YLR- 6000 S
Ytterbium Fiber Laser

User Guide

Rev. Date 12-06-2005

Please take time to read and understand this User Guide and familiarize yourself with information we have compiled for you before you start using the product. This User's Guide should stay with the product to provide you and all future users and owners of the product with important operating, safety and other information.

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The IPG Laser Mode YLR- 6000 is a class IV laser product.

This laser emits over 6000 Watts of invisible laser radiation in the optical band near 1070 nm.

Avoid eye or skin exposure to direct or scattered radiation emitted from the optical output.
Do not open the front and rear doors of the laser case, if laser emission is ON.

Do not open the device. There are no user serviceable parts, equipment or assemblies in this product. All service and maintenance shall be performed by qualified IPG personnel.

IPG- Group

IPG delivers fiber laser in all domains of laser material processing, medical engineering and scientific institutes and universities. IPG is the accepted market leader in this modern fiber laser technology. The IPG- Group contains subsidiaries in many European, Asiatic and American developed counties. Main production site for these lasers is Burbach in Germany with a vertical range of manufacture of 90%. This guarantees you as user a high grade of competence and reliability.
High output power, excellent beam quality, high stability and mobility are outstanding predicates of the fiber laser. The superiority of the fiber laser is efficiency, flexibility, modularity, thermal and mechanical robustness that comes along with a simple constructive assembly. Further important characteristics for the industrial use are low running costs.
Economic feasibility studies show, that it is possible to realize faster, better and more cost-effective industrial applications with high power fiber laser. IPG has the production capacity for a production in high piece numbers. More information you can find under www.ipgphotonics.com.

IPG Companies with present service

Table of Content

1. General Safety Information

Safety Conventions

We use various words and symbols that are designed to call your attention to hazards or important information. These include:

Warning

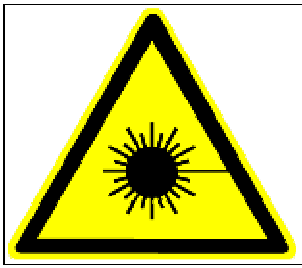
Refers to a potential *personal* hazard. It requires a procedure that, if not correctly followed, may result in bodily harm to you and/or others. Do not proceed beyond the WARNING sign until you completely understand and meet the required conditions.

Caution

Refers to a potential *product* hazard. It requires a procedure that, if not correctly followed, may result in damage or destruction to the product or components. Do not proceed beyond the CAUTION sign until you completely understand and meet the required conditions.

Important

Refers to any information regarding the operation of the product. Please do not overlook this information.

	This symbol indicates laser radiation. We place this symbol on products which have a laser output

In order to ensure the safe operation and optimal performance of the product, please follow these warning and caution notes in addition to other information contained elsewhere in this document.

WARNING: Make sure the instrument is properly grounded through a protective conductor of the AC power cable. Any interruption of the protective ground conductor from the earth terminal can result in personal injury.

CAUTION: Before supplying the power to the instrument make sure that a correct mains voltage of the AC power source is used. Failure to use the correct voltage could cause damage to the instrument

WARNING: No operator serviceable parts inside. Refer all servicing to qualified IPG personnel. To prevent electrical shock, do not remove covers. Any tampering with the product will void the warranty.

WARNING: Form continued protection against fire hazard, replace the line fuses only with the same types and ratings. The use of other fuses or materials is prohibited.

WARNING: If this instrument is used in a manner not specified in this document, the protection provided by the instrument my be impaired. This product must be used only in normal conditions.

WARNING: Make sure the instrument is properly grounded through a protective conductor of the AC power cable. Any interruption of the protective ground conductor from the earth terminal can result in personal injury.

WARNING: Do not open the front and rear doors of the laser case if laser emission is ON. It can present serious personal danger.

WARNING: For the operation conditions for processing of copper and its alloys you shall consult with IPG

IMPORTANT: YLR- 6000 S laser is a water cooled model. Tap water is used for cooling the laser, deionized water for external optics cooling. Absence of adequate water cooling will result in damage to the laser and external optics Provide water cooling for each fiber connector and optical head of at least 1.0 liter per minute

Laser Classification

This device is classified as a high power class IV laser instrument under 21 CFR 1040.10 [and under IEC 60825]. This product emits wavelength light at or around 1070 nm at total power of light radiated out of the optical output greater than 6000 W. This level of light power is extremely dangerous. Despite radiation being invisible, the scattered beam may cause irreversible damage to the cornea. Laser safety eye wear is not provided with this instrument, but must be worn at all times while the laser is in operation.

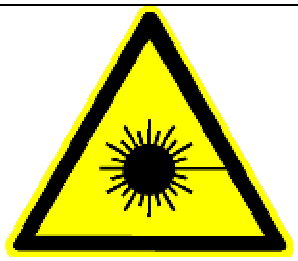
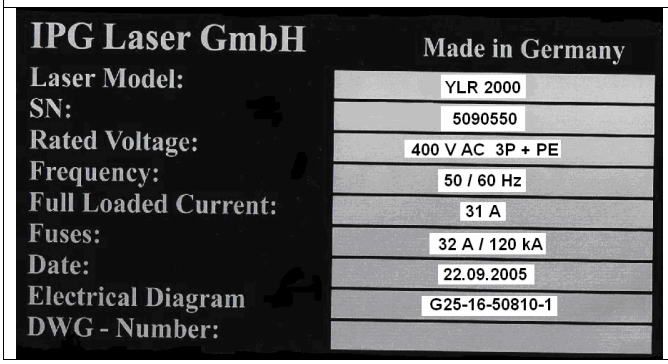
WARNING: Do not install output fiber connector when laser electrical power in ON.

WARNING: NEVER look directly into output connector when laser is ON and make sure that the appropriate laser safety glasses are worn at all times while operating the product

CAUTION: Use of controls or adjustment or performance of procedures other than those set forth in this guide may result in hazardous radiation exposure

Safety Labels and Labeling Locations

The figures below show the labels and their placement an the product

	**Aperture Label** **Location:** collimator assembly or output cable exit port
	**Certification Label** **Location:** rear panels of the unit
	**Warning Logotype** **Location:** top cover or front panel of the unit
	**Identification Label** (sample, may differ for each laser) **Location:** Rear panel of the unit

2. Description

The YLR-6000 S Series CW Ytterbium Fiber Laser was developed for the use industrial and research applications. This compact and efficient laser readily replace bulk and less efficient solid state lasers with the main target applications being welding, cutting and brazing.
The YLR-6000 S Series is a high power laser producing 6000 Watts of optical power at a wavelength around 1070 nm.

Main Features:

- High beam quality fiber output
- Reliable, long lifetime
- Compact, rugged package
- Efficient
- External computer interface, Hardwiring interface, bus systems (optional)
- Analog control mode
- Fast modulation possibility

Applications:

- Industrial applications
- Research

3. Delivery, Unpacking, Inspection

The fiber laser becomes delivered in a package offering maximal safety. The package becomes particulate delivered with a push detector which warns by misuse. If the package shows any signs of an external damage or if push detector became activated, check the device for damages and inform in written form the carrier about the damage.

