Bit
RDY_BSY_FLAG	0
CRC_ERROR_FLAG	1
PASSWORD_ERROR_FLAG	2
COMMAND_ERROR_FLAG	3
WARNING_BIT*	4
ERROR_BIT*	5
PASSWORD_SET_FLAG	6
CRC_OFF_FLAG	7

*see Errata

The CRC calculation is based on these Polynomials:

$$\text{CRC-CCITT: } 0x1021 = x^{16} + x^{12} + x^5 + 1$$

CRC-TGM refers to the entire telegram except the WR- and RD-device-ID.

A simple CRC calculator is given here:

http://www.zorc.breitbandkatze.de/crc.html

3.3.3 List of read telegrams

Feature	Reference
GET_LAS_STATUS– reads the system status byte. The system status indicates the successful completion of the previous write transmission.	

WR-Device-ID	CMD (0x60)	CRC-TGM Hi	CRC-TGM Lo	
RD-Device-ID	System Status	Laser Status	4 Warn. Bytes	4 Error Bytes
	CRC-TGM Hi	CRC-TGM Lo		

System Status Byte Codes:

Bit 0	Busy-Flag (1 = telegram not yet completely processed)
Bit 1	Telegram Error Flag (current telegram)
Bit 2	Password Error Flag (wrong password)
Bit 3	Command Error (NACK) Flag (1 = telegram discarded, e.g. premature telegram)
Bit 4	Warning Flag (laser gives back a warning. See warning codes)
Bit 5	Error Flag (laser gives back an error. See error codes)
Bit 6	Password Set Flag (the password is set)
Bit 7	CRC OFF Flag (**C**yclic **R**edundancy **C**heck is disabled)

Laser Status Byte Codes:

Bit 0	Laser ON_OFF Flag
Bit 1	LD Warning over temperature Flag
Bit 2	LD Warning under temperature Flag
Bit 3	LD Shutdown over temperature Flag
Bit 4	LD Shutdown under temperature Flag
Bit 5	LD NTC problem Flag
Bit 6	LD small power factor Flag
Bit 7	Fail Out ON_OFF Flag

Warning class 1 Codes – can't be reset during runtime	
Bit 0	WARNING_1_TEC_CURRENT
Warning class 2 Codes – can be reset during runtime	
Bit 6	WARNING_2_INVALID_CMD_FRAME
Bit 7	WARNING_2_CMD_OUT_OF_RANGE
Bit 8	WARNING_2_ACCESS_VIOLATION
Bit 9	WARNING_2_LD_OVERTEMP
Bit 10	WARNING_2_LD_UNDERTEMP
Bit 11	WARNING_2_END_OF_LIFE
Bit 12	WARNING_2_CAL_T_MIN_MAX_LIMIT
Bit 13	WARNING_2_NO_CALIBRATION
Bit 14	WARNING_2_EXTRAPOLATION
Bit 15	WARNING_2_CASE_OVERTEMP
Bit 16	WARNING_2_CASE_UNDERTEMP
Bit 17	WARNING_2_SYSTEM_ENABLE
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_CPU_CHECK (Interrupt and Timer Check)
Bit 4	ERROR_WATCHDOG_CHECK
Bit 5	ERROR_PELTIER_VERIFICATION
Bit 6	ERROR_WATCHDOG_RESET
Bit 7	ERROR_P_SET
Bit 8	ERROR_CMD_EXECUTION
Bit 9	ERROR_TWI_ERROR
Bit 10	ERROR_UART_ERROR
Bit 11	ERROR_MISSING_CALIB
Bit 12	ERROR_OVER_CURRENT
Bit 13	ERROR_UNDER_CURRENT
Bit 14	ERROR_CASE_OVERTEMP
Bit 15	ERROR_CASE_UNDERTEMP
Bit 16	ERROR_SHTDWN_DETECTED
Bit 17	ERROR_RAM_VARIABLE
Bit 18	ERROR_CALIBRATION_TABLE
Bit 19	ERROR_INTERPOLATION_TABLE
Bit 20	ERROR_LD_OVERTEMP
Bit 21	ERROR_LD_UNDERTEMP
Bit 22	ERROR_NTC_DIFF
Bit 23	ERROR_START_UP_TEST

GET_OPERATION_STATUS – reads the system operation status byte. The operation status indicates the status of the system acc. to 3.4.
Please note these inconsistencies:

- The POWERDOWN Status cannot be read, when it is active.

WR-Device-ID	CMD (0x84)	CRC-TGM Hi	CRC-TGM Lo	
RD-Device-ID	System Status	Op. Status	CRC-TGM Hi	CRC-TGM Lo

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

Module Status Byte Codes

0x00	OP_STAT_SYSTEM_STARTUP
0x01	OP_STAT_STANDBY
0x02	OP_STAT_READY_OPERATION
0x03	OP_STAT_SERVICE
0x04	OP_STAT_FAILURE
0x05	OP_STAT_POWERDOWN
0x06	OP_STAT_LD_TEST

GET_CLR_TWI_STATUS - reads the TWI Status Byte and clear busy, password, CRC and command error status flags.

WR-Device-ID	CMD (0x46)	CRC-TGM Hi	CRC-TGM Lo	
RD-Device-ID	System Status	System Status	CRC-TGM Hi	CRC-TGM Lo

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

Bits of the mode Byte

Bit 0	Enable on/off the digital modulation control input (1 == on)
Bit 1	Invert the digital modulation control input (1 == inverted)
Bit 2	Enable “System Enable” control input (1 == enabled) This Bit cannot be modified in SFTY configurations
Bit 3	Enable on/off the analog modulation control input (1 == on)

GET_POWER_VALUE - reads the current laser power as percentage (unsigned character – single byte) of nominal laser power
Example: 0x64 → 0d100 → 100% of nominal laser power.

