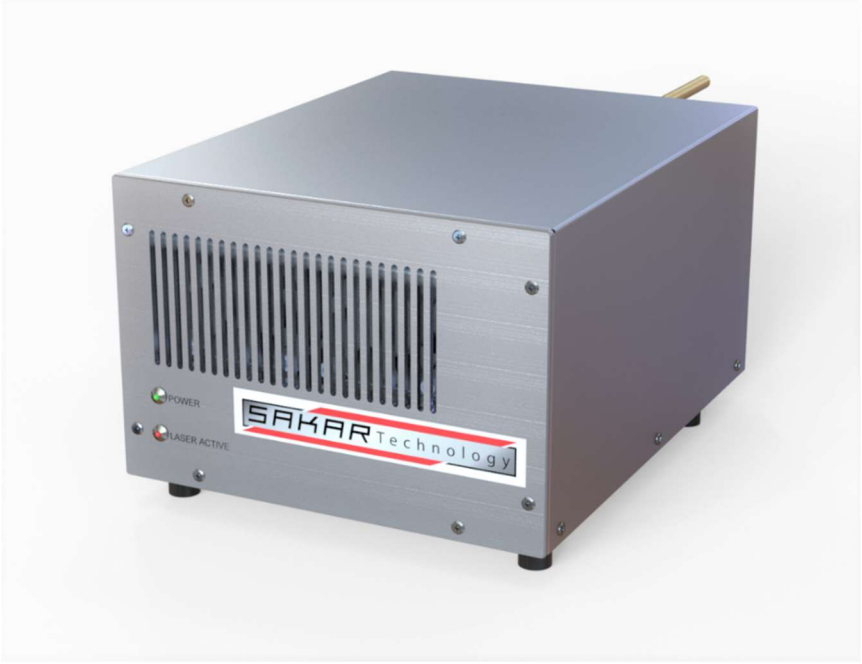
Compact Laser Manual



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Software Version 5.091.0

Contents

1.0 System Overview

1.1 Introduction

This manual is intended to aid the operator of the laser system in understanding how to prepare, install, operate, and troubleshoot the laser system. The contents of this manual will assist in operating the device safely and properly. Following this manual will minimize risks, reduce repair costs, and increase reliability of both the electronics and the integrated laser.

The manual must be kept with the laser system, and available at all times. The manual must be read and applied by anyone who uses the laser system. Specific topics covered include:

- Setting up the working environment (laser safety, security policies)
- Operation, setup, and troubleshooting during use
- Assembly, installation, and system integration
- System maintenance, inspection, and transportation
- Guidelines to maximize system uptime

This manual provides guidelines for safe and reliable laser operation. In addition to following the instructions within this document, the user should adhere to all mandatory safety regulations, professional technical rules for laser safety, and any other professional guidelines for safe laser operation.

1.2 Support

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1.3 Explanations & Symbol Identification

This section provides definitions to the terms used the manual, along with symbols and their meaning. This guide is provided to lessen the chance of misunderstanding for which the manufacturer cannot be held responsible. It is extremely important that anyone operating the laser system fully understands the manual in order to safely operate the laser.

Manufacturer: The manufacturer is the legal entity specified on the nameplate of the equipment delivered to the customer.

Buyer: The buyer is the person or company who can testify to the lawful acquisition of the laser system. The buyer is not the user or operator of the system.

Operator: An operator is any person employed and authorized by the **Buyer** to operate and maintain the laser system. The system should not be used by anyone other than trained and authorized operators.

Subject Specialist: A subject specialist is characterized by his or her expertise relating to the hazards and risks of laser system operation. This person also has knowledge on how to avoid liability resulting from damage to persons or property.

Unfinished Machine: An unfinished machine is a unit purchasable from a dealer or manufacturer that is not suitable for direct use. The machine has mechanical and/or safety deficiencies which prevent safe and proper operation. When purchasing an unfinished machine, the **Buyer** is responsible for ensuring that the completed system is checked along with provisioning for the safe operation of the final product.

Finished Machine: A finished machine is a unit purchasable from a dealer or manufacturer which is complete and suitable for direct use. This claim is ensured by the manufacturer and demonstrated via clear CE marking on the unit. This labeling certifies the manufacturer's claim that the product meets all applicable safety standards for proper operation.

Inspection: An inspection is the assessment of the current state of the machine. This action can only be performed by qualified personnel.

Maintenance: Maintenance refers to the performance of activities that have an effect on the state of the machine. All maintenance activities should be performed by the manufacturer, and the manufacturer cannot be held liable for damage to persons or property resulting from improper system maintenance by parties other than the manufacturer.

Repair: Repair work is any activity which restores the system to a safe, operable state. These activities may only be conducted by a trained person. The manufacturer cannot be held responsible for damage to persons or property resulting from repair work performed by entities other than the manufacturer.

Warranty: The warranty is the legal basis for the action taken between the Buyer and the Manufacturer in the case of a faulty system. While under warranty, the Manufacturer will provide additional services and perform necessary repair work to restore the system to a functional state within the terms of the warranty.

1.4 Safety Symbols

The following chart details the symbols used in this manual to indicate hazards based on DIN EN 61 310-1 along with other safety considerations.

Symbol	Explanation
	This symbol indicates an imminent danger to the lives and health of persons. Failure to follow this information can have serious health effects result in life-threatening injuries or death.
	This symbol indicates an imminent danger of electrical energy. Failure to follow the guidelines here can result in life-threatening injuries or death.
	This symbol is used to designate tips and other useful information. This symbol indicates a potentially hazardous situation for the operator. Disregarding these instructions can have serious adverse health effects, leading to life-threatening injuries or death.
	This symbol designates application tips and other useful information.

IMPORTANT: To ensure the safe use of this product, safety information is included within this section and throughout the manual at appropriate points to highlight key safety considerations. This safety information is in addition to any safety information relating to the laser beam and is highlighted with the IEC warning triangle.

Symbol	Explanation
	**WARNING** refers to a potential personal hazard. It requires a procedure which, if not correctly followed, may result in serious bodily harm or death to the operator and others. Do not proceed past the WARNING sign until you completely understand and meet the required conditions.
	**CAUTION** refers to a potential product hazard. It requires a procedure which, if not correctly followed, may result in damage to or destruction of the product or components. Do not proceed beyond the caution sign until you completely understand and meet the required conditions.
	**IEC WARNING TRIANGLE** refers to safety information related specifically to the laser output of this device.

The laser radiation figures below indicate various hazards of laser light. Ensure that any operator of the system is fully aware of the following figures and their meanings.

Symbol	Explanation
	Danger of coherent electromagnetic radiation
	Warning sign for Class IV laser beams
	Rated power and wavelength of the laser radiation
	Danger of personal injury due to dropping equipment
	Danger due to fire
	Danger due to explosion
	Danger due to toxic substances
	Risk of electrostatic discharge
	Danger from hot surfaces
	Wear safety shoes
	Wear laser safety glasses

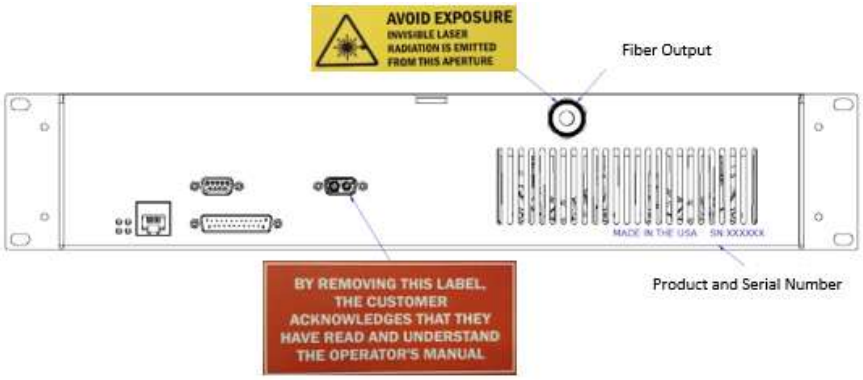
The following list of applicable laser safety standards makes no claim for completeness or accuracy. The end user is responsible for knowledge of the standards applicable to the operation and management of a Class IV laser device. For special applications, additional standards may be required.

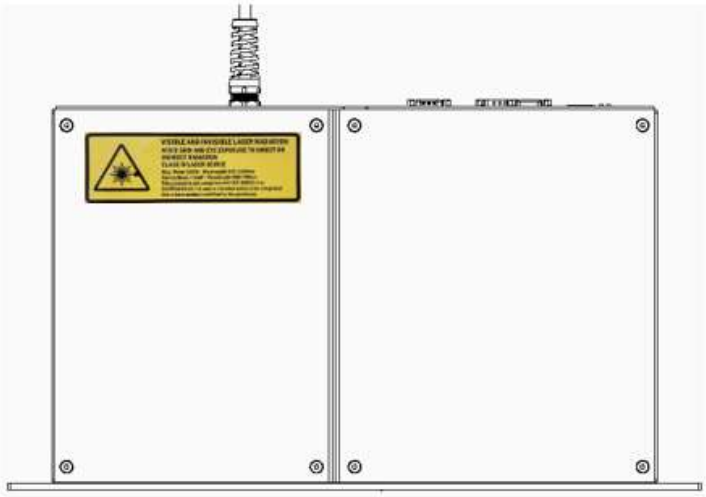
Standard	Details
DIN EN 60825-1	Laser safety, classification of laser systems, requirements and user policy
DIN EN 60825-4	Laser safety, laser guards, and safety measures
DIN EN 207	Personal safety protection - laser safety
DIN EN 208	Personal eye protection - laser adjustable glasses
21CFR1040.10	Performance standards for light emitting laser products
2006/42/EG	Machinery directive
2006/95/EG	Low voltage directives
2004/108/EG	Electromagnetic compatibility requirements
GPSG	Equipment and product safety act
1999/44/EG	Customer sales and warranty
BGV B2 UVV	Laser radiation
BGV A8	Safety and health signs at work
BGV A1	Principles of prevention
PSA - BV	Regulations on personal protective equipment users

1.5 Warning Labels

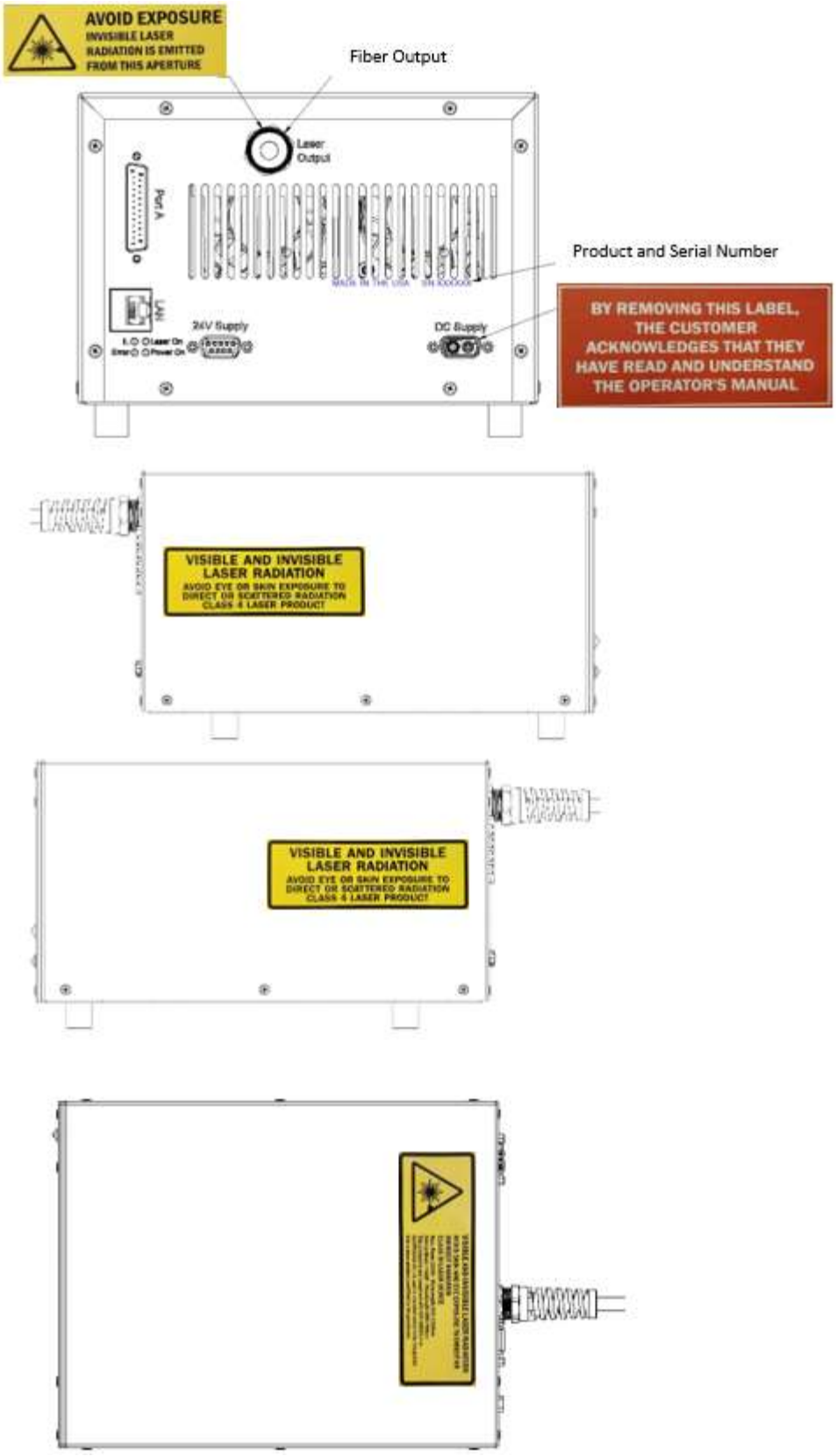
The laser system is equipped with several warning labels, describing the laser radiation exposure during normal operation and during servicing. The locations of these warning labels are shown below:

19” Rack





Compact System



2.0 Safety Considerations

This laser system is manufactured and developed based on the latest findings in laser diode development, production, reliability, and safety guidelines. Nevertheless, improper system use can lead to extreme danger to persons or property.

The Equipment and Product Safety Act requires manufacturers to have operators and users observe generally accepted laser guidelines and standards, as well as the Occupational Safety and Accident Prevention regulations.

2.1 Laser Safety

Directive EN 60825-1 places tight specifications on the manufacturer and operator of a Class IV laser facility. Since the laser system is an unfinished machine, the requirements listed below are not currently met by the delivered device and **must** be adhered to by the finalized device.

The laser system should not be put into service until all requirements of directive EN 60825-1 have been met.

2.2 Requirements of the Manufacturer

The manufacturer of the finished machine is required to ensure that adequate signage is present. The signage must:

- Be marked with required labels
- Make use of a warning light or sign installed on the device which warns nearby people of the current operating status of the laser.
- Contain a beam switch or splitter, with an active indication of the direction of the optical power signal.

The system has been pre-adjusted at the factory. A prerequisite for the operation of a Class IV laser device is that any adjustment to the laser cannot expose anyone in the vicinity to laser radiation.

If the finished machine is to be used in a hand-held fashion, the device must shut off when released from the hand.

The manufacturer is to ensure the laser system is completely enclosed. This encapsulation must minimize the exposure to the eyes and skin so that no hazard can occur through direct or indirect laser radiation.