Take the whole content out of the package and keep the package material and inserts. You should be extremely cautious while taking the device off the package. The optical cable must not become damaged or broken. The documentation includes a packing list. After receipt of the laser check if all parts are there and inform IPG immediately for missing or damaged part. In case of any supposed or apparent damage, do not try to install or run the laser.

Keep the package for later transport or storage of the device.

The transport of the laser happens on a euro-pallet with help of a forklift. On the upside of the laser transport eyes are fixed. With lifting equipment the laser can be lifted from the pallet. The laser can be moved with casters. Transport without the euro-pallet is not permitted. The Laser can be moved with fixable casters to the final place of installation if the subfont is appropriate to it. The laser must become brought in such a position that doors and side panels can be reached for service. The length of supply and control lines must be arranged in a way that laser can be moved 1m. The supply and control lines should be passed in order not to snap off. At laser installation in the laser cabin the general health and safety regulation of the operator have to be followed. The casters at the bottom side of the laser cabinet have to be fixed at the place of final installation. A rugged installation has to be assured. Consider the weights at higher places of installation.
If needed laser and chiller has to be equipped with appropriate intercepting tanks against leaking water.

The laser is lockable and should be secured after work against unauthorized use. The seal of the external cabinet secures power supply and laser modules against environmental dust. The in the laser cabinet (power supply) produced waste heat becomes derived trough installation of an internal heat exchanger. Thereby water chilled lasers do not need an additional fan.

Preparative actions of the operator:

Adequate place of installation with stated air flow rate for the Water-Air-Chiller
Supply cable inclusive CEE-connector for laser and chiller
Supply means of transport forklift and lifting equipment
Preparation of robot / robot control according to the demands

All lasers are equipped with casters. The laser can e.g. in a robot cabin without additional tools be moved to the place of final installation. The laser has to be installed on a plane base. Against autonomous movement the laser has to be secured through fixing the casters.

Fixable casters

Transport of a 10 kW fiber laser

4. Accessories

Part	Quantity	Note
YLR-6000 S	1	Ytterbium fiber laser SN 6070550
Control key	2	-
Cabinet key	6	For opening laser cabinet door
2-ways internal Beam Switch	1	6070550bs
Feeding fiber cable	1	100µm, 5m, QBH
User Guide	1	This document
IPG Test Results	1	-
Set of tubes and connectors for water connection	1	YLR-6000 S 6070550
Signal cables for laser – PC connection (Ethernet)	1	-
Set of cleaning needs with an IPG Microscope	1	-
Water-Air-Chiller Riedel PC160.01 NZ-DIS*	1	-
Software LaserNet 2.43.11 on CD	1	-

5. Specifications

1. Optical characteristics

NN	Characteristics	Test conditions	Symbol	Min.	Typ.	Max.	Unit
1	Operation Mode			CW, QCW			
2	Polarization			Random			
3	Nominal Output power		P_{nom}	6.0			kW
4	Output Power Tuning Range			10		105	%
5	Emission Wavelength	Output power 6 kW		1070		1080	nm
6	Emission Line width	Output power 6 kW			3	6	nm
7	Switching ON/OFF Time	Output power 6 kW			80	100	µsec
8	Output Power Modulation Rate	Output power 6 kW				5.0	kHz
9	Output Power Instability	Output power 6 kW			1.0	2.0	%
10	Internal 2-ways Beam Switch			Installed			
11	Beam Parameter Product* at entrance to Beam Switch	Internal feeding fiber core diameter 100µm, length 5 m	BPP*		4.0	4.5	mm*mrad
12	Beam Parameter Product* at output of Beam Switch	Process fiber core diameter 200 µm, length 15 m	BPP*			8.0	mm*mrad
13	Fiber Cable Bend Radius • unstressed • stressed		R	100 200			mm
14	Output connector			QBH compatible			

** Measurement accuracy by means of Primes Focus Monitor ± 10 %*

2. General characteristics

NN	Parameters	Test Conditions	Min.	Typ.	Max.	Unit
1	Operating Voltage, three phases		400 / 3P+PE or 480 / 3P+PE			VAC
2	Frequency		50 / 60			Hz
3	Power Consumption	P_{out} = 6		20	24	kW
4	Operating Temperature Range		10		50	℃
5	Humidity with built in conditioner	T < 40 ℃			95	%
6	Storage temperature	Without water	- 40		+ 75	℃
7	Dimensions, W x D x H		1480 x 806 x 1482			mm
8	Weight			730		kg

Important! Two-cannel External E-Stop (emergency stop) input is designed in accordance with EN 954-1 Cat. 3 norms. Both cannels should be used for E-Stop.

Important! EMI-Filter is installed at the input of main power supply of the laser in order to fulfil CE-norms. Typical leakage current (steady-state) at 400 V AC is about 16 mA due to Y-Capacitors inside of the EMI-Filter. In case of using Earth-leakage detection device for power connection, pulse leakage current during start-up of the laser can cause shutdown of such device. This well-known problem can be avoided using Earth-leakage detection device with delay during start up.

3. Laser Programs

Current version of the fiber laser firmware contains the possibility to create the programs for the laser processing.

The maximum amount of the different programs is 50,

maximum number of the commands for each program – 100.

Operator can write the laser programs as a sequence of the special commands and save them inside the laser.

The Robot can choose one of these programs and start to execute it.

The internal electronics design enables the fast control of the output laser power. In combination with the fast Hardwiring and analog interfaces this is a big advantage in comparison with the other types of the solid-state lasers.

4. Water-Air Chiller, model Riedel PC 160.01 NZW-DIS

NN	Item	Parameter	Value	Unit
1	Tap water for laser cooling, closed loop	Flow	40 - 60	l/min
		Pressure	2 - 4	bar
		Temperature	20 - 22	°C
2	DI water for the laser and external optics cooling	Flow	15 - 20	l/min
		Pressure	1.5 - 3	bar
		Temperature	25 - 35	°C
3	Operating voltage	3 Ph AC line	400 / 50 or 460 / 60 **	V/Hz
		Max. operation current	30	A
		Starting current	53	A
4	General characteristics	Operation temperature	-20 ... +44	°C
		Storage temperature without water	-40 … +70	°C
		Dimensions (W x D x H)	1440 x 860 x 1697	mm
		Weight (net)	350	kg