	WR-Device-ID | CMD (0x4E) | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | Power Value | CRC-TGM Hi | CRC-TGM Lo (Status followed by CRC and trailing fill bytes when data cannot be returned instantaneously) This command returns the programmed laser power. This command does not advise if the laser is switched on or off. GET_LASER must be used therefore.
	GET_UART_BAUDRATE - reads the UART Baudrate as unsigned integer value (2 bytes) in Baud*100 Example: 0x00C0 → 0d192 → 19200 Baud WR-Device-ID | CMD (0xD4) | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | Baud Hi-Byte | Baud Lo-Byte | CRC-TGM Hi | CRC-TGM Lo (Status followed by CRC and trailing fill bytes when data cannot be returned instantaneously)
	GET_TWI_ADDRESS - reads the I2C Address as unsigned integer value (1 byte)→ default Address 0x88 WR-Device-ID | CMD (0xFC) | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | TWI-Address | CRC-TGM Hi | CRC-TGM Lo (Status followed by CRC and trailing fill bytes when data cannot be returned instantaneously)
	GET_LD_TEMP_CELCIUS - reads the laser diode temperature as unsigned integer value (2 bytes) in °C/100 Example: 0x0A13 → 0d2579 → 25,79°C WR-Device-ID | CMD (0x40) | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | Temp Hi-Byte | Temp Lo-Byte | CRC-TGM Hi | CRC-TGM Lo (Status followed by CRC and trailing fill bytes when data cannot be returned instantaneously)
	GET_PELTIER_TEMP_CELCIUS - reads the Peltier element temperature as unsigned integer value (2 bytes) in °C/100 WR-Device-ID | CMD (0xB6) | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | Temp Hi-Byte | Temp Lo-Byte | CRC-TGM Hi | CRC-TGM Lo (Status followed by CRC and trailing fill bytes when data cannot be returned instantaneously)
	GET_CASE_TEMP_CELCIUS - reads the laser module case temperature as unsigned integer value (2 bytes) in °C/100

WR-Device-ID	CMD (0x04)	CRC-TGM Hi	CRC-TGM Lo		
RD-Device-ID	System Status	Temp Hi-Byte	Temp Lo-Byte	CRC-TGM Hi	CRC-TGM Lo

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

GET_LD_CURRENT - reads the laser current as unsigned integer value (2 bytes) in mA.

WR-Device-ID	CMD (0x12)	CRC-TGM Hi	CRC-TGM Lo		
RD-Device-ID	System Status	Current Hi-Byte	Curr Lo-Byte	CRC-TGM Hi	CRC-TGM Lo

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

GET_TEC_CURRENT - reads the TEC current as unsigned integer value (2 bytes) in mA.

WR-Device-ID	CMD (0x0E)	CRC-TGM Hi	CRC-TGM Lo		
RD-Device-ID	System Status	Current Hi-Byte	Curr Lo-Byte	CRC-TGM Hi	CRC-TGM Lo

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

GET_CALIBRATED_LASER - reads the calibrated laser power in 1 mW steps as unsigned character and wavelength in nm as unsigned integer (2 byte). This command returns the 100% nominal laser power at the end of the output as well as its wavelength.

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

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

GET_LASER_ON_TIME - reads the laser diodes accumulated operating hours as unsigned integer value (2 bytes for hours and 1 Byte for minutes) in hours and minutes.

WR-Device-ID	CMD (0x9C)	CRC-TGM Hi	CRC-TGM Lo		
RD-Device-ID	System Status	Time Hours Hi	Time Hours Lo	Time Minutes	CRC-TGM Hi
	CRC-TGM Lo				

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

GET_ ON_TIME - reads the laser module total operating time after the first power-on as unsigned integer value (2 bytes for hours and 1 Byte for minutes) in hours and minutes.

	WR-Device-ID | CMD (0x22) | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | Time Hours Hi | Time Hours Lo | Time Minutes | CRC-TGM Hi | CRC-TGM Lo (Status followed by CRC and trailing fill bytes when data cannot be returned instantaneously)
GET_FW_VERSION - reads the firmware version as unsigned integer value (3 bytes)	WR-Device-ID | CMD (0xF0) | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | Major Vers. | Middle Vers. | Minor Vers. | CRC-TGM Hi | CRC-TGM Lo (Status followed by CRC and trailing fill bytes when data cannot be returned instantaneously)
GET_HW_VERSION -reads the hardware version as unsigned integer value (3 bytes)	WR-Device-ID | CMD (0x6E) | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | Major Vers. | Middle Vers. | Minor Vers. | CRC-TGM Hi | CRC-TGM Lo (Status followed by CRC and trailing fill bytes when data cannot be returned instantaneously)
GET_MANUFACTURER_ID - reads the manufacturer product ID and technology as 8 ASCII bytes (0x2D…0x5A).	WR-Device-ID | CMD (0xBA) | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | 8 data bytes | CRC-TGM (Status followed by CRC and trailing fill bytes when data cannot be returned instantaneously)
GET_SERIAL_NO - get the serial number by 10 ASCII bytes (0x30…0x39) – can only be set in the authorized service status	WR-Device-ID | CMD (0xF2) | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | 10 data bytes | CRC-TGM Hi | CRC-TGM Lo (Status followed by CRC and trailing fill bytes when data cannot be returned instantaneously)
GET_ANALOG_MOD_ON_OFF- get the analog modulation ON/OFF flag (bit 0). 1 → ON; 0 → OFF	