2.3 Requirements of the Integrator

A laser shutter must be integrated into the final product.

The finished machine must be equipped with an emergency stop switch and have an interlock connected to the nominal hazard zone.

The power supply must be provided with a key switch and removable key to stop unauthorized use of the laser device.

2.4 Requirements of the Operator

The operator is obliged to notify the responsible parties at the company before first operation of the Class IV laser system. If the system is a mobile laser, then any change of location requires additional reporting.

Only authorized persons shall have access to the laser system, including places where the laser light is transported to. It is the responsibility of the Operator to adequately label and restrict access to these locations.

The nominal hazard zone (NHZ) should be kept as small as possible and should not be operated across walkways or roads.

The laser should operate far above or below eye level.

If the Operator does not have the required laser safety expertise, consultation from a qualified Laser Safety Officer should be received before operating the laser. This will require:

- Incorporating safety monitoring where the laser beam is directed
- Working closely with a laser safety professional to ensure safe laser operation
- Ensuring that employees are instructed at least once per year in laser safety procedures

The certification of the Laser Safety Officer shall be renewed every two (2) years to keep their training up to current standards.

The Operator will provide each employee within the NHZ with adequate personal protective equipment (PPE) including laser safety glasses, flame resistant clothing, and other equipment as necessary.

Important Safety Note

Laser processing of many materials can create harmful gases, fumes, dust, mist or even explosive compounds.

Appropriate measures for removing harmful gases should be taken. Continuous monitoring should be performed where there is fire or explosion hazard.

Hazardous, flammable, or explosive substances which are not required for the process should be removed from the location of laser beam delivery.

If the laser is to be used outdoors, additional security measures must be taken. The laser beam can affect a very large area. It is important to ensure that:

- The NHZ is sufficiently limited and labeled
- The laser beam is contained
- There are safety stops implemented at the end of the effective range of the laser beam
- The field of view available to the laser beam is sufficiently limited
- That the laser system can be operated and stopped remotely

A backup power supply is required if power failure represents a potential risk to persons or property.

If the laser beam is directed by a robotic arm, provisions must be taken to ensure that no laser leakage occurs, or uncontrolled laser radiation is released during movement of the arm.

Reflective surfaces should be removed from the beam path or covered with a suitable material

If major changes to the manufacturing process occur, the Laser Safety Officer must reassess the new risks presented by usage of the laser system.

The latest version of the operating and safety manual must be made available to all Operators

2.5 Residual Risks

Despite security measures incorporated into the laser system, there remain residual risks in the operation of all Class IV laser devices. The risks of a Class IV system should not be underestimated, and some major risks are listed below.

Primary Risks

The laser emits light the spectral range between 600-1600 nm, depending on specifications. The laser light in this range cannot be observed with the naked eye. There is significant risk to eye damage if proper procedures are not followed.

The laser beam may have a low divergence, which allows it to pass through the eye and be focused directly onto the retina. This can cause irreversible damage to the retina. Metallic surfaces, even those which appear dull and rough, can be highly reflective to infrared light. This presents an unpredictable risk, and these materials should be removed from the beam path.

The skin is transparent to infrared radiation. The risk of damage to the skin is highly dependent on the amount and location of IR radiation absorbed by the skin. Possible damage includes warming, burning, burning, blistering, and splitting of the skin.

Secondary Risks

Material processing with laser radiation can cause hazardous gases and dusts to be emitted. Ventilation with a suitable filtering device should be used to reduce this risk. Where appropriate, a suitable supply of fresh air should also be provided.

Flammable substances can be ignited by laser radiation.

Explosive substances can be ignited by laser radiation.

To avoid hazards caused by electrical voltages and currents, only qualified personnel may operate the electronics.

Important: For damages which result from incorrect use or failure to observe the operating instructions, the User or Operator assumes full responsibility.

2.6 Risks from Incorrect Installation

Before powering on the laser system, all cables, hoses, and fibers should be properly secured. Failure to follow this instruction can result in module malfunction and damage to the system, persons, or property.

Always used undamaged cables and hoses. Defective cables, tubes, and fibers must be immediately reported and removed from service. During the exchange process, the laser system should not be used.

The optical cable can be damaged if incorrectly stored or used. It is the responsibility of the Operator to care for the optical delivery fiber.

All parts with a red wax seal or marked screws may not be removed. Removal of these items represents a risk of exposure to uncontrolled laser light and will void the manufacturer's warranty.

2.7 Hazards Due to Laser System Malfunction

In the case of laser system malfunction, there can be damage to the laser system, persons, or other property. When a malfunction occurs, the laser system should be immediately shut down and secured in a way such that it cannot be operated again until serviced. The local support representative listed in section 1.2 should be immediately contacted.

2.8 General Safety Considerations

The laser system is designed with a three-step operational process.

3.0 System Setup Guide

This quick start guide describes the initial setup and bringing on-line the laser. It consists of a system with laser module, drive electronics and cooling integrated into a compact package or a 19” rack-compatible package. The system requires a 24VDC and 48VDC power supply to be supplied or will be included as an option. It is extremely important that all operating instructions be followed closely and carefully. The following instructions cover the powering, cooling, and optical aspects of the laser system.

Before you connect the laser to the driver, make sure to have a laser safe environment and be protected against laser radiation! Take care that the laser is connected with correct polarity. Consider the rules for ESD-safe environment.

3.1 System Overview - Identification of Parts

The Laser System comes supplied with the following items:

- Laser System with integrated fiber delivery cable
- USB memory stick with Manual and system datasheet
- DB25 connector hood and solder connector for Interlock and Analog control (Bridge Pin 2-3 and 15-17)
- Datasheet describing system specifications
- 48V Supply Cable
- 24V Supply Cable

Front panel of Compact 19” Rack Air-Cooled System

Front panel of Compact Air-Cooled System

Front Panel:

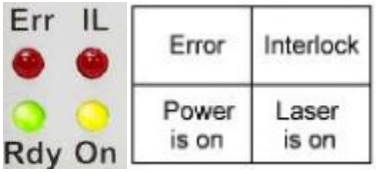
- The Green light will illuminate when Power is on.
- The Yellow light with illuminate when the Laser is On
- The 1st Red Light will illuminate when there is an Error
- The 2nd Red Light will illuminate when there is an Interlock

Rear Panel of 19" Rack Air-Cooled System

Rear Panel of Compact Air-Cooled System

Rear Panel:

- Input 24VDC Control Supply
- Input 48VDC Power Supply
- Ethernet Communication Terminal
- 4 LED's

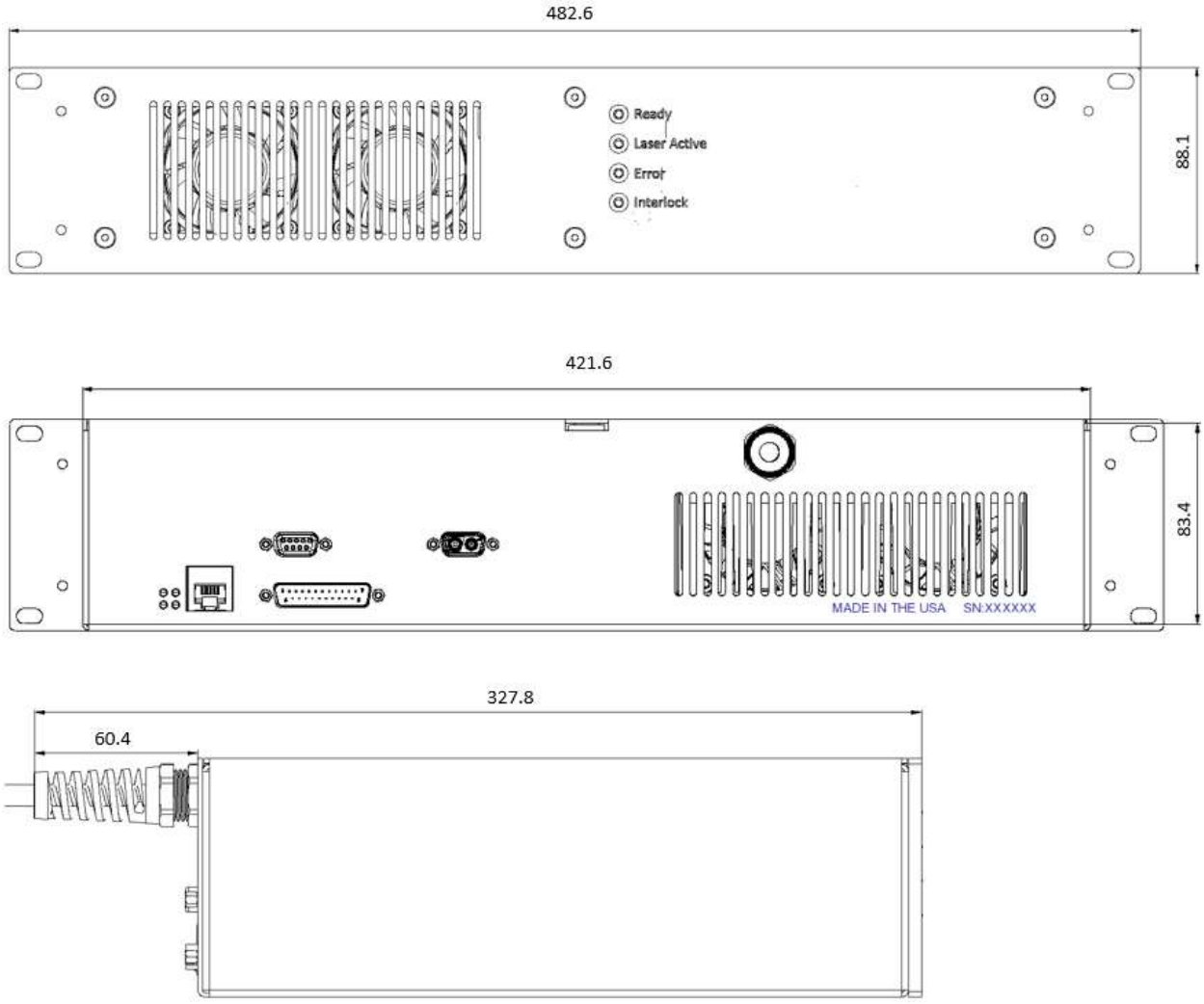


- DB25 connector for analog control. For test operation, bridge pin 2 to 3 and pin 15 to 17.
- Fiber Output

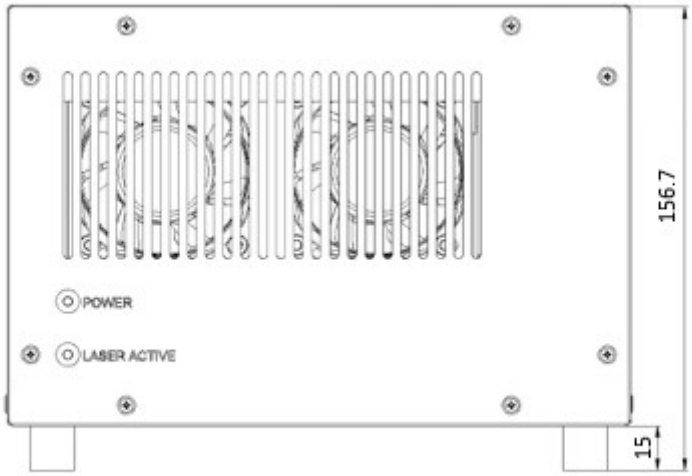
3.2 Mechanical Features

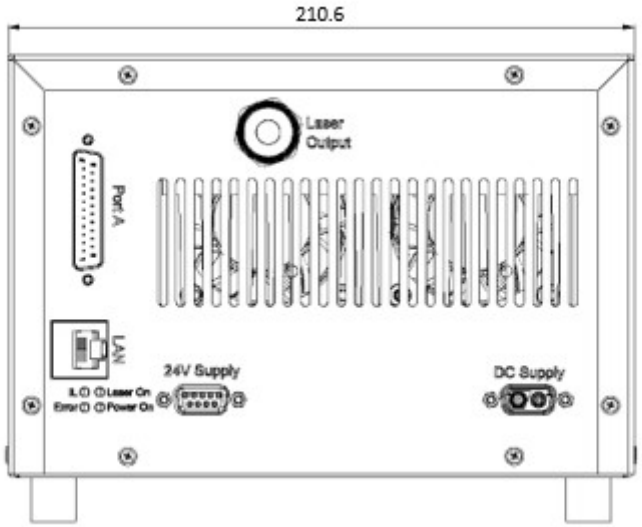
The laser system is a 19” rack-mounted system is a fully-functioning laser system in an 2RU tall packages.

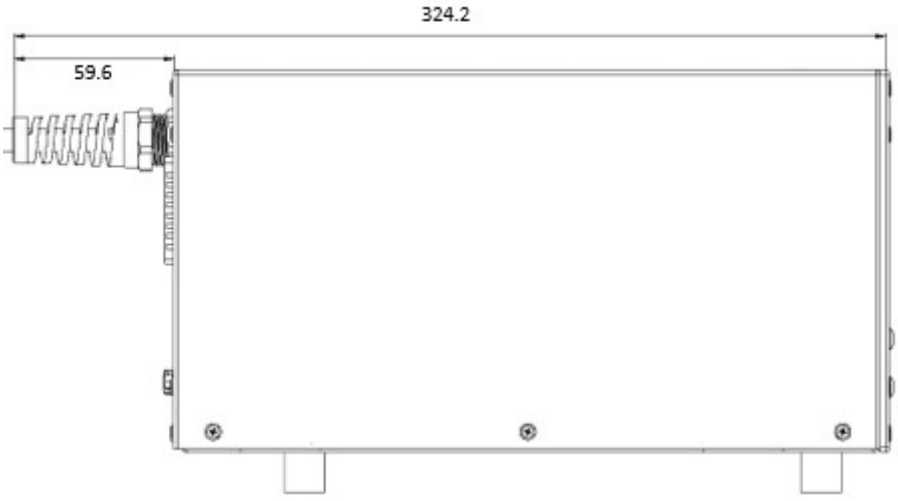
Mechanical drawings for the 19” rack (units in mm):



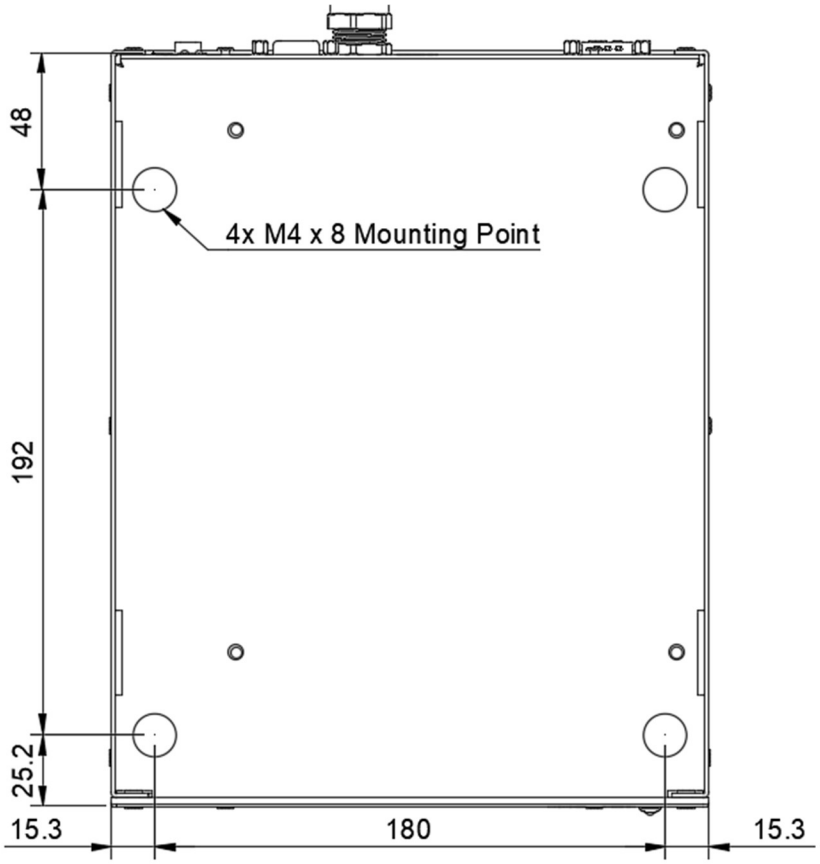
Mechanical drawings for the Compact System (units in mm):







Rubber feet are removable allowing for mounting interface:



3.3 System Setup

1. Remove system from packaging, taking care to not exceed the minimum bend radius of the fiber. A table with guidelines for minimum bend radius is shown below:

Fiber Core (um) NA = 0.22	Operational Minimum Bend Radius (mm)	Storage Minimum Bend Radius (mm)
105	25	22
200	30	25
400	75	65
600	115	100

2. Attach the DB25 connector which has the interlock connection. Shorted testing versions can be used for testing purposes but should not be present in the final system. To test, short pin 2 to pin 3 and pin 15 to pin 17 on the DB25 connector.
3. Inspect the end face of the delivery fiber. The end face should always be protected while the system is inactive and should be inspected frequently in between operations. Inspection and cleaning guidelines can be found in section 4.6 Fiber Care.