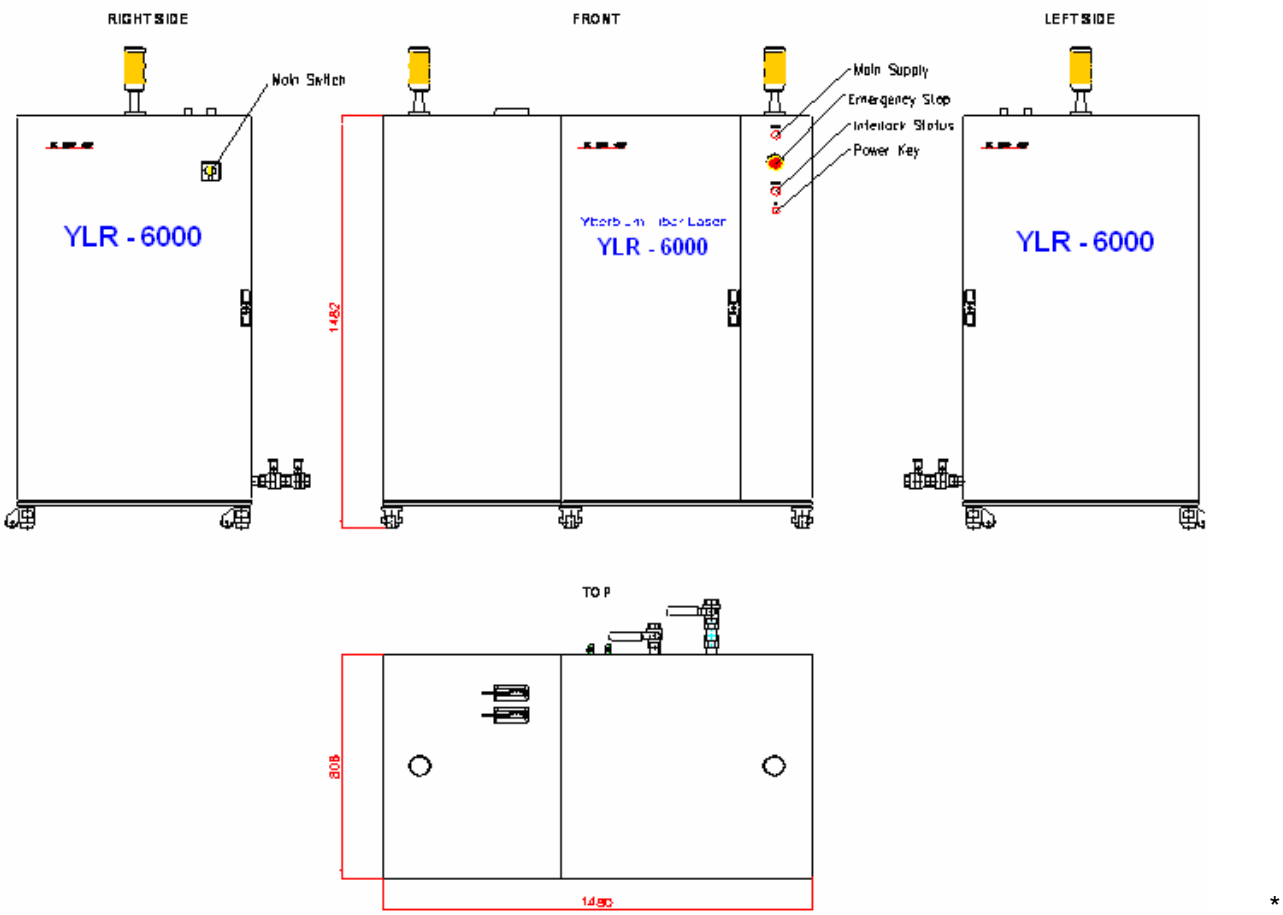
* Specially designed version for simultaneous cooling of laser by tap water and external optics by DI water.
** The chiller can not operate at 400 V / 60 Hz. IPG can deliver the chiller with operation at 400 V / 60 Hz on customer request. In this case the chiller will not operate at 400 V / 50Hz.

Water connection

The laser and external optics has to become chilled. Therefore several water pipes have to be plugged. This will be done by IPG Personal during laser installation.

- Normal water tubes: 1 inch inner diameter
- DI water tubes from chiller to beam switch: ¾ inch inner diameter
- DI water tubes inside beam switch: 6/4 mm
- DI water tubes from beam switch to fiber connector: ½ inch at fiber connector 6/4 mm

5. Outside Dimensions of the laser



*

Example, may differ for each laser

6. Options

NN	Options	Key Parameters	Related Parts
1	2-ways internal Beam Switch, Feeding fiber 100 µm, Process fiber 200µm	BPP* < 8 mm*mrad	Feeding fiber core diameter 100 µm Process fiber length 15 m, 200µm core diameter
2	ProfiBus interface	Type DP slave Protocol see below	Connection: 9 Pole SubD connector
3	Conditioner for laser cabinet Model: Seifert KG-4270 400	600 W cooling capacity 810(H) x 395(W) x 135(D) Weight: 33kg	Laser operation at high temperature and humidity

6. Control, Service and Safety interfaces

1. Control- and Service interfaces

NN	Name of interface	Functionality	Description
1	Analogue	Control and modulation of the pump laser diode current	Type of the connector: Han® 7 D, female part on the laser side Pin 1 - AIN_POS Pin 2 – AGND External Analogue Voltage Input 0…+10VDC. Output power control voltage in External control mode. 0V - 10 V corresponds to 0 % - 100% Pump Current Static Accuracy +/- 2 % Response Time ≤ 50 µs
2	Industrial Ethernet	Communications with an external PC for laser monitoring and control	Connector type: HARTING RJ45 DATA 3A PANEL FEED THROUGH Communication rate 100 Mbit
3	Laser ON/OFF	Digital laser modulation	Pin A1, A2 of Han® 25 D connector 0 V – Laser OFF, 24 V – Laser is ON Maximum modulation rate 5 kHz
4	Hardwiring	Laser control from robot	Type of the connector: Han® 64 D, female part on the laser side All inputs are potential free, see the attachment High level is active for all inputs Below is the preliminary assignment of the signals. Further changes are possible after negotiation with the customer. **A1 - Laser Request:** high active. With this signal one of several external controllers (robots) can request laser power. If only one robot is connected to the laser, this bit always must be set during the control process. Without this bit all other input bits are ignored. As a conformation that laser is connected now to this particular controller (robot), B7 will be set high. **A2 – Program start:** high active. With this input the laser programs can be started and stopped. A program gets started if input is active and stopped if the input is cleared or the program ends. Program starts only once. Program number is defined by bits A8-A14. If the program number is 0000000 and bit A6 is high, than laser power is controlled by Analog input. If the program number is 0000000 and A6 is low, laser power value can be set by Ethernet program if A3 is high. B1 must be high before start of the program. After start of the program conformation “Program active” (B9) will be set high. B9 will be cleared after the end of the program and B10 (End of the program) will be set high. B10 will be cleared after A2 (Program start) is cleared (handshake; - not valid if program number is 0000000). **A3 – Enable Internal control:** high active. Some control functions from Ethernet program are enabled with this bit.