WR-Device-ID | CMD (0x66) | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | Data On/Off | CRC-TGM Hi | CRC-TGM Lo (Status followed by CRC and trailing fill bytes when data cannot be returned instantaneously)	
GET_DIG_MOD_ON_OFF- get the digital modulation ON/OFF flag (bit 0). 1 → ON; 0 → OFF WR-Device-ID | CMD (0x68) | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | Data On/Off | CRC-TGM Hi | CRC-TGM Lo (Status followed by CRC and trailing fill bytes when data cannot be returned instantaneously)	
GET_INV_DIG_MOD_ON_OFF- get the invert digital modulation ON/OFF flag (bit 0). 1 → ON; 0 → OFF WR-Device-ID | CMD (0xXX) | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | Data On/Off | CRC-TGM Hi | CRC-TGM Lo (Status followed by CRC and trailing fill bytes when data cannot be returned instantaneously)	
GET_SYSTEM_ENABLE_ON_OFF- get the system enable ON/OFF flag (bit 0). 1 → ON; 0 → OFF WR-Device-ID | CMD (0x8A) | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | Data On/Off | CRC-TGM Hi | CRC-TGM Lo (Status followed by CRC and trailing fill bytes when data cannot be returned instantaneously)	

3.3.4 List of write telegrams

Feature	Reference
SET_CRC_ON_OFF disable CRC checks for the entire system (unsigned character: 0 = CRC checks on, 1 = CRC checks off) – default is to always check CRC's This command is only meant to support the user during lab setup and evaluation work. Some terminal programs cannot calculate CRC data dynamically. CRC checks are essential for system integrity and functional safety requirements. WR-Device-ID | CMD (0x47) | Parameter | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | CRC-TGM Hi | CRC-TGM Lo (RD transmission can be repeated) Example for the entire system: Write (WR-device-ID, 0x47, 0x80, 0x18, 0xDC) Read (RD-device-ID, 0x00, 0x??, 0x??) This setting cannot be stored permanently; it will turn back to the default value after the next power cycle.	
SET_UART_BAUDRATE - programs the communication speed between the host PC and the laser module as bps/100 (see example below). The possible Baudrates are: 2400, 4800, 9600, 19200, 57600, 115200 bps. WR-Device-ID | CMD (0xD3) | Parameter | Parameter | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | CRC-TGM Hi | CRC-TGM Lo (RD transmission can be repeated) Example for 19200 bps: Write (WR-device-ID, 0xD3, 0x00, 0xC0, 0x29, 0x14) Read (RD-device-ID, 0x00, 0x??, 0x??) This setting cannot be stored permanently; it will turn back to the default value after the next power cycle.	
SET_POWER_VALUE - programs the laser current statically (DAC setting) as percentage (unsigned character – single byte) of nominal laser power. WR-Device-ID | CMD (0x4F) | Power Value | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | CRC-TGM Hi | CRC-TGM Lo (RD transmission can be repeated) Linear range: 10%...100% of nominal laser power. 1% correspond to circa 10mW optical power.	

Attention: reducing the laser intensity via SET_POWER_VALUE command does not change the laser classification	
SET_LASER_ON - Switch ON the laser. WR-Device-ID | CMD (0x41) | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | CRC-TGM Hi | CRC-TGM Lo (RD transmission can be repeated)	
SET_LASER_OFF - Switch OFF the laser. WR-Device-ID | CMD (0x43) | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | CRC-TGM Hi | CRC-TGM Lo (RD transmission can be repeated)	
SET_LASER_ON_OFF - Switch ON or OFF the laser. **(unsigned character: 0 = LASER on, 1 = LASER off)** WR-Device-ID | CMD (0x45) | Parameter | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | CRC-TGM Hi | CRC-TGM Lo (RD transmission can be repeated)	
SET_ANALOG_MOD_ON_OFF- Switch the external analog modulation ON or OFF **(unsigned character: 1 = ANA_MOD on, 0 = ANA_MOD off)** WR-Device-ID | CMD (0x67) | Parameter | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | CRC-TGM Hi | CRC-TGM Lo (RD transmission can be repeated)	
SET_DIGITAL_MOD_ON_OFF- Switch the external digital modulation ON or OFF **(unsigned character: 1 = DIG_MOD on, 0 = DIG_MOD off)** WR-Device-ID | CMD (0x69) | Parameter | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | CRC-TGM Hi | CRC-TGM Lo (RD transmission can be repeated)	
SET_INVERT_DIGITAL_MOD_ON_OFF- Switch the invert external digital modulation ON or OFF (unsigned character: 1 = INV_DIG_MOD on, 0 = INV_DIG_MOD off)	

WR-Device-ID | CMD (0xXX) | Parameter | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | CRC-TGM Hi | CRC-TGM Lo (RD transmission can be repeated)	
SET_SYSTEM_ENABLE_ON_OFF- Switch the System Enable OUT/IN ON or OFF (unsigned character: 1 = SE on, 0 = SE off) WR-Device-ID | CMD (0x8B) | Parameter | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | CRC-TGM Hi | CRC-TGM Lo (RD transmission can be repeated)	
SET_DEFAULT_POW_FACT - save current laser power value to a non-volatile memory *** Before sending the "SET_DEFAULT_POW_FACT", must the analog modulation switched off with command: "SET_ANALOG_MOD_ON_OFF"** WR-Device-ID | CMD (0xF7) | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | CRC-TGM Hi | CRC-TGM Lo (RD transmission can be repeated)	
SET_REVERT_POW_FACTOR - sets laser power of an LDU to the factory calibrated value WR-Device-ID | CMD (0x6D) | CRC-TGM Hi | CRC-TGM Lo RD-Device-ID | System Status | CRC-TGM Hi | CRC-TGM Lo (RD transmission can be repeated)	

3.3.5 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.