4. Connect the fiber to desired connector by contacting the edge of the ferrule first, this will protect the fiber face from damage.

5. Connect the main 48VDC power line to the 2-pin connector. The power input voltage must match the input specifications listed on the unit. The exact input power specifications are unique to the system and can be found on the accompanying datasheet or on the unit itself, or an optional DC power supply would be supplied with the unit. **For further information see section 4.5 DC Voltage Input.**
6. Connect the main 24VDC power line to the 9-pin connector, if optional DC power supply is present it will have the respective 9-pin output.
7. Before supplying DC voltage, the system should be inspected for loose connectors and ensure that the surround environment is safe.
8. Attach an Ethernet cable from your computer to the laser system.
9. All laser systems have a fixed TCP/IP address set at time of delivery.
   Default IP address: 192.168.0.200 (Subnet mask: 255.255.255.0)
   For further information see section **Error! Reference source not found.**
10. Open a browser window and enter IP address for GUI access.

The laser system is now ready for normal operation.

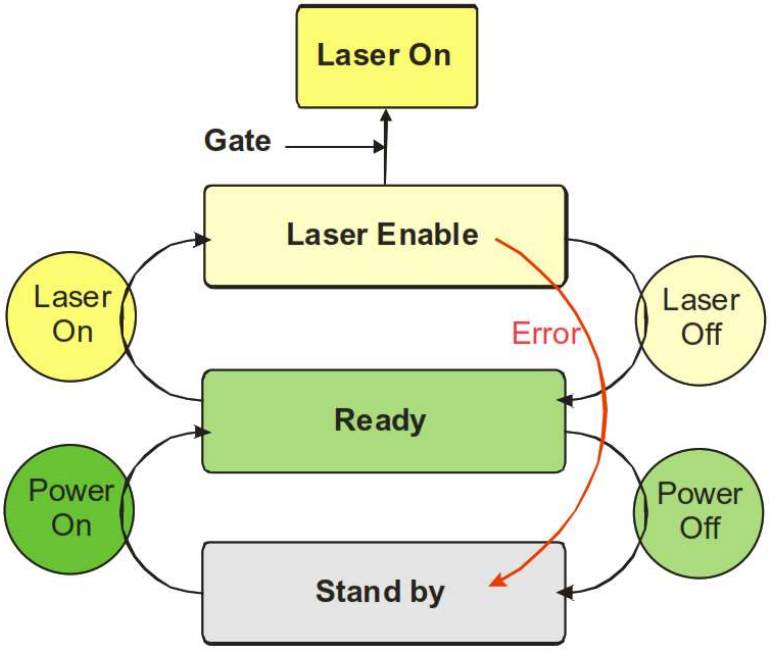
4.0 System Operation

It is the responsibility of the Operator to ensure that all interlocks are working correctly and that any and all safeguards are in place to protect the Operator and any personnel in the effective area.

The laser system should not be put into service until all of the safety requirements have been fulfilled.

4.1 Operation

In this section the basic control and states of the laser devices will be shown.



Stand by:
When the system is powered up, it is blocked for up to 15 seconds during its bootup process. Then it turns into the “stand by” state. In “stand by” the primary voltage sources are switched off and the laser current modules are not working.

Ready:
In ready state the system is fully powered. The primary voltage sources can be switched on with a selecting the “Power On”- Button in the Web-Menu. First, the LED in the button will light up orange. After a successful read of the primary voltage it will change to green.

Normally the Device needs about 2 seconds to switch from “Stand by” to “Ready” state.

4.1.1 Operation Modes

CW Operation
In CW Operation you directly switch the laser On/Off via “Laser On” Signal / Button.

Gated Operation
In Gated Operation you enable the “Laser On State” with the Laser Enable Signal / Button
The Laser Current is switched On and Off with the Gate Signal (Port A, pin 4).

Timer Operation
In Timer Operation you enable the laser with the “Laser On” Signal / Button.
The Laser Current is switched On and Off due to the internal Timer. You can configure the Timer Period and Pulse duration in the Browser Menu.

Trigger Operation
In Trigger Operation you enable the laser with the “Laser On” Signal / Button. The laser is triggered on the Positive Edge of the Trigger signal (Port A, pin4). The Pulse duration is programmed with internal Timer (Browser menu). The Pulse Period has no function in this context. The Trigger frequency is limited by the Pulse Duration and the maximum Duty Cycle in Register (A022).

4.1.2 Ethernet Connectivity

All laser systems have a fixed TCP/IP address set at time of delivery.
Default CM100 IP address: 192.168.0.200 (Subnet mask: 255.255.255.0)

In some cases, a different IP address configuration is used by customer requirements. Therefore, you should look into the quality acceptance test documentation to find out the actual values.

Directly plugging the system into a local network would usually end up with the system being invisible within the network because of non-fitting network mask and IP settings.
Therefore, and in order to safely establish a connection to the driver, connect it to your PC’s LAN interface in a one-by-one manner using a crossover Ethernet cable or a network hub/switch.

The LAN-Adapter of your PC then needs to be configured to a fixed IP-Address within the same subnet as the driver. Any IP address starting with 192.168.0.x should work except for the IP Address assigned to the driver. Once the connection is established, you can change network settings using the system Web interface.

Other operation modes like DHCP and usage of routers are also possible but need to be adjusted with your network administrator. For more details see Appendix A – LAN Connection Setup

4.1.3 Web-Interface

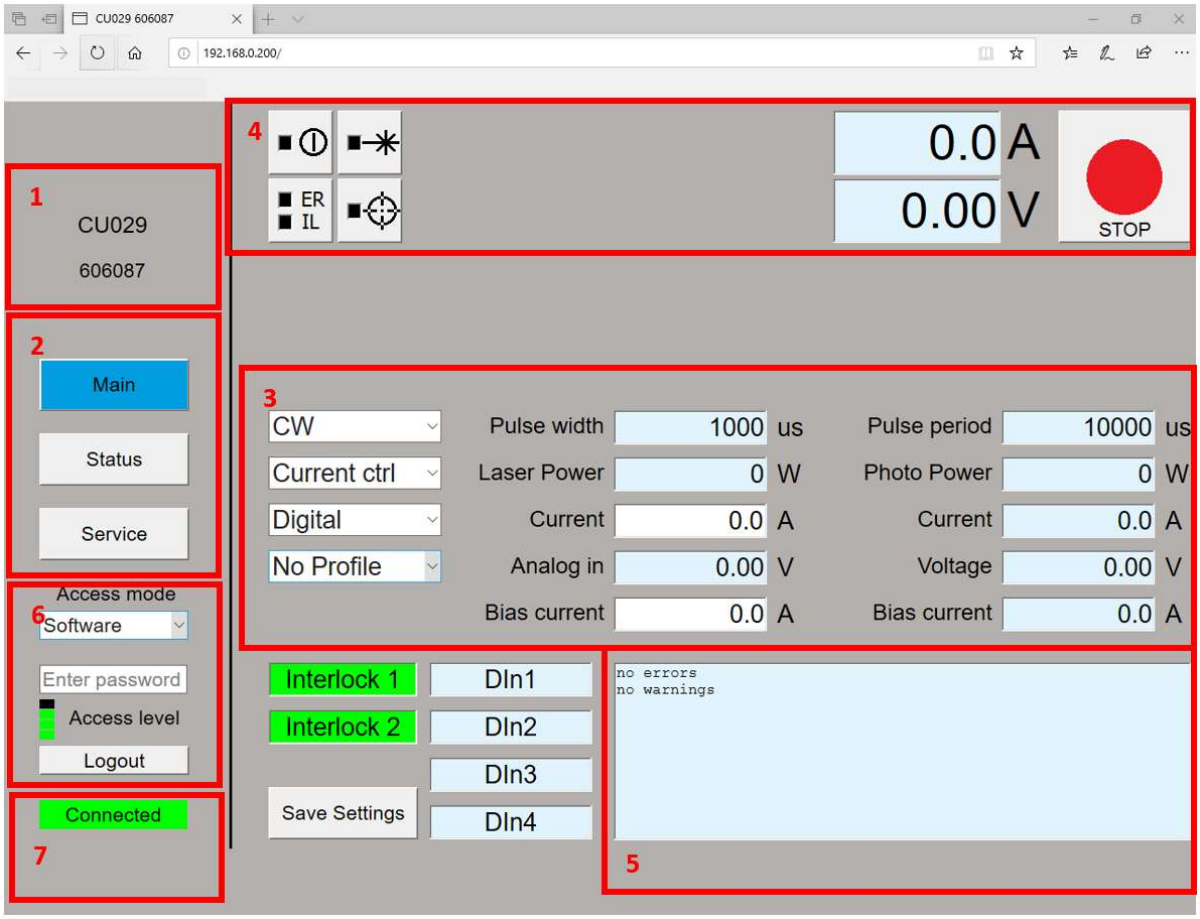
System Requirements

In order to use the web interface with all its functions you need to use:
- Mozilla Firefox (60.0.1 tested)
- Google Chrome (66.0.3359 tested)
- Safari (11.0.3 tested)

Microsoft Internet Explorer and Microsoft Edge are not recommended but can be used.

The web interface is best viewed at a resolution of 1280 x 1024 or higher.

Screen layout
The web interface consists of the following modules as shown in the picture below:



1: Device Identification

- Here you can identify the device type and serial number.

2: Menu

- Click ‘Main’ to reload the web interface.
- Under ‘Status’ you find general device information: Device type and serial number, IP and MAC address, device up time and firmware/hardware versions.
- Under ‘Service’ you can
    - Control the with a Terminal
    - Configure the network settings
    - Upload a new firmware
    - Upload a parameter patch file
    - Reboot the system
    - Edit the web interface title that is displayed on the web browser tab

3: Operation

- In the ‘Operation’ section the most common settings for system operation can be made:
    - Profile mode can be set to ‘No Profile’, ‘Single Profile’ and ‘Multi Profile’. If in profile mode, the output current follows the current shape that is defined under Parameters -> Profile. If in single profile the current follows the shape once, if in multi profile it follows the shape repeatedly.
    - Source mode can be set either to ‘Digital’ or to ‘Analog’. If set to ‘Digital’, the output current of the system is determined by the value entered behind Current (A) or Power (W) in the ‘Operation’ section. If set to ‘Analog’, the current is proportional to the voltage on the system analog input.
    - Control mode can be set either to ‘Current ctrl’ or to ‘Power set’. If set to ‘Current ctrl’, output current is directly chosen by entering a value behind Current (A), if set to ‘Power ctrl’ an output power can be chosen behind Power (W), that value is then transferred into a output current according to the laser characteristics set under Parameters -> Interface
- Operation mode can be set to one of the following values:
    - CW: Device makes a constant current after laser on
    - Gate: Device makes a constant current after laser on and a low-high transition on the gate input
    - Timer: Device makes pulses with chosen pulse width and period after laser on
    - Trigger: Device makes a single pulse with chosen pulse width after laser on and each low-high transition on the system gate input.
- Pulse duration and period are configured with Pulse width (us) and Pulse period (us)
- ‘Power (W)’ shows the laser power as measured by the photo diode (this and all other displayed values are refreshed according to the refresh rate set under Parameters -> Main, register 0032). Below ‘Set’ the output power can be preset (in power control mode)
- ‘Voltage (V)’ shows the actual measured output voltage to the laser module.
- ‘Current (A)’ shows the actual measured output current to the laser module. Below ‘Set’ the output current can be preset.

- ‘Bias Current (A)’ shows the actual measured output bias current to the laser module. Below ‘Set’ the output bias current can be preset.
- ‘Temperature (°C)’ shows the measured laser temperature.

In the ‘Operation’ section, textboxes turn cyan at the moment they are edited. After pressing ‘Enter’, for a second the textboxes turn green if the value was accepted or red if the value was not accepted.

The ‘Save Settings’ button saves the current system settings.

Next to the ‘Save Settings’ button, there is a connection indicator. If the connection between the PC and the system are working properly, the indicator is green and shows ‘Connected’. If some connection problem occurs, it turns red and shows ‘Disconnected’.

4: Status

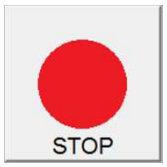
- The ‘Status’ section contains 5 buttons, next to every button a LED shows the status:


Power Supply On/Off


Laser Beam On/Off

Error and Interlock. Additionally, this can be used for clearing an error


Aiming Beam On/Off



Software Emergency Off

- Also displayed is the current and voltage being supplied to the Laser Modules.

5: Errors

- If an error, warning or interlock occurs, a short message is displayed in this section of the web interface. Errors can be cleared by clicking on the ‘Clear Errors’ button.

6: Access mode

- The access mode can be switched between ‘Software’ and ‘Digital Input’. If set to ‘Software’, the control with the web interface is activated. If set to ‘Digital Input’, the control with the external I/O’s on Port A is activated.