			A4 – Reset: high active. This input is used to reset all messages of the laser system and output bits: “Laser Error”, “Program is interrupted” and “Warning”. Input should be active at least for 1ms. **A5 - Guide laser ON:** high active. With this bit guide laser can be switched ON. **A6 - Analog control ON:** high active. Analog control input can be activated by this bit if program number is 0000000. **A7 – Program stop:** high active. Active program can be immediately stopped by this bit. If this happens before the end of the program, B11 and B13 will be set, B9 will be cleared and B10 will not be set. **A8 – Program number**, LSB **A9 – Program number** **A10 – Program number** **A11 – Program number** **A12 – Program number** **A13 – Program number** **A14 – Program number**, MSB **Any program number change is ignored until next low-to-high transition of A2.** **A15 – Synchronization input:** This input can be used in the laser program (wait for high or wait for low). **A16 - Common pin for all inputs (0V)** **C1 – Laser ON:** high active. This input is used to switch ON and OFF the Laser (main power supply). If the laser can not be switched ON (E-stop loop is open), B13 will be set. To switch ON the laser C1 should be cleared and set high again. As a conformation, B8 is set high when the laser is ON. **C2 – spare input** **C3 – Beam Switch Channel number**, LSB **C4 – Beam Switch Channel number** **C5 – Beam Switch Channel number** **C6 – Beam Switch Channel number**, MSB

			C 3 – C6 – Beam Switch optical way in binary code. The number **0000 (0-decimal)** - all Beam Switch mirrors are in down position. The number **0001 (1-decimal)** - the Beam Switch mirror of the channel 1 is in work position. The number **0010 (2-decimal)** - the Beam Switch mirror of the channel 2 is in work position. **C7 – spare input** **C8 – spare input** **C9 – spare input** **C10 – spare input** All outputs are potential free, see the attachment high level is active for all outputs **B1 - Laser Ready:** high active. If this bit is high, Laser program can be started by "Program Start" bit A2. Laser is not Ready if: Chiller Failure, Front Door opened, Rear Door opened, Out of the Temperature Range for the Water of the External Optics, Out of the Temperature Range for the Water of the Laser. **B2 - Emission is ON:** high active. Laser emits radiation. Power is more than 600Watts. **B3 - Internal control is enabled:** high active. Some control functions from Ethernet program are enabled. **B4 - Laser Error:** high active. Abnormal situation is detected inside the Laser. Module Overheat (t≥35°C), Module Unconnected, Laser Fiber Interlock, Coupler Failure, Water in Laser, Power supply Failure, Low Water Flow Laser, Low Water Flow Fiber Connector, Unexpected Pump Current, Unexpected Ground Leakage, High Back Reflection, Laser Light Scattered, Internal Failure of the Beam Switch. Operation is stopped. **B5 - Guide laser is ON:** high active. Guide laser is switched ON. **B6 - Analog control ON:** high active. Laser power is controlled by analog input. **B7 – Laser is assigned:** high active. This is the answer of the laser to bit A1. If this bit is low, all input information is ignored. **B8 – Laser is ON:** high active. Conformation that laser is switched ON. **B9 – Program active:** high active. Laser is executing the laser program

			B10 – End of the program: high active. Laser program was completely executed. B10 will be cleared after A2 is cleared. **B11 – Program is interrupted:** high active. Program has been interrupted. Reset (A4) is required to clear B11. **B12 – Synchronization output:** high active. Can be used in the Laser Program (set high or set low). **B13 – Warning output:** high active. A status is detected in the laser system that results in interruption of laser program (emission). If the output is not active, everything is fine in the system. The Warning output is activated if the reserve module is activated, if the power supply is not switched on after the signal to switch on was received or if the module is overheated. **B14 – Spare output** **B15/B16** - +24V/0V Potential free voltage, provided by the customer to drive outputs. **D1 – Beam Switch Channel number**, LSB **D2 – Beam Switch Channel number** **D3 – Beam Switch Channel number** D4 – Beam Switch Channel number, MSB **D1 – D4 – Beam Switch optical way in binary code confirmation**. The number 0000 - all Beam Switch mirrors are in down position. The number 0001- the Beam Switch mirrors of the Channel 1 is in work position. The number 0010- the Beam Switch mirror of the Channel 2 is in work position. **D5 – Chiller Warning:** high active. The DI cooling water conductivity is ≥ 15 µS, the water temperature of the tap circuit ≥ T_{Th1} - 2°C or ≤ T_{Th2} + 2°C, the water temperature of the DI circuit ≥ T_{Th3} - 2° C or ≤ T_{Th4} + 2°C. **D6 – Chiller Error:** high active. Conductivity is ≥ 25 µS, the water temperature of the tap circuit ≥ $_{TTh1}$°C or ≤ T_{Th2}°C, the water temperature of the DI circuit ≥ T_{Th3}°C or ≤ T_{Th4}°C, CHILLER FAULT. **D7 - Spare output.** **D8 - Spare output.**

2. Profibus interface and protocol

Profibus interface type: DP slave
Profibus interface connection: 9 Pole SubD connector
Profibus interface protocol

Byte	Name	Remark
		Inputs
1	Control	Every bit of this field is interpreted as a separate managing signal to the laser. (little-endian byte order)
2		
3	Power	Power of the laser in watts (up to 65kW).
4		(little-endian byte order)
5	Optical channel	For the laser with beam switch this field sets the optical channel.
6	Program number	This field sets the number of the laser program.
7	Ramping time	This field sets the ramping time in ms. Direction of the ramping time sets in the control field.(little-endian byte order)
8		

		Outputs
1	Status	Main status bits of the laser.
2		(little-endian byte order)
3	Output power	Output power of the laser in watts.
4		(little-endian byte order)
5	Optical channel	Current optical channel.
6	Program number	Current program number.
7	Reserved	
8	Reserved	

Bit	Name	Remark
	Control	
0	Laser request	Activates control via Profibus (without this signal all other bits will be ignored).
1	Laser ON	Switch on the main power supply.
2	Reset errors	Reset not fatal errors in the laser.
3	Guide laser ON	Switch on the guide laser.
4	Program start	Start the laser program (number of the program must be set in the byte 6).
5	Program stop	Stop of the running laser program.
6	Set optical channel	Set the optical channel (number of the optical channel must be set in the byte 5).
7	Analog control ON	Switch on analog control for set output power of laser.
8	Reserved	
9	Set rump up	Set the ramping time for up as a value in bytes number 7-8.
10	Set rump down	Set the ramping time for down as a value in bytes number 7-8.
11	Synchronization input	May be used in laser programs for synchronization
12	Reserved	
13	Reserved	
14	Reserved	
15	Reserved	

	Status	
0	Laser is assigned	Control of laser from Profibus (confirmation of control bit 0).
1	Laser is ON	The main power supply of laser is on.
2	Laser error	Laser has error(s).
3	Guide laser is ON	The guide laser is on.
4	Program active	Laser program is running.
5	End of program	Laser program is ended.
6	Program is interrupted	Laser program was interrupted.
7	Analog control is ON	Analog control in the laser is on
8	Warning	Laser has warning(s).
9	Laser is ready	Laser is ready for emission.
10	Emission is ON	Emission is on
11	Synchronization output	May be used in laser programs for synchronization
12	Chiller Warning	Chiller has warning(s). Please see the description in the Hardwiring interface.
13	Chiller Error	Chiller has error(s). Please see the description in the Hardwiring interface.
14	Reserved	
15	Reserved	

3. Safety interface

Type of the connector: Han® 25D, female part is on the laser side:

Pin number	Name	Description
A1	Emission ON	Potential free input, if +24 V is applied between A1/A2, the laser emission will be ON, if 0 V – laser emission will be OFF. The input is active, if Hardwiring interface is not used. Potential free output, A3 and A5 closed as the emission is activated.
A2	Emission ON	
A3	Emission ON	Two channel potential free output. B3-B6 channel 1; B4-B5 channel 2. When internal E-Stop push-button is activated, channels 1 and 2 are opened. Potential free output. B7 and B8 closed = Safety Circuit is ON.
A5	Emission ON	
B3	E-Stop OUT	Two channel external E-Stop input. C1-C4 channel 1; C2-C3 channel 2. Only potential free contacts can be connected between pins C1-C4; C2-C3. Potential free input, if +24 V is applied between A1/A2, the laser emission will be ON, if 0 V – laser emission will be OFF. The input is active, if Hardwiring interface is not used. Potential free output, A3 and A5 closed as the emission is activated.
B4	E-Stop OUT	
B5	E-Stop OUT	
B6	E-Stop OUT	
B7	SC Status	Two channel potential free output. B3-B6 channel 1; B4-B5 channel 2. When internal E-Stop push-button is activated, channels 1 and 2 are opened. Potential free output. B7 and B8 closed = Safety Circuit is ON
B8	SC Status	
C1	E-Stop IN	Two channel external E-Stop input. C1-C4 channel 1; C2-C3 channel 2. Only potential free contacts can be connected between pins C1-C4; C2-C3. Potential free input, if +24 V is applied between A1/A2, the laser emission will be ON, if 0 V – laser emission will be OFF. The input is active, if Hardwiring interface is not used. Potential free output, A3 and A5 closed as the emission is activated.
C2	E-Stop IN	
C3	E-Stop IN	
C4	E-Stop IN	
C5	SC Reset	Two channel potential free output. B3-B6 channel 1; B4-B5 channel 2. When internal E-Stop push-button is activated, channels 1 and 2 are opened.
C6	SC Reset	

Important! Two-channel External E-Stop (emergency stop) input is designed in accordance with EN954-1 Cat.3 norms. Both channels should be used for E-Stop.

Important! EMI-Filter is installed at the input of main power supply of the laser in order to fulfill CE-norms. Typical leakage current (steady-state) at 400VAC is about 8 mA due to Y-Capacitors inside of the EMI-Filter. In case of using Earth-leakage detection device for power connection, pulse leakage current during start-up of the Laser can cause shutdown of such device. This well-known problem can be avoided using Earth-leakage detection device with delay during start-up.

7. Environment and Precautions

CAUTION	During operation protective covers of the equipment shall not be removed and doors opened. No operator serviceable parts inside. Refer servicing to qualified IPG personnel.
WARNING	Do not open the front and rear doors of the laser if laser emission is ON. This can put the operating personnel in a very high risk situation.
CAUTION	Do not expose the device to a high moisture environment.
CAUTION	Before tuning the power of the device on, make sure the laser optical output is properly aligned and terminated.
CAUTION	The output of the YLR-6000 S delivers more than 6000 watts of optical power. Ensure that the end face of the connector and the lenses in the optical head are not damaged, of specified quality and clean. Any dust on the output can burn and lead to a damage to the laser. First, check the beam quality of the spot emitted from the laser output at low power levels by using an infrared viewer and then gradually increase the output power.
CAUTION	Always switch the laser off if working with the connector (mounting the connector into a fixture, viewing the end face with optical instruments, etc.). If necessary, align the connector at low output power and then increase the output power gradually.
CAUTION	It is essential that the output facet of the fiber connector is always maintained clean. After the use, protect the connector with a cup supplied. Do not touch the output facet and do not clean with any unspecified solvents. Cleaning with the special solvent and cleaning buds is allowed as described later on in this manual. Optical damage my result from failure to comply with the instructions above. Should such damage occur, this will not be covered by the warranty. Do not use the laser for processing of copper, this can lead to damage to the laser. On operation conditions you shall consult with IPG before considering processing copper or its alloys.
IMPORTANT	The warranty for the feeding fiber (fiber output of the laser) will void if the warranty seal labels are damaged, tampered with or removed. The customer is strongly advised not to disconnect the feeding fiber.
IMPORTANT	Failure to comply with the cautions and instructions in this manual can lead to damage to the fiber and its external optics and will render the warranty void
IMPORTANT	To put heavy or sharp-edged objects on the laser or to climb on top of the laser can lead to damage to the laser or its objects and is permitted. Such damages will not be covered by the warranty.

8. Preparation for use

NOTE: Upon receiving the laser check the packaging and parts for any possible damage that may have occurred while in transit. If damage is apparent contact the IPG representative immediately.

Ensure that there are no fiber bends with radius less then 10 cm and no excessive bending will apply during the robotic arm movements.

1. Before supplying the mains power to the laser and chiller, ensure, that the power supply AC line is 3 phase x 400 V, PE.

2. Connect the laser to the external chiller.

3. The main power supply inside the laser and each laser module are cooled by water. Water is filtered with residual particles under 500 µm. Check and clean the filter every six months. The filter is placed next to the water inlet of the laser.

4. There is a flow detector inside the laser. In case of low water flow the laser emission will be disabled. The water connection from the chiller to the laser is a 3/4 inch diameter (soft pipe). Optimal water temperature for the laser cooling is 20 – 22 °C. Ensure that the water flow rate through every fiber connector is at least 1.0 l /min.

5. Ensure that there is no jam of or water leakage from the cooling pipes. Additional flow switches inside the beam switch cabinet monitors the water flow through the external optics. In case of low water flow through the external optics, laser emission will be disabled.