In case of telegram failures, the user must query the module status of the addressed LDU module and react accordingly.

3.3.6 Communication Status

A telegram can fail in the transmission or in the interpretation phase. Whenever this occurs a warning is indicated and the command is not executed. The user must query the system and reset the failure condition.

The system is not shut down as a consequence of a telegram failure.

3.4 System Status

The MCU software steers the functions of the entire system and presents them to the user. For a clean use model, the systems behavior is described by a few major operation modes that can be read out with GET_OPERATION_STATUS telegrams.

System Startup Status (Powerup)	
After powering up, the system housekeeping and self-test tasks are performed. During this period, the system is not ready for further user interaction. Laser Class: -- System Control: • System Enable* (X2.6 and X2.8) = not shorten (or open) → "inactive" *if enabled from GUI or I2C/RS232 command (by default is disabled) LED-Indication: • green LED blinking fast Activities: • Powering up the system until all supply voltages are stable, release reset states • Invalidate system password setting (reset user setting) • Warm-up of the laser diodes • Waiting for an environmental target value, e.g. temperature • Self-test of all system main functions • Initialize the system with calibrated settings or if available with saved settings from the last session (e.g. after a failure occurrence) • Communication Interfaces are active • Measures ON time of the device Inactivity's: • Laser Light cannot be emitted	

Signaling: • System Enable (X2.6 and X2.8) can toggle due to self-test procedures • Fail Out (X1.5 and X2.5) is low (active) Attention: For a very short time, this signal might not yet be stable Transition to Failure Status: • Upon encountering a nonconformity (Error, Attention: no correct action might be possible in this case) • Upon reaching a time limit Transition to Standby Status • Upon completion of all activities Transition to Ready Status • Upon completion of all activities AND System is in a calibrated mode AND No system nonconformity is pending (warning, error) Transition to System Startup Status: • Upon power cycling the LDU, i.e. switching it OFF and ON again	
Standby Status	
Laser Class: -- System Control: • System Enable* (X2.6 and X2.8) = not shorten (or open) → "inactive" *if enabled from GUI or I2C/RS232 command (by default is disabled) LED-Indication: • green LED blinking slowly Activities: • Measures ON time of the device • Listens to TWI telegrams Inactivity's: • Laser Light cannot be emitted • Unaccepted TWI commands: SET_LASER (and others) Signaling: • Fail Out (X1.5 and X2.5) indicates warnings upon occurrence Transition to Ready Status: • System Enable active(short X2.6 and X2.8) AND System is in a calibrated mode AND No system nonconformity is pending (warning, error)	

Transition to Failure Status:
- Upon encountering a nonconformity (Error)

Transition to System Startup Status:
- Upon power cycling the LDU, i.e. switching it OFF and ON again

Ready Status

Laser Class: --

System Control:
- System Enable* (X2.6 and X2.8) = short → "active"

*if enabled from GUI or I2C/RS232 command (by default is disabled)

LED-Indication:
- green LED permanently ON

Activities:
- Measures ON time of the device
- Listens to TWI telegrams

Inactivity's:
- Unaccepted TWI commands: SET_LASER (and others)

Signaling:
- Fail Out (X1.5 and X2.5) indicates warnings upon occurrence

Transition to Operation Status:
- Upon Digital modulation = high (active)
  AND Laser light emission is switched ON via TWI telegram

Transition to Standby Status:
- Upon System Enable (X2.6 and X2.8) = not shorten (inactive)

Transition to Failure Status:
- Upon encountering a nonconformity (Error)

Transition to System Startup Status:
- Upon power cycling the LDU, i.e. switching it OFF and ON again

Operation Status

Laser Class: 3B or 4

System Control:
- System Enable* (X2.6 and X2.8) = short → "active"

*if enabled from GUI or I2C/RS232 command (by default is disabled)

LED-Indication:
- green LED permanently ON
- yellow LED ON when laser beam is ON

Activities:
- Laser starts emitting light upon Digital Modulation input (X1.2) = high
- Measures ON time of the device
- Measures ON time of the laser source and calculates remaining life time
- Listens to TWI telegrams

Inactivity's:
- Unaccepted TWI commands: SET_LASER (and others)

Signaling:
- Fail Out (X1.5 and X2.5) indicates warnings upon occurrence

Transition to Ready Status:
- Upon Digital modulation = low (inactive)
- Upon Switching off the laser light emission via TWI telegram

Transition to Standby Status:
- Upon System Enable (X2.6 and X2.8) = not shorten (inactive)

Transition to Failure Status:
- Upon encountering a nonconformity (Error)

Transition to System Startup Status:
- Upon power cycling the LDU, i.e. switching it OFF and ON again.

Failure Status

System encountered a system Error. The user must actively query then and power cycle the system. The last system parameters are saved and resumed in the next run.