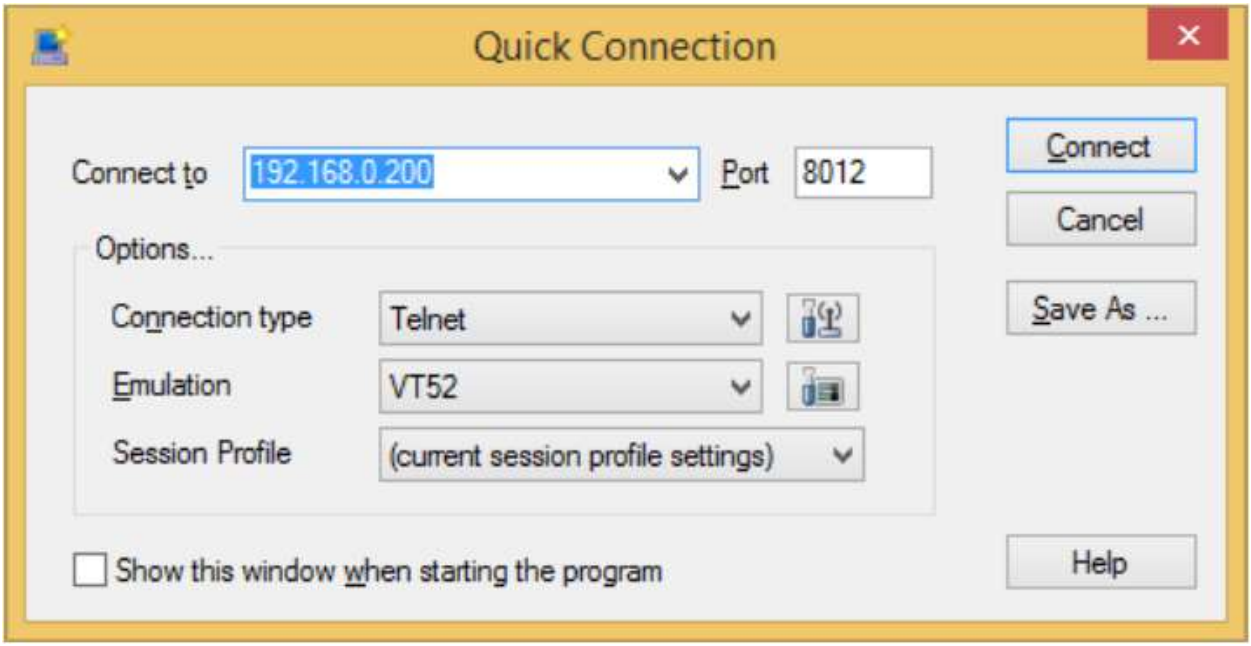
- The access level is shown in the bar-graph. The standard user level is only one bar. The level can be changed with passwords for OEM- costumers or the manufacturer. If a password was entered, the logout button can be pressed to return to the user level.

7: Connection display

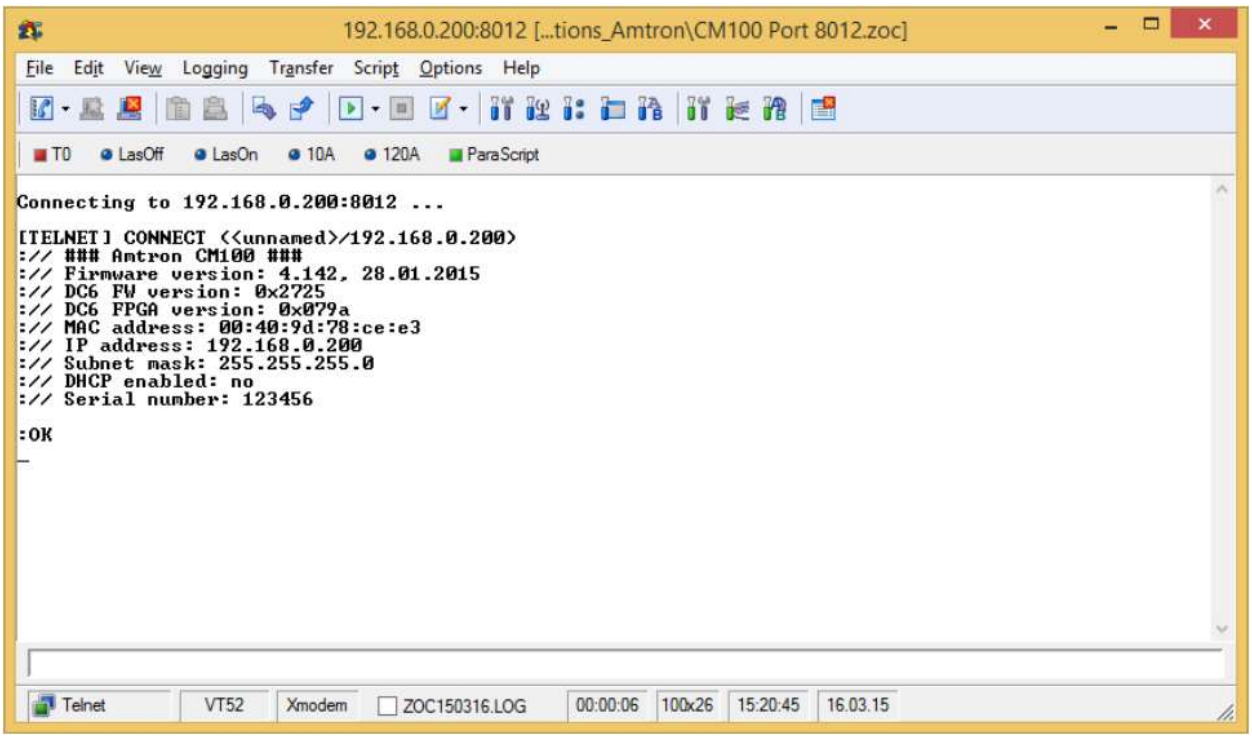
- This display shows the connection status between the browser and system (connected or disconnected).

4.1.4 Terminal Access

The Laser System can easily be accessed using terminal software, like ZOC (or HyperTerminal).
Using ZOC, a new connection has to be established using the following settings:



If the connection with the device has been established, the following message will appear:



Now, the device can be accessed via the command prompt. A command is always started by ":", followed by one or two letters specifying the command type and one or two parameters. Leading zeros and the space between commands and the register number can be omitted. For direct access to the device registers, the commands "r" and "w" are used. For example, typing

:r 2020

On the command prompt and hitting ENTER reads out the register 2020 (set current). The response of the device appears in the connection window:

:r 2020
:250
:OK

In this case, the device responds that the value is set to 250. To alter the value

:w 2020 300:
:OK

Confirms that the current was successfully set to 300.

The "r" and "w" commands can be used together with the suffix "h" stating that the value is in the hexadecimal format. For example,

:wh 6005 6

sets the register 6005 to the hexadecimal value 0x0006.

:rh 6005

reads out register 6005 and shows the result in the hexadecimal format:

:rh 6005
: 6
:OK

When writing into the registers, the range of the value parameter is checked. If the value is out of range, the writing request is confirmed with ":ER R" instead of ":OK".

Some registers are protected and can only be accessed with the proper access rights. Trying to access those registers without access rights leads to the confirmation message ":ER A", the value is not printed or changed in this case.

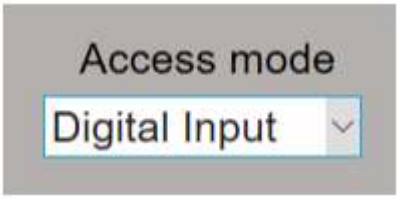
Besides ":r" and ":w", there are several other commands. ":p" prints a list of the most commonly used register. ":pa" prints a list of all registers, ":pe" prints an overview of currently detected errors and warnings. ":t" followed by a number opens the specified debug screen, debug screens available can be listed by ":t?". Debug screens are terminated by ":t0".

To save all registers to the device nonvolatile memory (Flash memory), ":s" can be used.

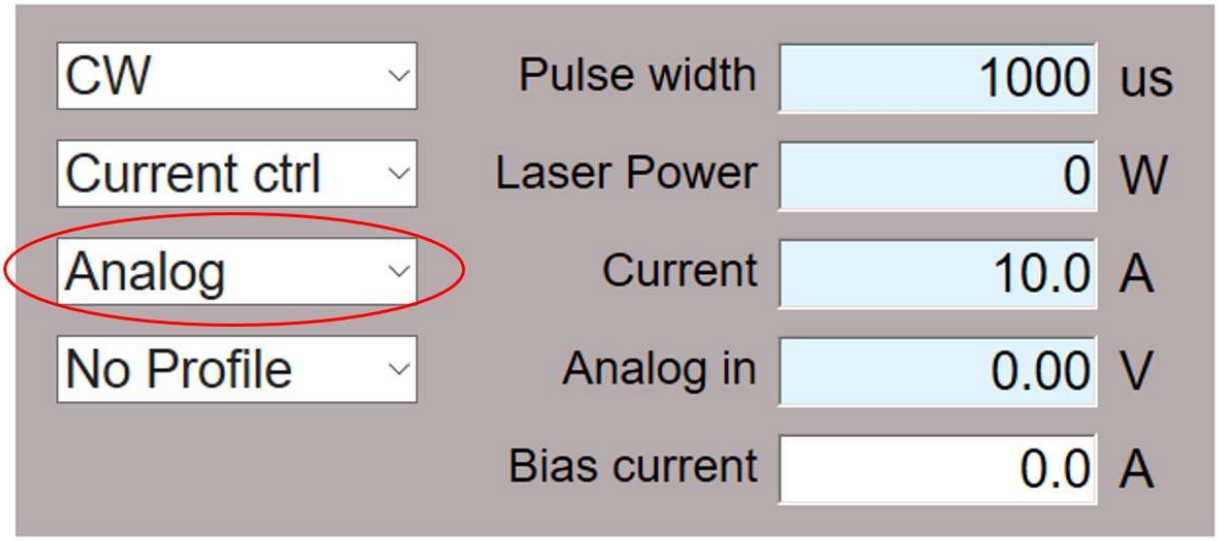
4.2 Control Interface - Analog Access (DB25)

The system can be controlled via the DB25 connector and will respond to external analog commands when in this mode. The system may have been configured to start in external control mode by default, depending on customer specification.

In the left side of the GUI, an option labelled "Access mode" will show whether or not the system is in external control mode.



In the operation section the input is required to be changed from "Digital" to "Analog". This prepares the laser system to expect a 0-10V signal to control the output power on a linearized scale from 0-100%.

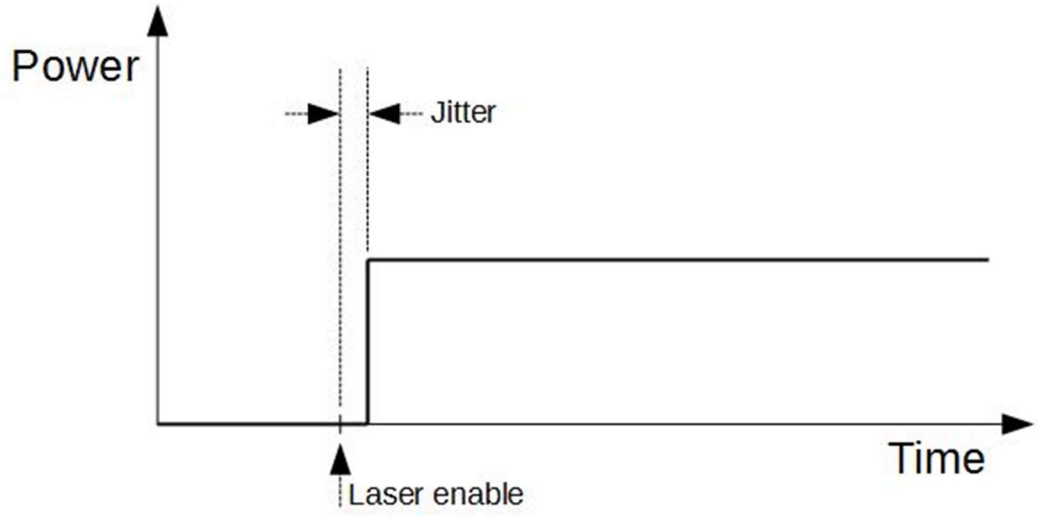


In external control mode, all GUI functions will be grayed out and unavailable, but all sensor values and output parameters can be monitored.

The operating modes of the Power Engine are designed to cover a wide range of applications and requirements.

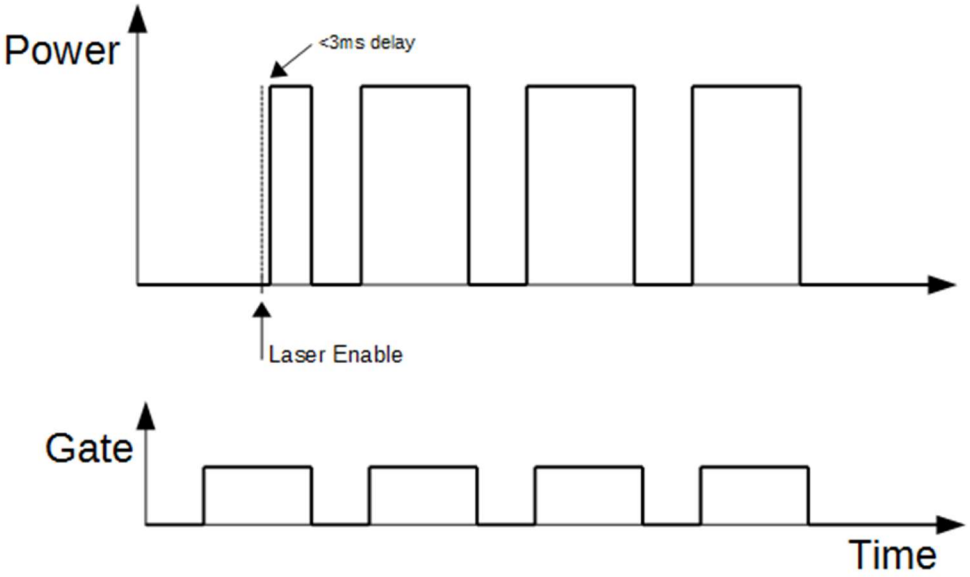
CW Mode without Gate:

The laser system can be operated in CW mode by switching the laser module on and off with the laser enable signal via the I/O interface. A variable delay of up to 3ms will occur before the laser diode responds to a change in the enable signal.



Gated Operation:

The laser can also be operated with a gate signal supplied from an external source to the DB25 connector (Pin 4), which can activate the current with a nearly jitter-free time delay of <50us. The system will have the laser current already enabled and the analog signal set at the desired power level.



Timer Operation:

In Timer Operation, the current is switched on and off from an internal timer. The user can configure the Timer Period and Pulse Period in the GUI interface. switching the laser module on and off with the laser enable signal via the GUI interface

Trigger Operation:

In Trigger Operation you enable the laser with the “Laser On” Signal / Button. The laser is triggered on the Positive Edge of the Trigger signal (DB25, pin4). The Pulse duration is programmed with internal Timer (GUI menu). The Pulse Period has no function in this context. The Trigger frequency is limited by the Pulse Duration and the maximum Duty Cycle in Register (A022).

The following table shows the pinout for the DB25, DB9 and Supply connectors on the rear panel of the unit.