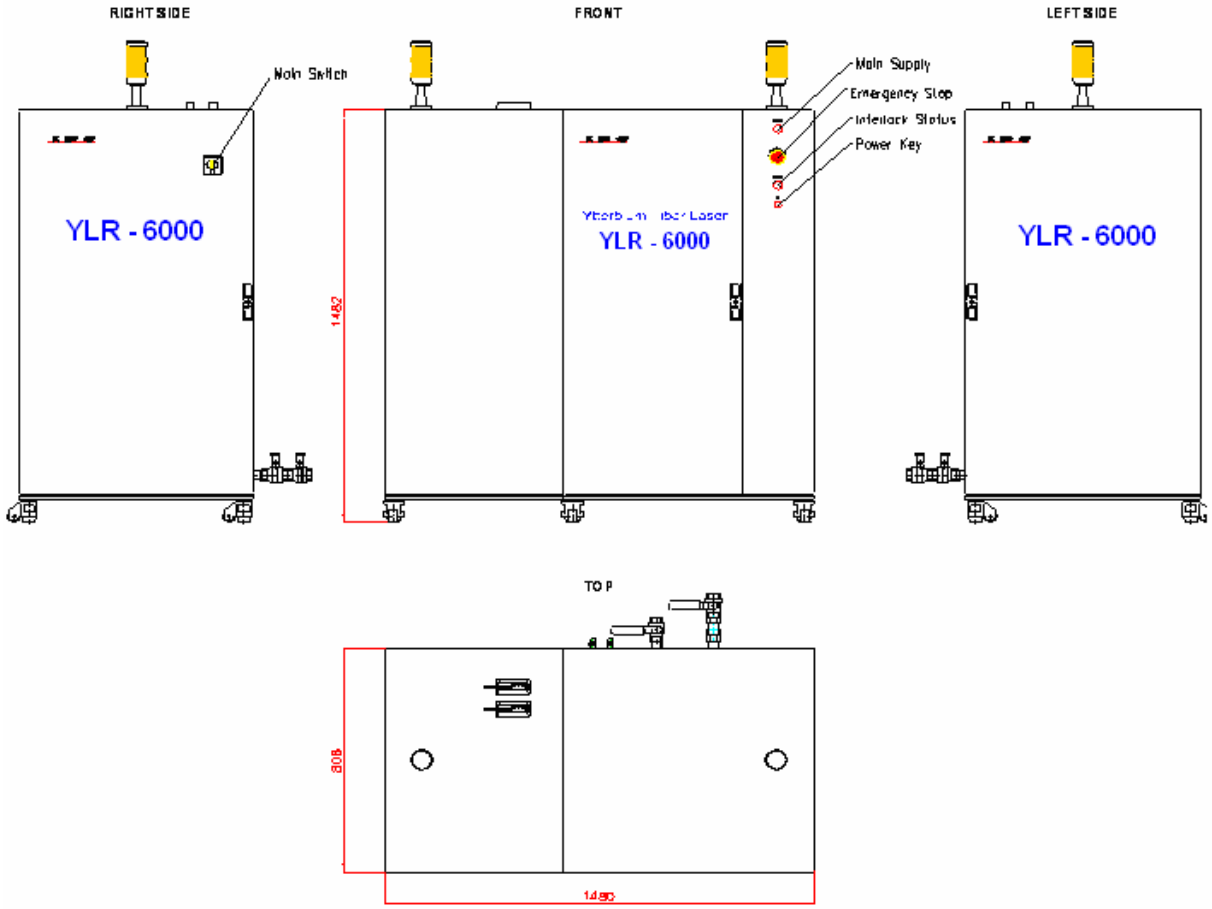
6. Connect laser to computer and external interfaces.

7. Connect the feeding fiber connector to the 2-ways internal Beam Switch.

8. Connect the process fiber to the 2-ways internal Beam Switch and optical processing head.

9. Align the 2-ways internal Beam Switch.

9. Laser controls, indicators and connectors



Main Laser Switch	Switches the power of the laser ON / OFF
E-Stop button	Switches the laser OFF in case of emergency
Start / Reset button	Starts the laser
Power key	Switches control electronics of the laser ON in test mode or in robot-control mode
Ethernet connector	Ethernet
HAN 64D connector	Input / Output Hardwiring interface XP1
HAN 25D connector	E-Stop interface XP2
HAN 15D connector	Chiller interface XP3
HAN 7D connector	Analog control input XP4
Power supply cable	400 VAC x 3, 32A
Water inlet of the laser cooling systems	Water inlet of the laser cooling and external optics. The water quality: Tap water with particles < 500 µm.
Output QBH-compatible fiber	Feeding fiber: 100 µm / 5 m,
Orange lamps	Upper lamps blink if laser is ready for emission. Lower lamps light constantly if power supply is ON.
Water filter	For input water filtering / clean regularly

Connectors description XP9 (HAN 24B)

XP 9: External optics safety interface connection. Female parts on laser and external optics side

Pins	Description
1	Interlock channel 1 input – connected to interlock relays inside laser
2	Interlock channel 2 input – connected to interlock relays inside laser
3	Interlock channel 2 output – connected to interlock relays inside laser
4	Interlock channel 1 output – connected to interlock relays inside laser
5	E-Stop channel 1 input – connected to E-Stop relays inside laser
6	E-Stop channel 2 input – connected to E-Stop relays inside laser
7	External E-Stop Signal channel 1 input
8	External E-Stop Signal channel 2 input
9	E-Stop channel 1 output – connected to E-Stop relays inside laser
10	E-Stop channel 2 output – connected to E-Stop relays inside laser
11	External E-Stop Signal channel 2 output
12	External E-Stop Signal channel 1 output
13	Shortcut to 14
14	Shortcut to 13
15	230 V AC power connection from inside the laser
16	Neutral line from inside the laser
PE	Protective earth connection

10. LaserNet program description

Settings and minimum system requirements

The LaserNet program is supplied with the laser and allows to monitor current state/statuses and to operate the laser. The program can control up to 100 different lasers chained through the Fast Ethernet 100 Mbit/sec (Standard IEEE 802.3) *.

Computer requirements for operation of LaserNet:
Pentium III/IV 1GHz or compatible (recommended - Pentium IV 2 GHz);
RAM 256MB (recommended 512MB);
Screen resolution 1024x768 (XGA) 256 colors (recommended - True Color);
Free space on the hard disc drive (HDD) – 20 MB;
Ethernet 100Mbit;
CD-ROM;
Modem (optional) or VPN connection
Operating system Windows 2000/XP

***Note:** If a single laser is connected to the computer it is possible to establish connection with the laser by using a cross cable.*

Installation instruction

To install the LaserNet program on your computer
1. Create a new folder and name it. (Recommended - LaserNet)
2. Insert the installation CD in the CD ROM drive
3. Copy all data from the CD into the LaserNet folder
4. Create a shortcut to LaserNet.exe on your desktop (optional) or execute the LaserNet setup.exe itself.

The LaserNet-CD contains the following data:
LaserNet.exe – main executable file
MFC71u.dll, msvcr71.dll, msvcp71.dll – library files
LaserNet.cfg – Configuration file (this file is optional and contains standard setting to facilitate the first run of the program).

Check that IP address of the computer and of the laser are correctly set:
IP address of the laser = 192.168.100.1 subnet mask = 255.255.255.0.
IP address of the computer 192.168.100.100 subnet mask 255.255.255.0. *

***Note:** After connection between Laser and LaserNet program has been established for the first time, The IP address assigned to the laser can be altered.*

General program information

In the LaserNet program three different color LED-style indicators are generally used to reflect statuses of the laser.

The red LEDs represent alarm signals which generally disable the laser emission or warning signals that indicate presence of emission.

The green and yellow LEDs indicators do not affect emission and are generally used to display information.