Laser Class: --

System Control:
- Fail Out (X1.5 and X2.5)= low → "active"

LED-Indication:
- green LED blinking (failure indication by special blink-code)
- red LED blinking

Activities:
- Listens to TWI telegrams
- Invalidate system password setting (reset user setting)
- Disable laser supply and TEC supply

• Program current DAC's to 0x000 Inactivity's: • Laser cannot emit light • Unaccepted TWI commands: SET_LASER (and others) Transition to System Startup Status: • Upon power cycling the LDU, i.e. switching it OFF and ON again.	

3.5 How to control the laser

The driver electronics of the "ZQ1" laser module has a digital control interface; it can statically be controlled via TWI (I2C telegrams)

Attention: reducing the laser intensity via TWI telegrams does not change the laser classification

3.5.1 Static laser output power via I2C

The laser output power of the "ZQ1" module can be controlled statically via I2C telegrams. The user has to take care in understanding how the laser power is controlled in principle.

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 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 linearly between ~10% and 100%. The target percentage is set via a TWI telegram (see chapter 3.3.4) or via the analogue control input X1.4. The control system preserves the user set power value over the temperature range and lifetime.

Attention: Reducing the intensity via Analog Modulation (X2.4) effect the intensity distribution along the line.

3.5.2 Failure Output – System Shutdown

Upon any severe system integrity violation, the "ZQ1" laser module is shut down. Pin X1.5 und X2.5 are an active low signal that is internally operated by an open-drain switch in the module. The host system can shut down the module as well or just use the pin as indicator that a severe internal error has occurred.

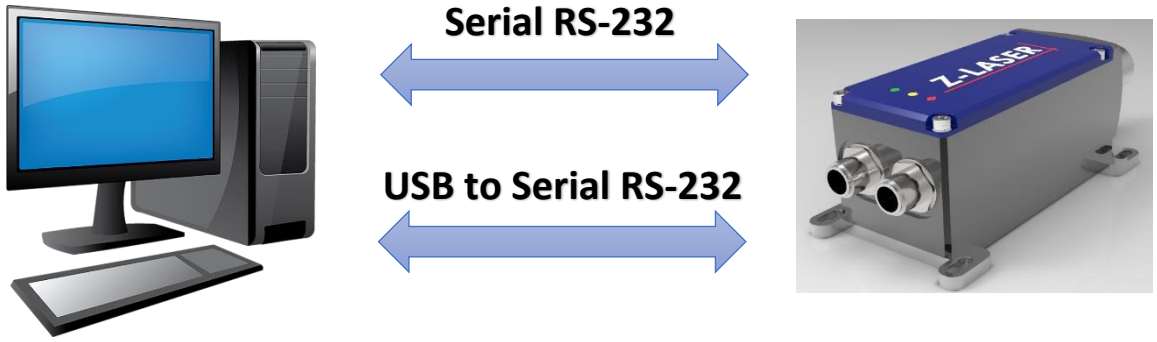
To determine what error happened and in which sub module, the user must query the module via TWI telegrams, or use the ZQ1 GUI Software. For error codes please refer to the GET_LAS_STATUS command in chapter 3.3.3.