DB25:

Pin	Name	Type	Meaning	Remarks
1	WarningLight	Output	Warning Lights	24V
14	Fan	Output	External Fan	24V
2	Interlock1	Input	Interlock #1 Laser System	Bridge to pin 3
15	Interlock2	Input	Interlock #2 Laser System	Bridge to pin 17
3	I/Osupply	Output	Supply for I/O	24V
16	LaserOn	Input	Laser Enable	Level 4-24V
4	Tripper/Gate	Input	Gate/Trigger	Level 4-24V
17	Ground	GND	Ground for I/O and sensors	Ground for 24V/5V
5	Ready	Output	Ready for Operation	Level 24V
18	Error/Error-Bus	I/O	Error Active/Shut Off	Level 24V
6	PowerOn/F-IL	Input	Power is on/F-Interlock	Level 4-24V
19	TriggerOut	Output	Trigger Output	Level 5V TTL
7	PilotLaser	Output	Pilot Laser is enabled	5V, max 100mA
20	NTC	GND	Temperature Sensor	For all I/O
8	Analogin	Input	Analog Input	Level 0-10V
21	AnalogOut	Output	Analog Output	Level 0-5V
9	ErrCir	Input	Error Clear	Level 4-24V
22	CurrentSource	Output	PT100 Current Out	1mA Current Loop
10	PT100-1	Input	PT100-1 Input	PT100 Upper Point
23	PT100-common	Input	PT100-1/2 Input	PT100 Points
11	PT100-2	Input	PT100-2 Input	PT100 Lower Point
24	CurrentSink	Input	PT100 Current In	1mA Current Loop
12	SensorsSupply	Output	Supply for Sensors	5V
25	PhotoCathode	Input	Photodiode Cathode	Power
13	PhotoAnode	GND	Photodiode Anode	Measurement

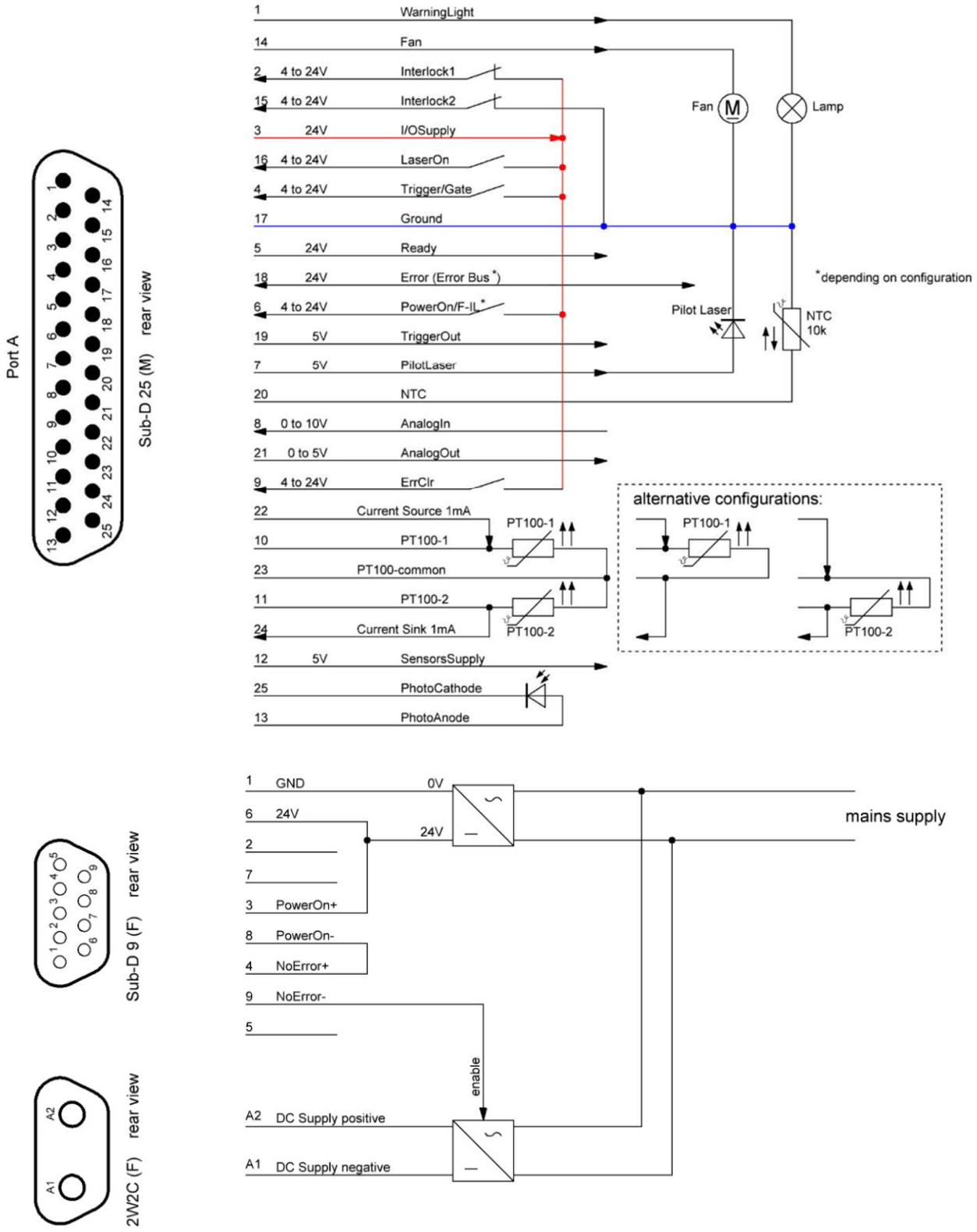
DB9:

Pin	Name	Type	Meaning	Remarks
1	GND	Input	Controller Power Input	
6	24V	Input	Controller Power Input	
2				
7				
3	PowerOn+	Output	Primary Source Control	
8	PowerOn-	Output		Closed on Power On
4	NoError+	Output	Primary Source Control	
9	NoError-	Output		Open on Error
5				

Supply:

Pin	Name	Type	Meaning	Remarks
A1		Input	DC Source Negative	48V 10A
A2		Input	DC Source Positive	48V 10A

The following diagram shows a sample of wiring.



4.3 Security Interlock

The security interlock uses 2 interlock inputs IL1+ (pin 2) and IL2- (pin 15). Both inputs are referenced to Ground and 24V. They have to be used synchronously in order to comply with performance level PL'e' (EN ISO 13849). The following table shows the possible input states of IL1+ and IL2- and the corresponding behavior of the system:

IL1+	IL2-	Interlock	Error
24V (closed)	0V (closed)	No	No
0V (open)	24V (open)	Yes	No
0V (open)	0V (closed)	Yes	Yes
24V (closed)	24V (open)	Yes	Yes

To remove the interlock state, pins 2-3 and pins 15-17 need to be bridged. Whenever IL1+ and IL2- are not served synchronously, an error 'interlock sync DC6' is generated after a latency period of 200ms. Hereafter, this error can only be reset by either power cycling or error clearing after one valid 'interlock cycle'. A valid interlock cycle strictly has to be in the following order:

No.	IL1+	IL2-	Remark
1	24V (closed)	0V (closed)	Switch to 'no interlock' state with both inputs synchronously
2	0V (open)	24V (open)	Switch to 'interlock' state with both inputs synchronously
3	24V (closed)	0V (closed)	Switch to 'no interlock' state with both inputs synchronously
4	0V (open)	24V (open)	Switch to 'interlock' state with both inputs synchronously

After the correct execution of these switching procedures, the error 'interlock sync DC6' can be reset.

4.4 Control Interface – Register Command (LAN)

Normal operation of the system is most easily accomplished with the inbuilt software. Custom software may be developed if more specialized behavior is required. This can be achieved using the Register command interface described in Appendix B.

4.5 DC Voltage Input

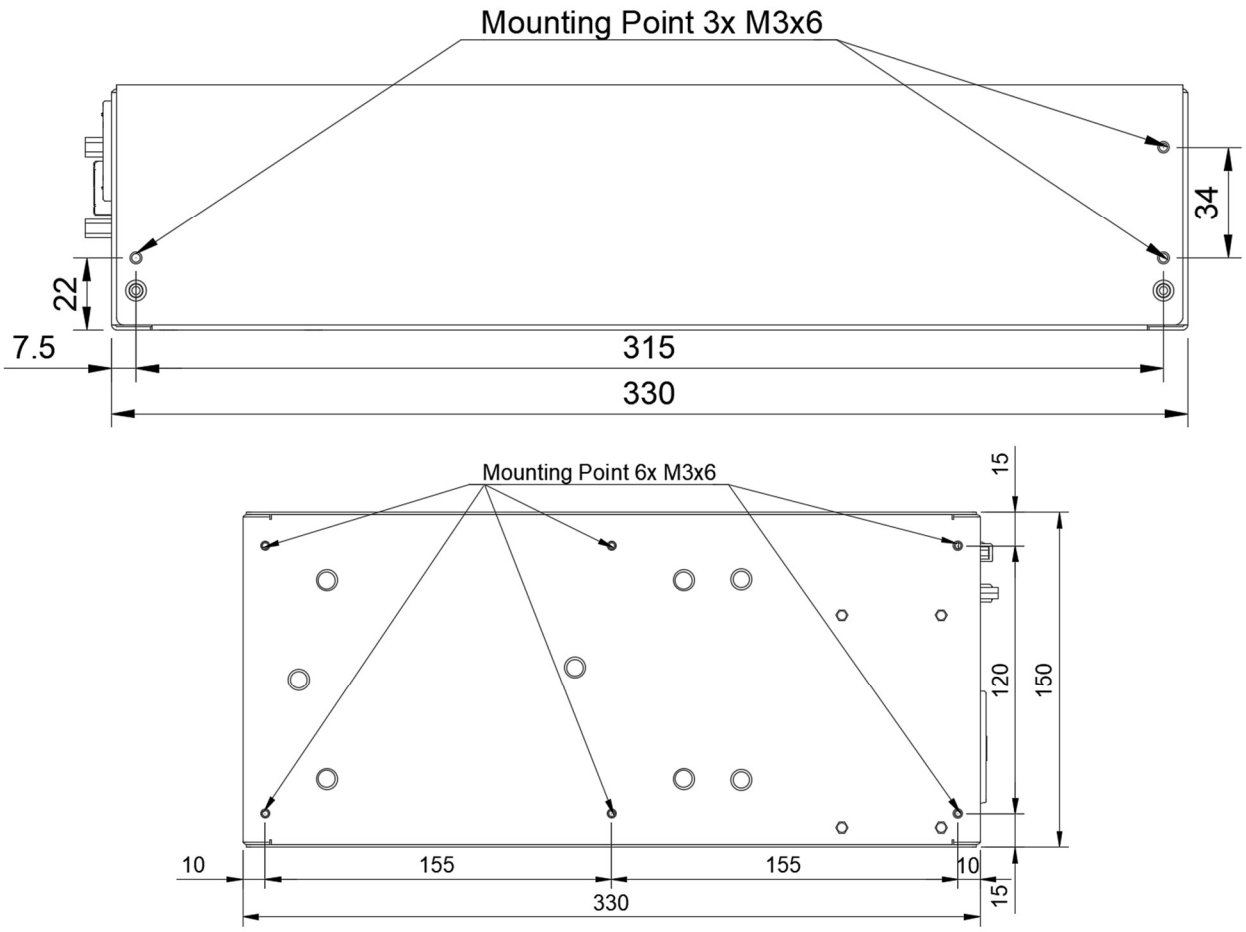
The compact laser system is designed to be integrated into a larger system and to save cost and size it requires DC voltage input. This is further split into two inputs, the first being the main power to the electronics to drive the laser itself and a second input that powers the controls. It is separated as a safety consideration as the main power can be disconnected while the logic circuits are still powered to give feedback.

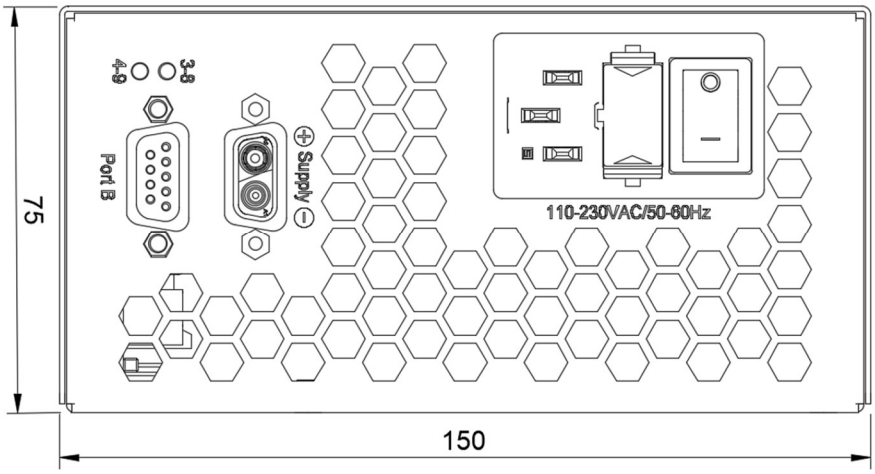
4.51 Optional AC/DC Power Supply

An optional AC/DC power supply is available for standalone operation or can be integrated into a larger system if consolidation of overall power supply is not desired. Input conditions are:

100-240VAC 50-60Hz with 500W maximum load.

Mechanical Features:





4.52 VDC Required Input

If the laser system will be integrated into a system where the power supply is consolidated the following inputs to the laser system need to be satisfied.

- F2W2SC connector is used for high power input of 48VDC +/-2% with maximum ripple of 150mVp-p. Output wattage should be at least 1.1x the requirement of the laser system as described on the datasheet; this is based on what laser module is used in the system.
    - Example: Input requirements from datasheet 20V/10A = 200W, a minimum of 200W x 1.1 = 220W AC/DC power supply must be used to properly drive laser system.
- DB9 connector is used for logic power input of 24VDC +/-2% with maximum ripple of 250mVp-p, with a minimum power required of 15W (or 0.625A), if warning lamps are used the delivered power should be increased. The optional AC/DC power supply delivers 60W (2.5A) to allow for all conditions. This should be a separate input from the high-power input to allow for safety considerations.
- Pins 4-9 and 3-8 are safety outputs from the laser system and can be used to enable the high-power input as soon as bridged. If the AC/DC power supply has an enable input these pins should be used (3-8).
    - 3-8 is bridged as soon as the ‘Power On’ status is reached (i.e. power button enabled in web interface)
    - 4-9 is bridged as long as there is not an error reported from laser system.

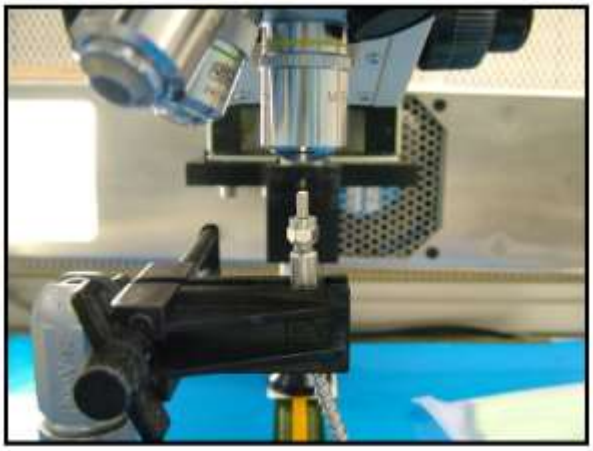
4.6 Fiber Care

The optical delivery fiber is an extremely sensitive component. To avoid damage to the device and injury to persons or property, the following points must be considered:

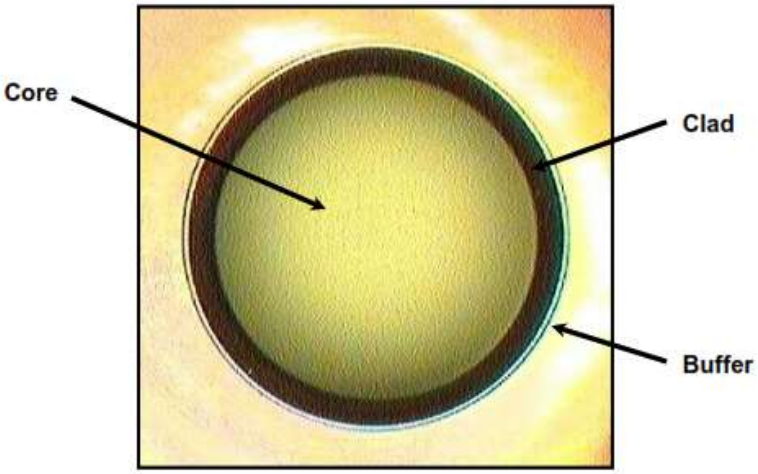
- The minimal bend radius of each fiber must be observed.