Green LED in “OFF” state 

Green LED in “ON” state 

Yellow LED in “OFF” state 

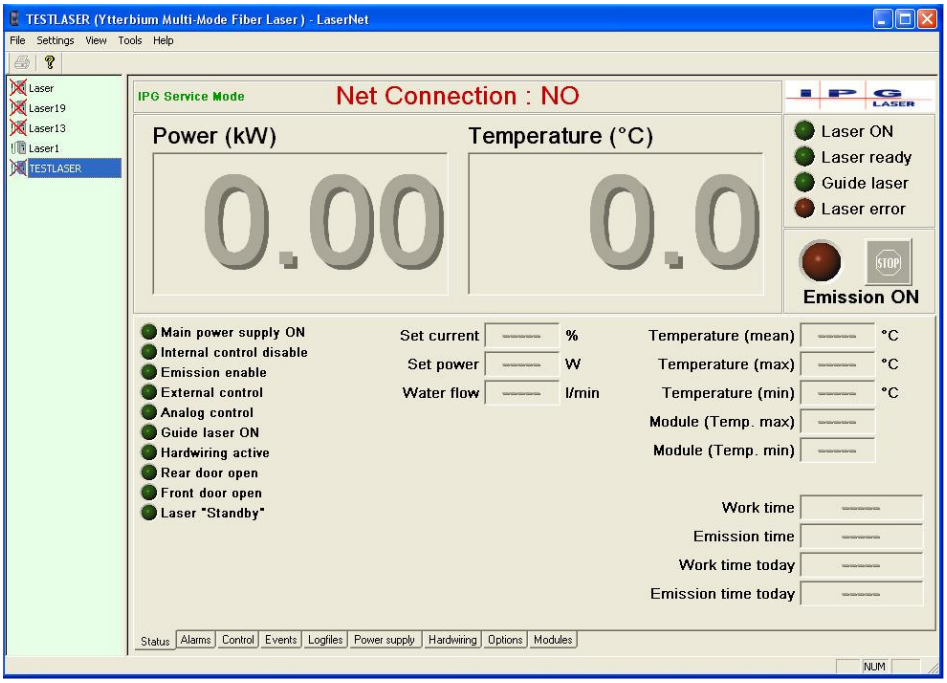
Yellow LED in “ON” state 

Red LED in “OFF” state 

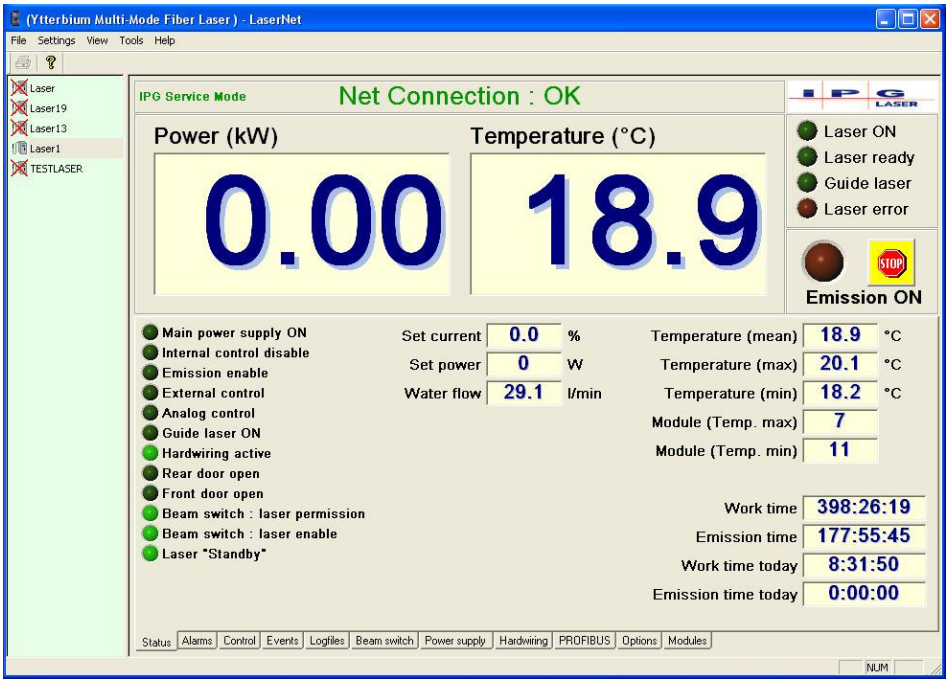
Red LED in “ON” state 

Starting LaserNet

Before starting the LaserNet program ensure that both the laser and the computer are connected to the same LAN. (If a single laser is used, a cross-cable connection can be employed)
Start the program LaserNet.exe and the following window will appear:



After the connection between laser and program has been established the window will change*:



***Note:** The number of parameters and indicators may vary due to different laser models and options.*

Main menu of LaserNet

The main window contains the following system of submenus 

Submenu	Content	Description
File	Exit	Closes the LaserNet program
Setting	IP Configuration	Opens the dialog "IP Configuration" for changing the connected laser names
	Laser… Reset critical errors	For reset of critical errors
	Laser… Interbus settings	Allows to change the Interbus settings, if one is installed
	Change password	Opens a window for changing the password
	Control	Opens the dialog window "Settings of control" for disabling control, emission, and possibility always to reset
View	Toolbar	Shows and hides the program tool bar
	Status bar	Shows and hides the program status bar
Tool	Program Editor	Opens the LaserProgram editor *
Help	About LaserNet	Opens a window with program information

**** Note:** This option is not active if the laser does not support the LaserProgram option.*

Toolbar

The toolbar in the upper left corner of the main window gives brief description for selected menu item

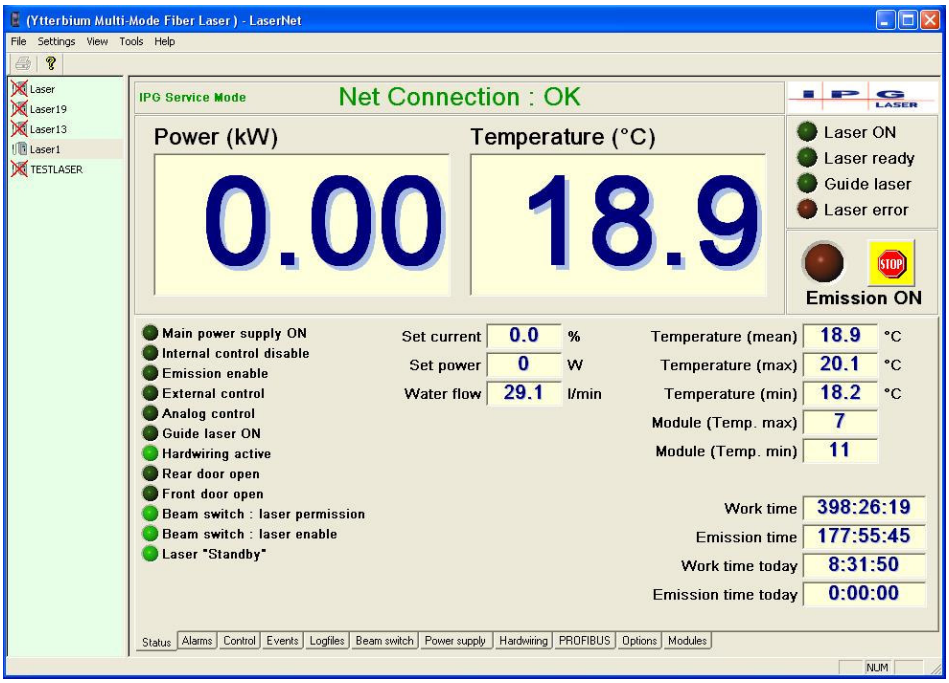
 Reserved

 Opens window "About LaserNet"

Status Bar

The status bar in the bottom left side of the main window gives brief description for selected menu item or control button

Main window of LaserNet



The LaserNet main window shows three panes:

Left pane shows a number of lasers currently connected to the LaserNet program (in the displayed case three lasers are connected) and the state of each connection. If connection is active the laser the laser symbol is shown without red cross. The red cross appears over the connections if the laser is OFF, the connection between the laser and program is interrupted or if the TCP/IP settings of the laser and computer do not match each other. In the figure above the connections between LaserNet and “Laser 5” and “Laser 6” are inactive and connection to “Laser 1” is active and working.