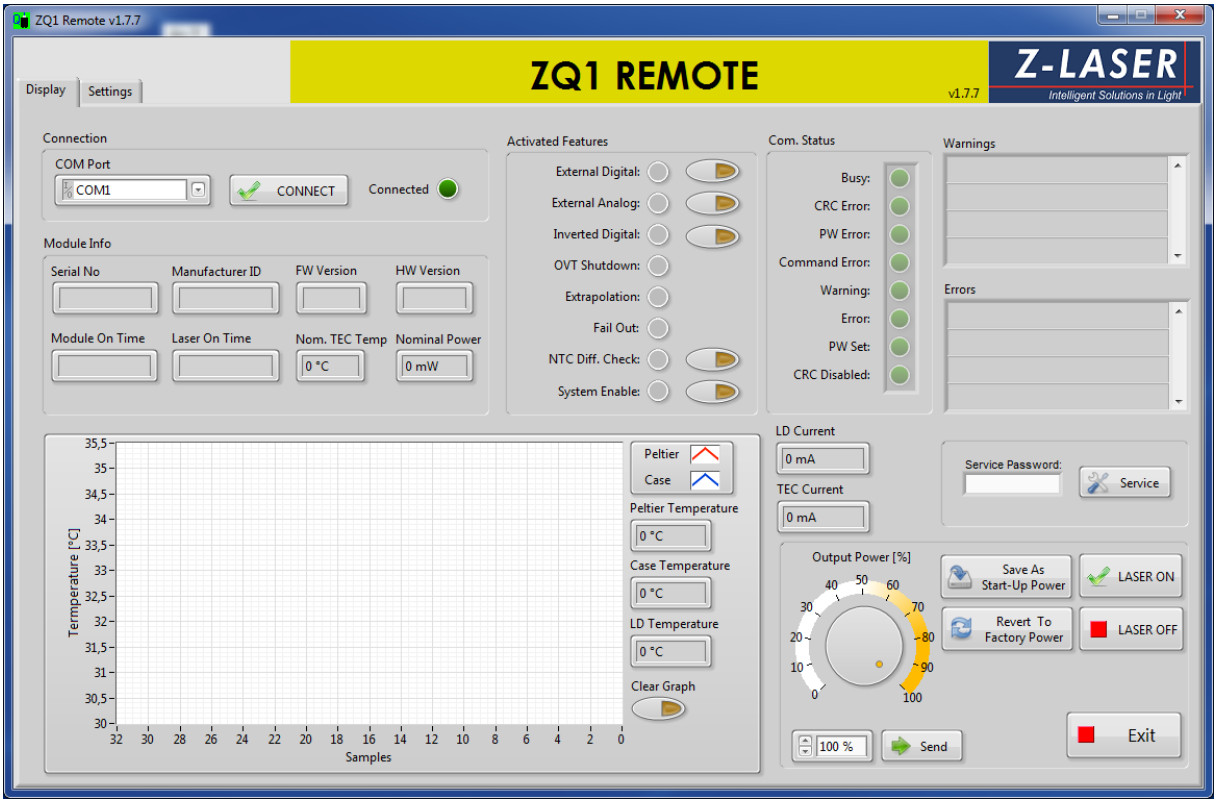
3.6 Graphical User Interface

The monitoring software ZQ1 REMOTE is available on the included USB Stick and www.z-laser.com.

The ZQ1 GUI provide easy option to control, change and monitor the main features and parameter of the laser projector. The on-time counter is an excellent tool to analyze laser aging as well allowing for preventive maintenance to reduce down time in factory.

The software use RS-232 communication protocol. You can connect the ZQ1 Laser direct to the serial interface on your PC (if available) or use USB-RS232 Adapter)





3.7 LED status indication

Note: the LED's are placed on the upper side of the laser housing near the connector's side.

- ➔ Warning Indication (continuous wave)/Failure Indication (blink operation)
- ➔ Laser ON Indication (laser light emitted)
- ➔ Blink Codes Indication for different warning/failure identification.

Behavior		Meaning	Reference
Green LED blinking fast		System Startup Status / Warm-Up stage (communication channels are active)	
Green LED blinking slowly		Standby Status (communication channels are active)	
Green LED permanently ON		Ready Status (communication channels are active)	
Green LED permanently ON, Yellow LED ON (when laser light is ON)		Operation Status – Laser ON (communication channels are active)	
Green, Yellow and Red LED light sequentially		Service Status (communication channels are active)	
Red LED permanently ON, Green LED giving blink code		Warning Status, green blink code indicates Warning condition (communication channels are active)	
Red LED permanently ON	Green LED blinks 12 times	Over 24 Hours On-Time	
	Green LED blinks 8 times	Over-/Under Temperature at Laser diode	
	Green LED blinks 6 times	Case Over/Under Temperature	
	LED blinks 2 times	Approaching End of Life	
	Other	Other warnings	
Red LED blinking, Green LED giving blink code		Failure Status, green blink code indicates failure condition (communication channels are active)	
Red LED blinking	Green LED blinks 13 times	Start-Up Test Error	
	Green LED blinks 1 times	TEC Driver Error	
	Other	Other Failures	