Fiber Core (um) NA = 0.22	Operational Minimum Bend Radius (mm)	Storage Minimum Bend Radius (mm)
105	25	22
200	30	25
400	75	65
600	115	100

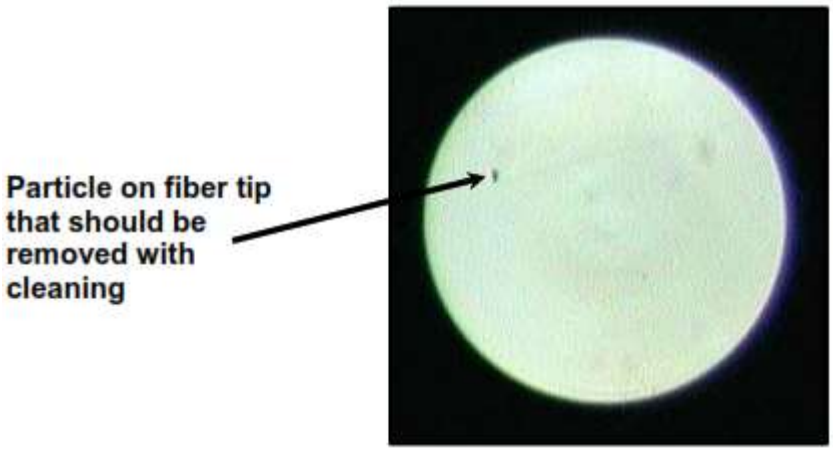
- Do not touch or contaminate the ends of the fiber.
- Keep the fiber dust caps in a safe and clean place in close proximity to the deployed laser system.
- The fiber dust caps should be installed at all times during transportation and storage.
- Ensure that the caps are removed before the laser is operated.
- Inspect the fiber end whenever the fiber has been exposed to environment (the cap has been removed or fiber has been disconnected from optics).
  Fiber tip inspection should be done at 50x magnification to ensure cleanliness.



Fiber Tip Inspection



Fiber face Identification



- The fiber ends should be cleaned only using extreme caution.

1. Use lint-free swabs or optical wipes and reagent-grade methyl alcohol. **Do not use acetone to clean optical surfaces as it could damage any adhesives.**
2. Wet the optical wipe with a alcohol and allow the wipe to partially dry, it should not be dripping wet.
3. Gently wipe across the fiber face in one direction, it is recommended to preform this under magnification to avoid damaging the fiber tip.
4. For some particles multiple wipes may be required, be sure to replace the optical wipe and re-wet with alcohol often.

- The fiber should be secured against falling.
- To prevent damaging the fiber during installation, the metal shaft should be touched to the coupling unit before inserting the fiber into the holder. The necessary connections should then be screwed in and secured.
- Extreme caution should be used if the optical cable is used in a wet or very hot environment. The laser should not be operated in a condensing environment. Humidity should not be allowed to condense on the fiber ends.
- The fiber should not be used if damage can be visually observed.
- Excessive force should never be used to assemble or disassemble the laser. If the fiber resists installation, the coupling unit and fiber should be inspected for damage or debris.
- The fiber should never be twisted, pinched, or kinked.
- There should always be sufficient slack in the fiber for a robot arm to have full range of motion without stressing the delivery cable.
- If an optical cable needs to be placed along a walkway, the cable should be stored in a solid shell, such as a pipe or conduit.

The fiber should NEVER be handled while the laser is operating. Any adjustments or modifications to the fiber positioning or mounting should only be performed after fully shutting down the laser system. Failure to follow these instructions could expose the Operator or others to invisible laser radiation, causing significant damage to persons or property.

Appendix A – LAN Connection Setup

This manual describes how to prepare a PC to display the laser system web interface. A web browser has to be installed and configured, and network settings have to be made. In the following, the installation is described for

- Mozilla Firefox (60.0.1 tested)
- Google Chrome (66.0.3359 tested)
- Safari (11.0.3 tested)

Microsoft Internet Explorer and Microsoft Edge are not recommended.

The web interface is best viewed at a resolution of 1280 x 1024 or higher.

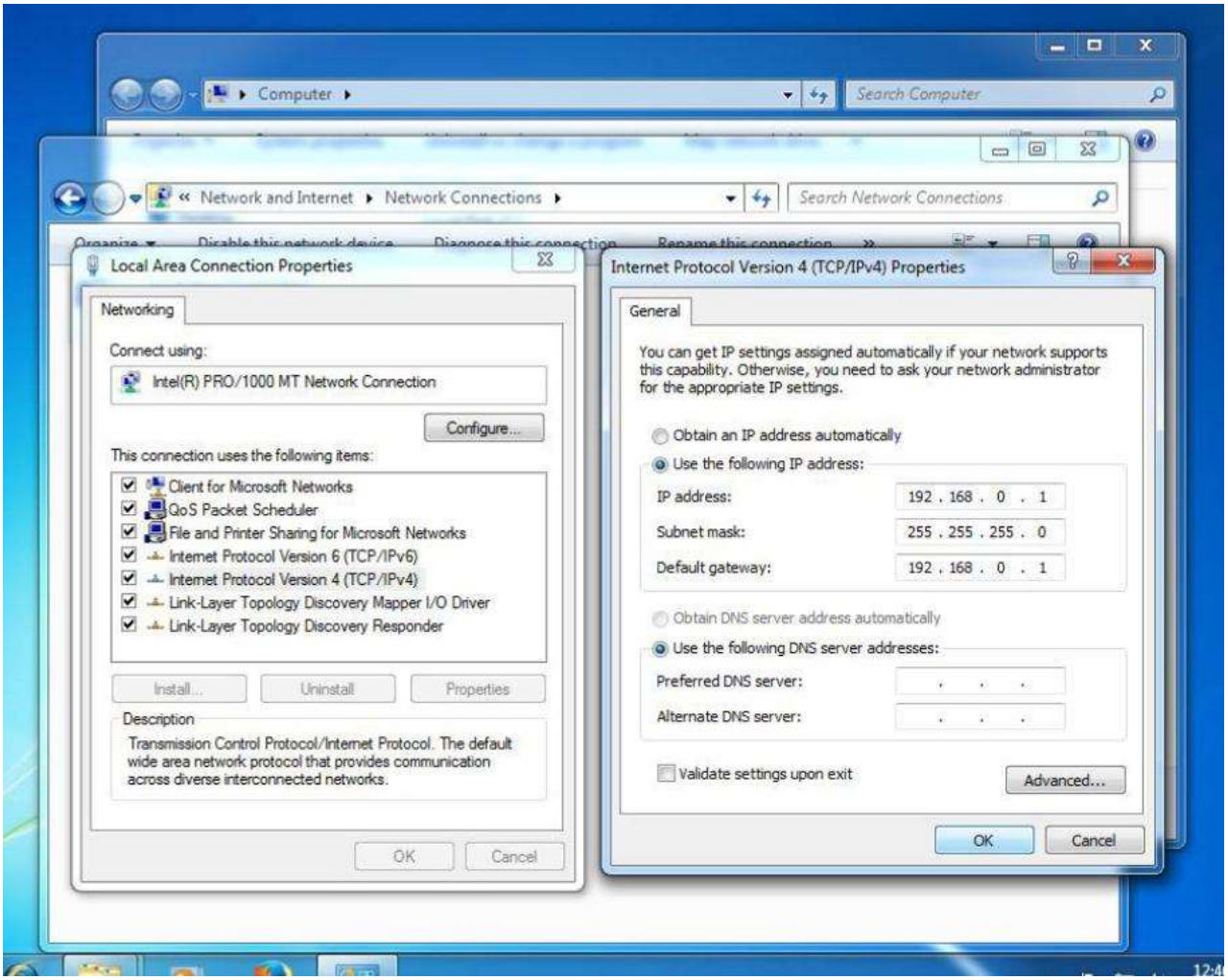
This setup has been tested for the laser devices.

Installation of Mozilla Firefox

To install Firefox, open the website as displayed below and follow the instructions.

Before you can open the laser system web interface in the Firefox browser, the PC and the laser system have to be connected to the same LAN Network. In addition to that your PC's IP address has to be set statically within the same subnet as the laser system. You find the IP address for each laser system in the datasheet delivered with the system. For most devices, this is 192.168.0.200 by default.

Open Windows Explorer, on the left side right click on Network and choose Properties. Then on the left side click on Change adapter settings, then right click on Local Area Connection and choose Properties. Choose Internet Protocol Version 4 (TCP/IPv4) and click on Properties. Now you should see the following:



For example, if the laser system has the address 192.168.0.200, the PC's address could be 192.168.0.1, the subnet mask 255.255.255.0 and the gateway 192.168.0.1, as shown in the screenshot. After you made the settings matching for the laser system, click on Ok.

Now you can open Firefox to connect to a laser system. Please enter the IP address of the laser system in the address bar of Firefox (this example here was for IP address 192.168.0.200). Now the laser system web interface is ready for operation.

Appendix B – Variable Fan Control

Starting with firmware version 5.091.0/0x289c, the Compact Laser supports a new fan control feature. The user can configure the fan behavior according to his needs by choosing 3 temperature levels and according fan speeds. In addition to that, different temperature inputs can be selected for fan control.

B.1 - Configuring the Temperature Inputs

Multiple temperature controls can be selected for fan control. If more than one input is selected, the maximum temperature of all inputs is used. Each temperature is activated by setting the related bit in the Fan config register:

Register	Description	Range	Factory Value	Example
5050	Laser Temperature	1	1	:wh 5050 1 - Read Laser Temp for Fan Control
	Fan Permanently On	8000		:wh 5050 8000 - Fan is Permanently
5051	Fan PWM	0-40	40	:w 5051 40 - Fan Speed Set to 100%

If the fan is set to be permanently on, the selected temperature signals are ignored, and the fan is turned on permanently. In this case, the fan speed must be set between 0 and 40 by the register fan PWM, which is set by register 5051. 0 = Min Fan Speed and 40 = Max Fan Speed

B.2 - Configuring the Fan Switching Points

3 fan switching points can be configured, each consisting of a temperature [0.1°C] and a fan speed (0 - 40). If the laser is on, the fan behaves like in the following example:

- If Fan Med Temp is crossed in positive direction, the fan is set to Fan Med Speed
- If temp 2 -2°C is crossed in negative direction, the fan is set back Fan Low Speed

This is to prevent a hysteresis of 2°C to avoid permanent fan switching.

Fan Switching Points:

Register	Description	Units	Range	Factory Value	Example
5053	Fan Low Temp	0.1C	0 - 400	250	:w 5053 250 - Sets Low Temp at 25C
5054	Fan Low Speed	N/A	0-40	4	:w 5054 8 - Sets Low Speed at 10%
5055	Fan Med Temp	0.1C	0 - 400	320	:w 5055 320 - Sets Med Temp at 32C
5056	Fan Med Speed	N/A	0-40	24	:w 5056 24 - Sets Med Speed at 60%
5057	Fan High Temp	0.1C	0 - 400	380	:w 5055 380 - Sets High Temp at 38C
5058	Fan High Speed	N/A	0-40	40	:w 5056 40 - Sets High Speed at 100%

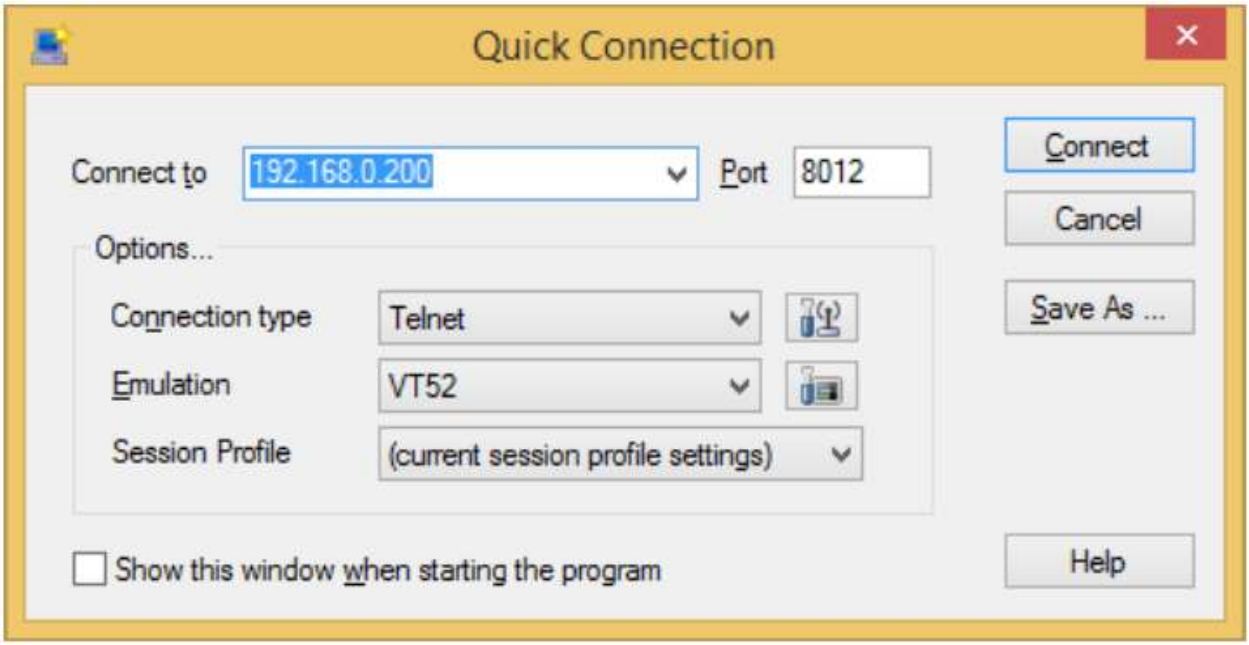
Before power cycling save setting to prevent loss of configuration.

Appendix C - Command Index

C.1 - Register Commands

Connection Parameters

The laser system can be accessed using a terminal program such as HyperTerminal or ZOC. To connect a PC to the laser system, connect the communications cable (Ethernet) and direct the program to connect to the created port. The connection can be established using the following parameters:



C.2 - Register List for firmware version 5.066.0

Index	name	function
00xx	Main	main registers with superordinate functions
01xx	Main	error/warning summary registers
10xx	Profile	sampling points for profile mode
20xx	Control	registers directly used for device operating
5nxx	Laser Temp	registers used for laser temperature monitoring/control
6nxx	Interface	interface configurations and states
Anxx	Power	Power Unit specific register

Note: The "n" in the register numbers is used when multiple units of the specific type (laser, interface, cooler, TEC and power units) are present in a system device to distinguish the registers of these units (first or single unit n=0, second unit n=1 etc).