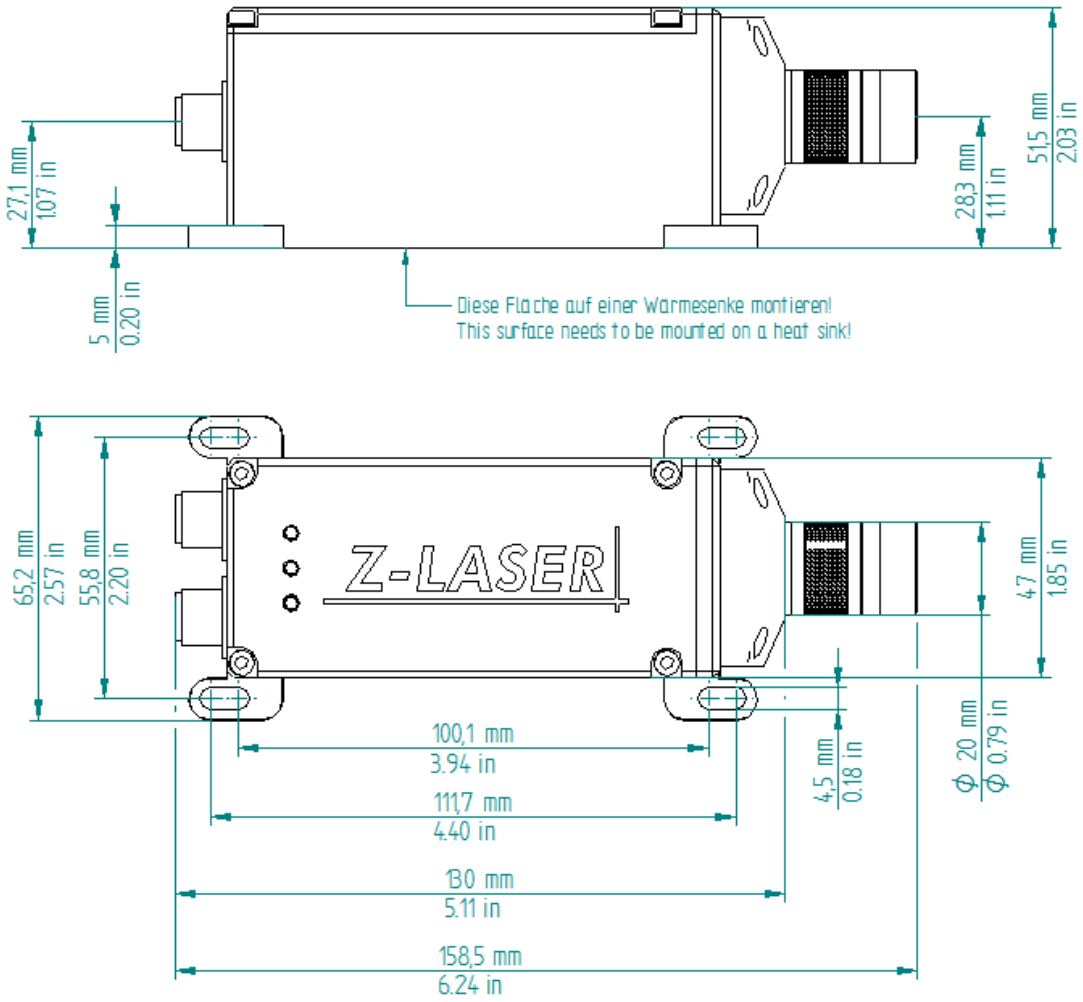
3.8 Typical operating errors

The most common operating error is caused by an insufficient thermal coupling of the ZQ1 to the heat sink. In that case the temperature will increase in a short time and the LDU will switch off the laser when it exceeds the specified temperature limits. The user can read out the temperature via TWI protocols or measure the case temperature directly.

4. Diagnosis and security functions

Feature	Reference
Laser diode supervision During the initial system calibration routine the physical parameters of the laser diode (threshold current, forward voltage) are recorded. In the lifetime of the laser these parameters are measured and verified.	
Power up checks of the MCU Safety surveillance functions are tested to ensure that no single failures are accumulated. In every system startup phase the correct function is being self-tested as well as typical failure conditions. 1. RAM, ROM, Flash, CPU, EEPROM, Watchdog test 2. Over Current Detection 3. MCU setup the system for a new laser current 4. Tests of sensor devices **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.	
Independent methods of laser power shut-down Ordinary functional switch via digital modulation control (X1.2). This switch must be released by the MCU to take effect. General disable via global system enable (short circuit between X2.6 and X2.8) control. This control signal initiates the MCU to ordinary enable or disables the LDU. DAC's are programmed, the laser diode is powered and all switches are enabled / released. System shut-down by MCU via laser power supply switches. In emergency states, the MCU can disable the laser diodes current supply.	

5. Drawings



Note: 3D STEP file available on request. Please contact our sales department.

6. Product Labelling

This “ZQ1” product is measured and labelled according EN60825-1:2015-07.
Each ZQ1 Laser projector is labeled with laser safety label in german language from the factory. There are five further laser safety labels on different languages included. Please use the appropriate one for your application. If labels are missing, do not operate the laser.

Laser Radiation
Avoid Exposure to Beam

Class 3B Laser Product

EN60825-1:2015-07

VISIBLE and/or INVISIBLE Laser Radiation
Avoid Eye or Skin Exposure to Direct or Scattered Radiation

Class 4 Laser Product
EN60825-1:2015-07

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.

7. Product Warranty

Z-LASER guarantees its “ZQ1” 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.

8. 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 ZQ1 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 or can be read via a TWI telegram. 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.

9. Disposal

The “ZQ1” 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.

10. In the case of a damage

The “ZQ1” module is considered damaged when it

- has any visible mechanical damage to electrical contacts or the optical output
- does not emit light
- continuously shows errors after self-test procedures (after power up)
- Light intensity can obviously not be controlled as expected.
- …

Please contact Z-LASER Service.

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

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

Ask for a RMA Tracking No.

11. Measurements

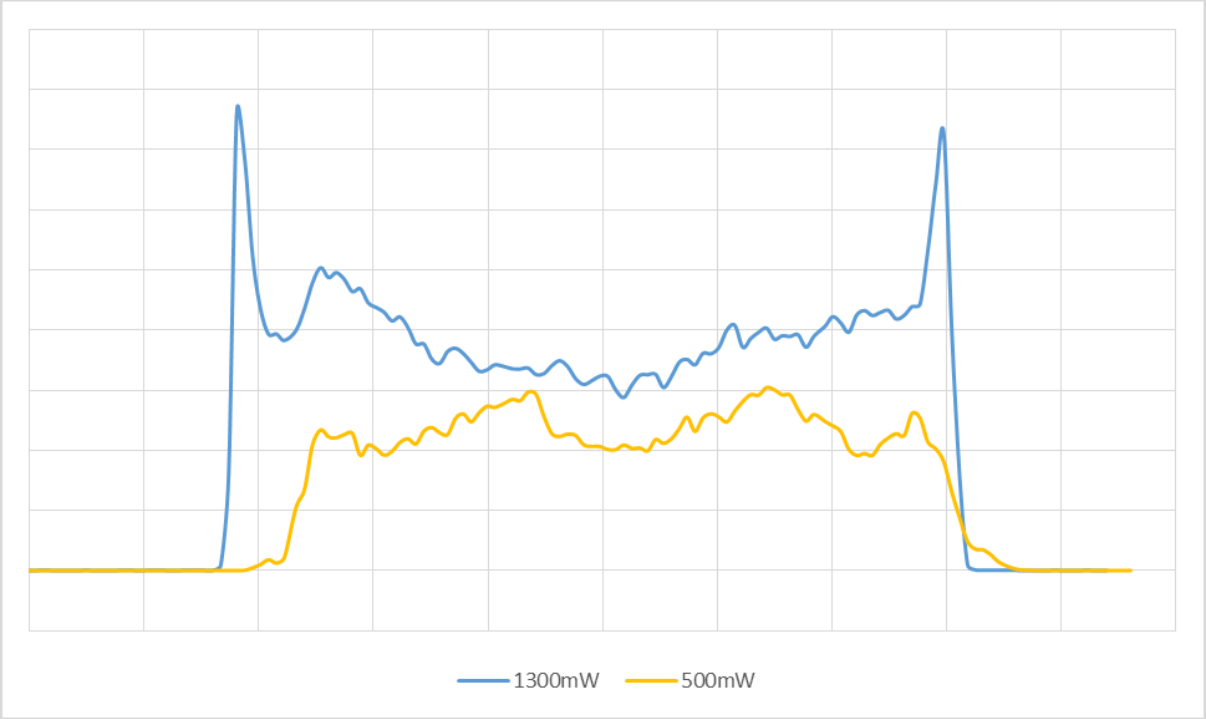
11.1 Power Stability (Example)