C.3 – Main Registers

Register	Name	Description	Unit	Access	Size	View Mode	Min	Max	Default	Notes
0001	ERR0	errors group 0	1	R1	32	hexadecimal	0	0xffff	0	errors in group 0
0002	RES01	reserved 01	1	R1	16	not displayed	0	10	0	reserved
0003	WRN0	warnings group 0	1	R1	32	hexadecimal	0	0xffff	0	warnings in group 0
0004	RES02	reserved 02	1	R1	16	not displayed	0	0	0	reserved
0005	MCNF1	main config	1	R1W1	16	hexadecimal	0	0xffff	0	bit 2 (0x0004): laser on timeout without error bit 15 (0x8000): TEC adjustment mode
0006	MCNF2	main config (OEM)	1	R1W3	16	hexadecimal	0	0x0000	0	no bits defined yet
0007	FVER	firmware version	0,001	R1	16	unsigned integer	0	65535	0	Device firmware version
0008	FTYPE	firmware type	1	R1W4	16	hexadecimal	0	0xffff	FIRMTYPE	Device firmware type
0009	PARAMVER	parameters version	1	R1W4	16	hexadecimal	0	0xffff	FILEVER	Device parameters version
000a	SERNUM	serial number	1	R1W4	32	unsigned long	0	2147483647	123456	Device serial number
000b	DEVNUM	device number	1	R1W4	16	unsigned integer	0	65535	0	Device number (appears behind serial number)
000c	DEVTYPE	device type		R1W4	6	string				String with 5 characters, terminated with \0

000d	CMD	command	1	R1W1	16	unsigned integer	0	105	0	RW1 Commands 0-Command ready (automatically set after execution) 12-EStop by web interface RW2 Commands 1-clear errors 2-standby off 3-power on 4-laser on 5-TEC on 6-TEC off 7-save parameters 9-bias on 11-print Digi/DC6 handler states 13-power on 1 20-enable pilot laser 21-disable pilot laser 26-set configured 27-reset configured 28-reset new error info 29-get error info 51-print exit state 60-go to RW1 RW4 Commands 10-reset Digi/DC6 command handler 30-set default access rights 50-start selftest 98-reboot CM100 99-reset reboot counters

000e	DEVSTATE	device state	1	R1	32	hexadecimal	0	0xffff	0	bit 0 (0x0001): POWER ON 1 bit 1 (0x0002): POWER ON 2 bit 2 (0x0004): LASER ENABLED bit 3 (0x0008): BIAS ENABLED bit 4 (0x0010): TERMINAL ACCESS bit 5 (0x0020): RW level bit 0 bit 5 (0x0040): RW level bit 1 bit 8 (0x0100): PILOT ENABLED bit 9 (0x0200): INTERLOCK 1 ON bit 10 (0x0400): WARNING PRESENT bit 11 (0x0800): ERROR PRESENT bit 12 (0x1000): GATE ENABLED bit 13 (0x2000). Error info available bit 14 (0x4000): CONFIGURED bit 16 (0x10000): INTERLOCK 2 bit 17 (0x20000): On 2 blocked (Testmode) bit 18 (0x40000): Device is currently printing over terminal bit 19 (0x80000): Pilot laser is on bit 20 (0x100000): Pending save bit 22 (0x400000): Testmode without PUs
000f	DEVMODE	device mode	1	R1W1	16	hexadecimal	0	0xffff	0	set device mode as displayed in 000e
0010	DATA1	data 1	1	R1	16	hexadecimal	0	0xffff	0	not yet used
0011	DATA2	data 2	1	R1	16	hexadecimal	0	0xffff	0	not yet used
0012	OEM	OEM	1	R1W4	16	unsigned integer	0	65535	0	customer code
0013	DEVCONF	device config	1	R1W4	32	hexadecimal	0	0xffffffff	1	bit 0 (0x0001): CW supported bit 1 (0x0002): pulse modes supported bit 3 (0x0008): TEC supported bit 4 (0x0010): analog in supported bit 5 (0x0020): gate timer modes not supported bit 6 (0x0040): device shows current resolution 1A in web interface bit 7 (0x0080): device has power resolution 0,1W bit 8 (0x0100): device is control unit without PUs bit 10 (0x0400): force NXP to be present

0014	EVENTS	events	1	R1	16	hexadecimal	0	0xffff	0	bit 0 (0x0001): Power off by bus
0020	REMACCTO1	remote acc. timeout	1ms	R1W1	16	unsigned integer	0	9000	0	remote access timeout for application control port 8010
0021	REMACCTO2	web browser timeout	1ms	R1W1	16	unsigned integer	0	9000	0	remote access timeout for application control port 8010
0030	WEBGUITYPE	web GUI type	1	R1W4	16	unsigned integer	0	65535	0	0: standard GUI
0031	WEBGUILANG	web GUI language	1	R1W1	16	unsigned integer	0	65535	0	only English is available
0032	WEBREFRESH	web GUI refresh rate	1Hz	R1W1	16	unsigned integer	4	30	10	refresh rate for the web operation window
0040	DEBUG1	debug 1	1	R1W4	32	hexadecimal	0	0xffffffff	0	Used for internal debugging purposes
0041	DEBUG2	debug 2	1	R1W4	16	unsigned integer	0	4088	0	Used for internal debugging purposes
0042	DEBUGOEM	debug OEM	1	R1W3	16	hexadecimal	0	0xffff	0	Used for internal debugging purposes
0050	TOP	op time	1s	R1W1	32	unsigned long	0	2147483647	0	seconds powered up since last register reset
0051	TLON	laser on time	1s	R1W1	32	unsigned long	0	2147483647	0	seconds with laser on since last register reset
0052	TOPMAN	op time man	1s	R1W4	32	unsigned long	0	2147483647	0	seconds powered up since last register reset (RW4)
0053	TLONMAN	laser on time man	1s	R1W4	32	unsigned long	0	2147483647	0	seconds with laser on since last register reset (RW4)
0060	DSPCNFTOP	display config top	1	R1W3	32	hexadecimal	0	0xffffffff	0x0b000000	Values to display on top of the web interface
0061	DSPCNFROW1	display config row 1	1	R1W3	32	hexadecimal	0	0xffffffff	0x010809	Values to display on row 1/sect.main of the web interface
0062	DSPCNFROW2	display config row 2	1	R1W3	32	hexadecimal	0	0xffffffff	0x02060c	Values to display on row 2/sect.main of the web interface
0063	DSPCNFROW3	display config row 3	1	R1W3	32	hexadecimal	0	0xffffffff	0x03050b	Values to display on row 3/sect.main of the web interface
0064	DSPCNFROW4	display config row 4	1	R1W3	32	hexadecimal	0	0xffffffff	0x04000e	Values to display on row 4/sect.main of the web interface
0065	DSPCNFROW5	display config row 5	1	R1W3	32	hexadecimal	0	0xffffffff	0x00000f	Values to display on row 5/sect.main of the web interface

C.3 – Profile Registers

Register	Name	Description	Unit	Access	Size	View Mode	Min	Max	Default	Notes
1001	PMODE	profile mode	1	R1W1	16	unsigned integer	0	2	0	0-no profile (profile mode off) 1-single profile (profile is driven only one time) 2-multi profile (profile is repeated automatically)
1002	PR0A	point 0 amplitude	0,1%	R1W1	16	unsigned integer	0	1000	0	relative amplitude, 100%=maximum
1003	PR01T	point 0 -> 1 time	1ms	R1W1	32	signed long	0	200000000	0	time between two profile points
1004	PR1A	point 1 amplitude	0,1%	R1W1	16	unsigned integer	0	1000	0	relative amplitude, 100%=maximum
1005	PR12T	point 1 -> 2 time	1ms	R1W1	32	signed long	0	200000000	0	time between two profile points
1006	PR2A	point 2 amplitude	0,1%	R1W1	16	unsigned integer	0	1000	0	relative amplitude, 100%=maximum
1007	PR23T	point 2 -> 3 time	1ms	R1W1	32	signed long	0	200000000	0	time between two profile points
1008	PR3A	point 3 amplitude	0,1%	R1W1	16	unsigned integer	0	1000	0	relative amplitude, 100%=maximum
1009	PR34T	point 3 -> 4 time	1ms	R1W1	32	signed long	0	200000000	0	time between two profile points
100a	PR4A	point 4 amplitude	0,1%	R1W1	16	unsigned integer	0	1000	0	relative amplitude, 100%=maximum
100b	PR45T	point 4 -> 5 time	1ms	R1W1	32	signed long	0	200000000	0	time between two profile points
100c	PR5A	point 5 amplitude	0,1%	R1W1	16	unsigned integer	0	1000	0	relative amplitude, 100%=maximum
100d	PR56T	point 5 -> 6 time	1ms	R1W1	32	signed long	0	200000000	0	time between two profile points
100e	PR6A	point 6 amplitude	0,1%	R1W1	16	unsigned integer	0	1000	0	relative amplitude, 100%=maximum
100f	PR67T	point 6 -> 7 time	1ms	R1W1	32	signed long	0	200000000	0	time between two profile points
1010	PR7A	point 7 amplitude	0,1%	R1W1	16	unsigned integer	0	1000	0	relative amplitude, 100%=maximum
1011	PR70T	point 7 -> 0 time	1ms	R1W1	32	signed long	0	200000000	0	time between two profile points

C.4 – Control

Register	Name	Description	Unit	Access	Size	View Mode	Min	Max	Default	Notes
2001	ERR2	errors group 2	1	R1	32	hexadecimal	0	0xffff	0	errors in group 2
2002	RES21	reserved 21	1	R1	16	not displayed	0	0	0	reserved
2003	WRN2	warnings group 2	1	R1	32	hexadecimal	0	0xffff	0	warnings in group 2
2004	RES22	reserved 22	1	R1	16	not displayed	0	0	0	reserved
2010	OMODE	operational mode	1	R1W1	16	unsigned integer	0	5	0	0-CW (gateless) mode 1-CW (gated) mode 2-pulse trigger mode 3-pulse timer mode 4-gated pulse timer mode (not yet tested) 5-gated pulse mode (not yet implemented)
2011	RMODE	control mode	1	R1W1	16	unsigned integer	1	2	1	0=not defined yet 1=current control 2=power control 3=power regulation
2012	SMODE	source mode	1	R1W1	16	unsigned integer	0	1	0	0=digital input (via register access) 1=analog input (via analog ports)
2013	TIMEOUT	timeout laser on	0,1s	R1W1	16	unsigned integer	0	3000	0	retrigger via gate pin or laser on command
2020	ISETT	set current total	0,1A	R1W1	16	unsigned integer	0	65535	10	total current
2021	ISETC	calc set current tot	0,1A	R1	16	unsigned integer	0	65535	0	calculated current as result of any reference (digital, analog, current, power, etc.)
2022	IACTT	act current total	0,1A	R1	16	unsigned integer	0	65535	0	total actual current
2023	PSETT	set power total	0,1 W	R1W1	16	unsigned integer	0	65535	0	total power
2024	PACTTC	act calc power total	0,1 W	R1	16	unsigned integer	0	65535	0	total actual power
2025	PMAXT	max power total	0,1 W	R1W3	16	unsigned integer	0	65535	65535	maximum power
2026	PMAXTA	max power total avg	0,1 W	R1W3	16	not displayed	0	65535	65535	maximum mean power (for pulse applications)

2030	TPDUR	pulse duration	1us	R1W1	32	unsigned long	0	2147483647	250	timer pulse duration
2031	TPPER	pulse period	1us	R1W1	32	unsigned long	0	2147483647	750	timer pulse period
2032	PCNT	pulses counted	1	R1	32	unsigned long	0	2147483647	0	pulses made since driver has been powered up
2033	PCNTRW4	pulses counted man	1	R1	32	unsigned long	0	2147483647	0	pulses made since driver has been powered up (RW4)
2040	RIMAX	reglt max current	0,1A	R1W1	16	unsigned integer	0	65535	65535	upper margin for control
2041	RIMIN	reglt min current	0,1A	R1W1	16	unsigned integer	0	65535	0	lower margin for control
2042	RP	reglt P-term	1	R1W1	16	unsigned integer	0	65535	0	P-term for PID-control
2043	RI	reglt I-term	1	R1W1	16	unsigned integer	0	65535	0	I-term for PID-control
2044	RD	reglt D-term	1	R1W1	16	unsigned integer	0	65535	0	D-term for PID-control

C.5 – Temperature Control

Register	Name	Description	Unit	Access	Size	View Mode	Min	Max	Default	Notes
5001	ERR5	errors group 5	1	R1	32	hexadecimal	0	0xffff	0	errors in group 5
5002	RES51	reserved 51	1	R1	16	not displayed	0	0	0	reserved
5003	WRN5	warnings group 5	1	R1	32	hexadecimal	0	0xffff	0	warnings in group 5
5004	RES52	reserved 52	1	R1	16	not displayed	0	0	0	reserved
5005	LCNF1	laser config	1	R1W1	16	hexadecimal	0	0xffff	0	no bits defined yet
5006	LCNF2	laser config OEM	1	R1W3	16	hexadecimal	0	0xffff	0	bit 5 (0x0020): get laser temp from NTC (instead of PT100)
5010	TLSET	set laser temp	0,1C	R1W1	16	unsigned integer	0	800	220	set temperature for laser
5011	TLACT	act laser temp	0,1C	R1	16	signed integer	-10	900	0	actual laser temperature
5012	TLMINMAN	min ltemp wner man	0,1C	R1W4	16	unsigned integer	0	65535	100	manufacturer limit for registers 5014 and 5015
5013	TLMINOEM	min ltemp wner OEM	1s	R1W3	16	unsigned integer	0	65535	100	OEM limit for registers 5014 and 5015
5014	TLMINW	min laser temp wn	0,1C	R1W1	16	unsigned integer	0	65535	0	minimum laser temp before warning
5015	TLMINE	min laser temp er	0,1C	R1W1	16	unsigned integer	0	65535	0	minimum laser temp before error
5016	TLMAXMAN	max ltemp wner man	0,1C	R1W4	16	unsigned integer	0	65535	300	manufacturer limit for registers 5018 and 5019
5017	TLMAXOEM	max ltemp wner OEM	0,1C	R1W3	16	unsigned integer	0	65535	300	OEM limit for registers 5018 and 5019
5018	TLMAXW	max laser temp wn	0,1C	R1W1	16	unsigned integer	0	65535	0	maximum laser temp before warning
5019	TLMAXE	max laser temp er	0,1C	R1W1	16	unsigned integer	0	65535	0	maximum laser temp before error
5021	THOT	act hot side temp	0,1C	R1	16	signed integer	-10	900	0	actual hot side temperature
5022	THMINMAN	min hot temp er man	0,1C	R1W4	16	unsigned integer	0	65535	100	manufacturer limit for register 5023
5023	THMINE	min hot side temp er	0,1C	R1W1	16	unsigned integer	0	65535	0	minimum hot side temp before error
5024	THMAXMAN	max hot temp er man	0,1C	R1W4	16	unsigned integer	0	65535	300	manufacturer limit for register 5025