11.2 Optical characteristics (Example)

Reducing the intensity via Analog Modulation (X2.4), “ZQ1 REMOTE” GUI Software or the commands **SET_POWER_VALUE** and **SET_DEFAULT_POW_FACT** effect the intensity distribution along the line and the effective length of the line projection.

Z-LASER recommends to use power values below 50% of the nominal laser power only for alignment purposes, but not for measurement and other real applications.

The graphic below shows an example intensity distribution along the line on the same laser module by two different power values.



11.3 Errata

The following items are out of line with the initial target spec (17.11.2016)

- Laser with Firmware versions before 2.0.0 need the GUI Software “ZQ1 REMOTE” with version 1.5.
- I2C communication Protocol in the Firmware Versions up to 3.0.0 stuck when 5 or 12 bytes have been read.
    - always read other from 5 and 12 number of Bytes and interpret only the needed at each write command

- Fixed from Firmware release 3.0.1.

- The error and warning flag in the system status are currently not active.

11.4 Laser classification

The most ZQ1 Laser Projectors are Laser Class 3B or 4. Please read carefully and follow the laser safety information (Chapter 12) before using this product.

12. 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:

1. Unanticipated eye exposure during alignment

2. Misaligned optics and upwardly directed beams
3. Available eye protection not used
4. Equipment malfunction
5. Improper methods of handling high voltage
6. Intentional exposure of unprotected personnel
7. Operators unfamiliar with laser equipment
8. Lack of protection for ancillary hazards
9. 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.

Ready indicator:
The Z-LASER ZQ1 laser system includes a ready indicator on the top side of the laser. If the laser is connected correctly to the power supply the ready LED (green) will blink fast, during the heat up phase, then the ready LED (green) will be illuminated constantly.

Laser on/off indicator:
The laser indicator LED (orange) on the top side is illuminated, if the laser is on. In modulation mode the LED may flicker in the same way the modulation is set, if the frequency is no too high.

Eye Protection:
Always wear proper eye protection. Be sure, that the wavelength of the laser and the protection band of your protective eye wear match and that the attenuation for this wavelength is high enough.

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.

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

No hazardous voltages are contained in the laser head. The system does not contain any user accessible components within the laser head. The warranty will void if the laser or enclosures are disassembled.

ESD
It is recommended to take proper ESD precautions when handling the laser. The laser system is designed with internal safeguards for protection from ESD. Never the less high energy ESD discharge events may cause damage to the laser system. Z-LASER GmbH recommend the use of shielded power cable, where the shield is connected to the mounting M12 nut and therefore to the laser case. The supplied cable is shielded, but the shield is not connected to the mounting M12 nut.

Emergency Shutoff:
An emergency shutoff switch must be available to the operator or the assistant to rapidly shutdown the equipment.

The system perform shut down by itself, if an error occurs. This means, that no laser light is emitted from the optic head.

Possible errors are:

- Temperature failure
- System Enable open
- Laser diode over current

Depending on the operation mode different actions are necessary to start the laser again.

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).

13. Declaration of Conformity

(This declaration refers to the released product. Engineering samples are shipped without full certification and might deviate from the below stated standards. Conformity to EMC standards refer to housed ZQ1 and do not include customer cabling)

We therefore confirm that the devices described in the following

Name/Product: ZQ1

ZQ1

meets the requirements of the directive 2004/108/EC.

The product is RoHS conform and free of silicon

The following standards were applied:

EN 60825-1: 2015-07
EN 55022:2010
EN 55011:2010

The following guidelines were applied:

2014/30/EU EMC-guideline
2014/35/EU Low voltage guideline

CE

Product „ZQ1“

Manufactured by

Z-Laser Optoelektronik GmbH
Merzhauserstr. 134
D-79100 Freiburg
Complies to:
04/108/EG EMI-Guideline
06/95/EG Low-Voltage-Guideline

***Z-LASER* Optoelektronik GmbH**
Merzhauser Str. 134
79100 Freiburg

14. Glossary

LDU: Laser Driver Unit

MCU: Micro Controller Unit (main unit)

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

SFTY: Specification item related to a safety critical laser product.

LCsw: Laser current main switch.

DAC: Digital to Analog Converter.

ADC: Analog to Digital Converter.

Revision	Date	Editor	Changes
0.1	07/03/16	Todorov	Initial Version – advanced information (Preliminary)
0.2	05/07/16	Todorov	Overall changes
0.3	05/08/16	Todorov	Overall changes
0.4	19/09/16	Todorov	Communication description
0.5	07/10/16	Todorov	Communication description
0.6	05/12/16	Todorov	New commands included
0.7	10/04/17	Todorov	Small changes and Errata entries
0.8	11/09/17	Todorov	New Z-LASER Layout/Changes in Laser Safety and Optics changes
0.9	13/09/17	Todorov	“ZQ1 Remote” GUI Software Chapter included