5025	THMAXE	max hot side temp er	0,1C	R1W1	16	unsigned integer	0	65535	0	maximum hot side temp before error
5026	TAUX	act aux temp	0,1C	R1	16	signed integer	-10	900	0	actual axillary temperature
5027	TAMINMAN	min aux temp er man	0,1C	R1W4	16	unsigned integer	0	65535	100	manufacturer limit for register 5028
5028	TAMINE	min aux temp er	0,1C	R1W1	16	unsigned integer	0	65535	0	minimum auxiliary temp before error
5029	TAMAXMAN	max aux temp er man	0,1C	R1W4	16	unsigned integer	0	65535	300	manufacturer limit for register 502a
502a	TAMAXE	max aux temp er	0,1C	R1W1	16	unsigned integer	0	65535	0	maximum auxiliary temp before error
502b	TINT	act int temp	0,1C	R1	16	signed integer	-10	900	0	actual internal temperature
502c	TIMAXE	max int temp er	0,1C	R1W1	16	unsigned integer	0	65535	0	maximum internal temp before error
5030	ITACT	act TEC current	0,01 A	R1	16	signed integer	-32768	32767	0	actual TEC current
5031	UTACT	act TEC voltage	0,01 V	R1	16	signed integer	-32768	32767	0	actual TEC voltage
5040	PELTP	TEC P-term	1	R1W3	16	unsigned integer	0	65535	1000	P-term for laser temperature regulation
5041	PELTI	TEC I-term	1	R1W3	16	unsigned integer	0	65535	200	I-term for laser temperature regulation
5042	PELTD	TEC D-term	1	R1W3	16	unsigned integer	0	65535	0	D-term for laser temperature regulation
5043	PELTDFAC	TEC D time fact	1	R1W3	16	unsigned integer	1	65535	1	D-term is calculated every 2*[5033] ms
5044	ITMAXCLRW3	max TEC cur cool man	0,1A	R1W4	16	unsigned integer	0	65535	1000	maximum TEC current for cooling, limits register 5046
5045	ITMAXHTRW3	max TEC cur heat man	0,1A	R1W4	16	unsigned integer	0	65535	1000	maximum TEC current for heating, limits register 5047
5046	ITMAXCL	max TEC current cool	0,1A	R1W3	16	unsigned integer	0	65535	1000	maximum TEC cooling current
5047	ITMAXHT	max TEC current heat	0,1A	R1W3	16	unsigned integer	0	65535	1000	maximum TEC heating current
5048	ITECSET	TEC current set	0,1A	R1W4	16	signed integer	-32768	32767	0	TEC current set (for calibration)

C.6 – I/O Registers

Register	Name	Description	Unit	Access	Size	View Mode	Min	Max	Default	Notes
6001	ERR6	errors group 6	1	R1	32	hexadecimal	0	0xffff	0	errors in group 6
6002	RES61	reserved 61	1	R1	16	not displayed	0	0	0	reserved
6003	WRN6	warnings group 6	1	R1	32	hexadecimal	0	0xffff	0	warnings in group 6
6004	RES62	reserved 62	1	R1	16	not displayed	0	0	0	reserved
6005	ICNF1	Input config	1	R1W1	16	hexadecimal	0	0xffff	0	bit 8 (0x0100): Laser enable, power on and error clear over digital in
6006	ICNF2	Input config OEM	1	R1W3	16	hexadecimal	0	0xffff	0	no bits defined yet
6007	OCNF1	Output config	1	R1W1	16	hexadecimal	0	0xffff	0	no bits defined yet
6008	OCNF2	Output config OEM	1	R1W3	16	hexadecimal	0	0xffff	0	bit 0 (0x0001): Enable warning lights defective warning bit 1 (0x0002): Enable warning lights defective error bit 4 (0x0010): Analog photo output signal 5V (instead of 10V)
6009	AOUTSEL	Analog out select	1	R1W3	16	unsigned integer	0	2	0	0: Current 1: Load voltage 2: Photo power
6010	IDIN1	I/O digital in	1	R1	16	hexadecimal	0	0xffff	0	bit 0 (0x0001): DIn1 bit 1 (0x0002): DIn2 bit 2 (0x0004): DIn3 bit 3 (0x0008): DIn4 bit 4 (0x0010): IL1 bit 5 (0x0020): IL2
6011	IDOUT1	I/O digital out	1	R1W1	16	hexadecimal	0	0xffff	0	bit 3 (0x0008): Pilot laser
6012	TRONDEL	regl. start delay	1us	R1W1	16	unsigned integer	1	65535	1	delay before power regulation starts
6013	TRONLEN	trigger out length	1us	R1W1	16	unsigned integer	0	65535	65535	length of trigger output signal for each pulse
6020	PACTPHOTO	act photo power	0,1W	R1	16	unsigned integer	0	65535	0	actual photo diode power
6021	PHOTORAW1	power raw 1	1	R1W3	16	unsigned integer	0	4096	0	photo calibration point 1 raw power value
6022	PHOTOCAL1	power cal 1	0,1W	R1W3	16	unsigned integer	0	0	0	photo/laser calibration point 1 calibrated power value

6023	CURCAL1	current cal 1	0,1A	R1W3	16	unsigned integer	0	65535	5000	laser calibration point 1 calibrated current value
6024	PHOTORAW2	power raw 2	1	R1W3	16	unsigned integer	0	4096	200	photo calibration point 2 raw power value
6025	PHOTOCAL2	power cal 2	0,1W	R1W3	16	unsigned integer	0	65535	10	photo/laser calibration point 2 calibrated power value
6026	CURCAL2	current cal 2	0,1A	R1W3	16	unsigned integer	0	65535	5000	laser calibration point 2 calibrated current value
6027	PHOTORAW3	power raw 3	1	R1W3	16	unsigned integer	0	4096	400	photo calibration point 3 raw power value
6028	PHOTOCAL3	power cal 3	0,1W	R1W3	16	unsigned integer	0	65535	20	photo/laser calibration point 3 calibrated power value
6029	CURCAL3	current cal 3	0,1A	R1W3	16	unsigned integer	0	65535	8000	laser calibration point 3 calibrated current value
602a	PHOTORAW4	power raw 4	1	R1W3	16	unsigned integer	0	4096	600	photo calibration point 4 raw power value
602b	PHOTOCAL4	power cal 4	0,1W	R1W3	16	unsigned integer	0	65535	20	photo/laser calibration point 4 calibrated power value
602c	CURCAL4	current cal 4	0,1A	R1W3	16	unsigned integer	0	65535	8000	laser calibration point 4 calibrated current value
602d	PACTRAW	act photo raw	1	R1	16	hexdecimal	0	0xffff	0	actual photo diode power raw value
602e	PHOTOLEVEL	Photo level	1		16	unsigned integer	0	4095	0	threshold (raw value) for laser power too low error
602f	PHOTOTO	Photo timeout	1		16	unsigned integer	0	4095	0	delay for laser power too low error
6030	STARTDEL	device ready delay	0,1s	R1W3	16	unsigned integer	0	200	10	delay for device to get ready from power off
6040	AINUMAX	Ain Umax	0,01V	R1W1	16	unsigned integer	0	65535	1000	analog in calibration maximum voltage
6041	AINUMIN	Ain Umin	0,01V	R1W1	16	unsigned integer	0	65535	0	analog in calibration minimum voltage
6050	AINMAX	Ain max	1	R1W3	16	unsigned integer	0	65535	0	upper threshold for Ain max error
6051	AINMIN	Ain min	1	R1W3	16	unsigned integer	0	65535	0	lower threshold for Ain min error
6052	AINACTRAW	act Ain raw	1	R1	16	unsigned integer	0	65535	0	actual analog in raw value
6053	AINACTCAL	act Ain cal	1	R1	16	unsigned integer	0	65535	0	actual analog in calibrated value
6080	P100PERC	Pact 100%	0,1W	R1W3	16	unsigned integer	0	65535	0	Pact 100%

C.7 – Current Registers

Register	Name	Description	Unit	Access	Size	View Mode	Min	Max	Default	Notes
a001	ERRA	errors group A	1	R1	32	hexadecimal	0	0xffff	0	errors in group A
a002	RESA1	reserved A1	1	R1	16	not displayed	0	0	0	reserved
a003	WRNA	warnings group A	1	R1	32	hexadecimal	0	0xffff	0	warnings in group A
a004	RESA2	reserved A2	1	R1	16	not displayed	0	0	0	reserved
a005	CURCNFA1	current config	1	R1W1	16	hexadecimal	0	0xffff	0	no bits defined yet
a006	CURCNFA2	current config OEM	1	R1W3	16	hexadecimal	0	0xffff	0	no bits defined yet
a010	ISETC1	calc set current	0,1A	R1	16	unsigned integer	0	65535	0	calculated current as result of any reference (digital, analog, current, power, etc.)
a011	IACT	act current	0,1A	R1	16	unsigned integer	0	65535	0	actual output current
a012	IBIAS	set bias current	0,1A	R1W1	16	unsigned integer	0	65535	0	bias set current
a013	IBACT	act bias current	0,1A	R1	16	unsigned integer	0	65535	0	actual output bias current
a014	UACT	act voltage	0,01V	R1	16	unsigned integer	0	10000	0	actual output voltage
a015	VM31IACT	VM6 #1 act current	0,1A	R1	16	unsigned integer	0	65535	0	actual output current on PU 1
a016	VM32IACT	VM6 #2 act current	0,1A	R1	16	unsigned integer	0	65535	0	actual output current on PU 2
a017	VM33IACT	VM6 #3 act current	0,1A	R1	16	unsigned integer	0	65535	0	actual output current on PU 3
a020	IMAXRW3	max current man	0,1A	R1W4	16	unsigned integer	0	65535	65535	maximum current (for diode protection), limits register a021
a021	IMAXEOL	max current EOL	0,1A	R1W3	16	unsigned integer	0	65535	1000	maximum current at end of life (for diode degradation), limited by device specification
a022	IMAX	max current	0,1A	R1W3	16	unsigned integer	0	65535	1000	maximum current (for diode protection)

a023	IMAXRW3AV	max current avg man	0,1A	R1W4	16	unsigned integer	0	65535	65535	maximum average current (for diode protection), limited by device specification, limits register a024
a024	IMAXAV	max current av	0,1A	R1W3	16	unsigned integer	0	65535	1000	maximum average current (for diode protection), limited by device specification
a025	IBIASMAXRW3	max bias current man	0,1A	R1W4	16	unsigned integer	0	65535	600	maximum allowed bias current, limits register a026
a026	IBIASMAX	max bias current	0,1A	R1W3	16	unsigned integer	0	65535	600	maximum allowed bias current
a027	UMIN	min voltage	0,01V	R1W3	16	unsigned integer	0	20000	150	minimum voltage (for short circuit detection)
a028	UMAX	max voltage	0,01V	R1W3	16	unsigned integer	0	20000	1000	maximum voltage (for open circuit detection)
a029	EPULSEMAX	max pulse energy	0,001 As	R1W4	32	unsigned long	0	200000000	200000000	maximum allowed energy in one pulse
a030	PDURMIN	pulse duration min	1us	R1W4	32	unsigned long	0	2147483647	5	minimum allowed pulse duration
a031	PDURMAX	pulse duration max	1us	R1W4	32	unsigned long	0	2147483647	2147483647	maximum allowed pulse duration
a032	PPERMIN	pulse period min	1us	R1W3	32	unsigned long	0	2147483647	100	minimum allowed pulse period
a033	PDURADD	pulse duration add	1us	R1W4	16	unsigned integer	0	100	0	added to pulse duration set in 2030
a040	IDEVMAX	max cur deviation	0,1A	R1W3	16	unsigned integer	0	65535	0	not yet implemented
a041	PDEVMAX	max power deviation	0,1W	R1W3	16	unsigned integer	0	65535	0	
a060	NPUSEXP	Nr expected VM6s	1	R1W4	16	unsigned integer	0	65535	0	If nr detected VM6s is lower, system is rebooted (max 2x)
a061	NREBOOTS	Nr reboots	1	R1	16	unsigned integer	0	65535	0	Nr of reboots since last power on
a062	NREBOOTST	Nr reboots total	1	R1	16	unsigned integer	0	65535	0	Nr of reboots since last reset of register

C.8 – Error/Warning Lists

Main Errors

ERR0	Bit	Function
	0 (0x00000001)	internal error 1
	1 (0x00000002)	internal fan
	2 (0x00000004)	internal error 3
	3 (0x00000008)	internal error 4
	4 (0x00000010)	internal error 6
	5 (0x00000020)	wrong firmware version
	6 (0x00000040)	wrong FPGA version
	7 (0x00000080)	DC6 connection error
	8 (0x00000100)	DC6 connection error 2
	9 (0x00000200)	DC6 conn error 1 (by DC6)
	10 (0x00000400)	DC6 conn error 2 (by DC6)
	11 (0x00000800)	DC6/VM3 params nosync
	12 (0x00001000)	DC6 -> VM3 Comm Error 1
	13 (0x00002000)	DC6 -> VM3 Comm Error 2
	14 (0x00004000)	DC6 FPGA error
	15 (0x00008000)	unknown DC6 error
	16 (0x00010000)	laser on timeout
	17 (0x00020000)	PU1 hardware config
	18 (0x00040000)	PU1 internal-nosync
	19 (0x00080000)	PU1 internal-nocom2
	20 (0x00100000)	PU1 internal-nocom3
	21 (0x00200000)	PU1 unknown VM3 error

	22 (0x00400000)	PU1 temp error 1
	23 (0x00800000)	PU1 temp error 2
	24 (0x01000000)	link error
	25 (0x02000000)	PU1 overcurrent main
	26 (0x04000000)	PU1 overcurrent bias
	27 (0x08000000)	PU1 overcurrent main
	28 (0x10000000)	PU1 internal error 1
	29 (0x20000000)	PU1 internal error 2
	30 (0x40000000)	n.def.
	31 (0x80000000)	PU1 internal error 4

Warnings

WRN0	bit	function
	0 (0x00000001)	Backup image loaded
	16 (0x00010000)	PU update running
	17 (0x00020000)	Parameter upload running

I/O Errors

ERRI	Bit	Function
	0 (0x00000001)	Ain max
	1 (0x00000002)	Ain min
	2 (0x00000004)	remote access timeout
	3 (0x00000008)	web browser timeout
	4 (0x00000010)	laser warning light
	5 (0x00000020)	emergency stop web
	6 (0x00000040)	interlock external
	7 (0x00000080)	n.def.
	8 (0x00000100)	Interlock PU

	9 (0x00000200)	laser temp too high
	10 (0x00000400)	hot side temp too high
	11 (0x00000800)	auxiliary temp too high
	12 (0x00001000)	laser temp too low
	13 (0x00002000)	hot side temp too low
	14 (0x00004000)	auxiliary temp too low
	15 (0x00008000)	laser power too low
	16 (0x00010000)	internal temp too high
	17 (0x00020000)	interlock sync DC6
	18 (0x00040000)	interlock sync VM6
	19 (0x00080000)	n.def.
	20 (0x00100000)	n.def.

A Current Errors

ERRA	Bit	Function
	0 (0x00000001)	PU1 short circuit
	1 (0x00000002)	PU1 open circuit
	2 (0x00000004)	PU1 prim volt min error
	3 (0x00000008)	PU1 prim volt max error
	4 (0x00000010)	PU error 1
	5 (0x00000020)	PU1 power up timeout
	6 (0x00000040)	PU error 2
	7 (0x00000080)	power deviation max
	8 (0x00000100)	PU error 3
	9 (0x00000200)	n.def.
	10 (0x00000400)	n.def.