The left pane allows choosing the current “active” laser. Parameters of the active laser can be monitored and controlled by the LaserNet. To set a desired laser as active, right-click the laser symbol you want to control with the mouse.

The upper right pane displays connection status of the active laser, its optical output power (in kW), mean temperature of the laser modules in ℃ and five main status indicators which are displayed as LED lights.

If the active laser is not connected the status message "Net connection: NO" will appear in red. Alternatively, "Net connection: OK" in green will be shown indicating that the laser is ready for monitoring and control.	Net Connection : NO Net Connection : OK

Following status signals display as LED lights:

Laser ON	In "ON" state if the main power supply is switched on
Laser ready	In "ON" state if emission is allowed
Guide laser	In "ON" state if the guide laser is on
Laser error	In "ON" state if an error is detected by the program
Emission ON	In "ON" state if the laser emits radiation

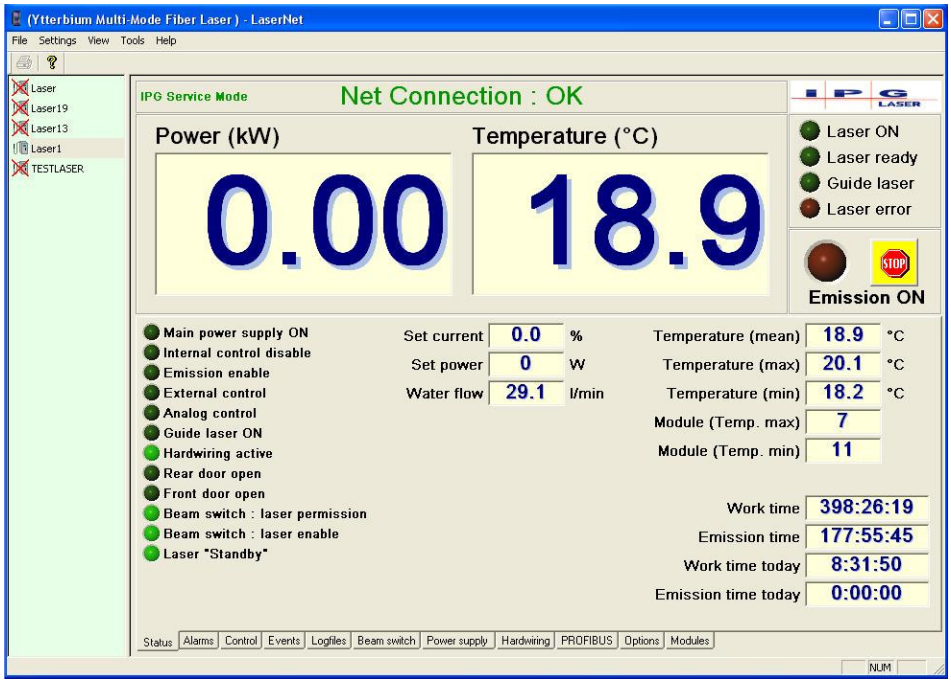
Next to the LED “Laser ON” there is a button: 

This Button is an E-Stop button. To right click on this button switches off the power supply and Emission immediately. This function does not conform to the safety category CAT III

The lower right pane of the main window shows a number of tabs for property pages “Status”, “Alarms”, “Control”, “Events”, “Logfiles” and “Power supply”. Depending of the setting of the laser and the delivered accessories additional pages may be present such as “Beam switch”“, “Chiller”, “Hardwiring” and “Options”. To switch between different tab pages click with the mouse the desired tab.

Properties window Status

This window gives general information about the laser status



The signals received from the laser are shown as green active LEDs on the left side of the window:

Signal name	Description of the status and its effect
Main power supply ON	Indicates that the power supply is ON. Without this signal the laser emission is disabled. If this signal disappears the laser emission will be switched OFF and the signal Laser ready will turn OFF and "Laser "Standby"" will turn ON. The main power supply will not switch ON if - the E-Stop button at the laser is pressed, - E-Stop external is active, - E-Stop is active
Internal control disabled	Indicates that most of the control functions are disabled. Only buttons “Reset” and the beam path choice for the beam switch (if a beam switch is installed) on the property page “Control” will be enabled. This signal will only appear if the laser is controlled by an external system through the hardwiring interface.
Emission enabled	Indicates that the emission is allowed. This is similar to signal “Laser ready”. If this signal is not present the laser emission will be switched OFF and signal “Laser ready” will turn OFF. Possible reasons for this signal being disabled: • Safety circuits of the laser are open • Signal “Laser fiber interlock” is active • Internal defect in the combiner (Signal “critical error” is active)

	• One of the laser cabinet doors is open (Signal “Rear door open” or Signal “Front door open” is active) • The signal “Laser Permission” from the beam switch is missing • Command to switch emission ON is not set • Signal “High Back Reflection” is reported by one of the parallel laser modules
External control	Indicates that the start and stop of the laser emission are externally controlled. If the laser is fitted with a hardwiring interface, the status can be set only if the “Test mode” is active. Once the external control is enabled, the laser emission can start (stop) on applying (removing) +5…24 V DC to the pins A1 [positive] and A2 [negative/ground] of the safety interface XP2. In this case, the output power (or pump current) has to be set on the property page “Control” and emission ON button should be pressed. External control can enabled by pressing buttons “External control ON/OFF” or “Analog control ON/OFF” on the property page “Control” (see also the description of Analog control below).
Analog control	Lights if the laser is in the analog control mode. If the laser is in the “Test” mode (hardwiring interface is present) the external control will turn ON automatically once the “Analog control” is switched ON. Switching emission ON/OFF operates in the way described above for the “External control”. The output power can be directly set by applying an analog voltage to the pins 1 [positive] and 2 [negative, ground] of the analog control interface XP4. 0V DC corresponds to 0% power and 10V DC to 100% output power. This mode can be activated/deactivated by using the button ”Analog ON/OFF” on the property page “Control”. If the laser is in the mode “Robot”, the analog control mode can be enabled/disabled by applying/removing the analog signal through the hardwiring interface XP1. In the “Robot” control mode, the output power (0 to 100%) is proportional to the 0 to +10 V DC signal applied via the analog interface XP4.
Guide laser ON	Lights if the red guide laser is switched ON.
Hardwiring active	Lights if the data communication between the hardwiring µ-controller (inside the laser) and the laser µ-controller has been established.
Chiller ready	Provides information on the chiller’s readiness. If not lit, check that the chiller is ON, water temperature and the water level inside both loops are normal and that water conductivity is within specified range. If “Chiller ready” status goes off, the emission will stop and signal “Laser ready” will be removed.
Rear door open	Indicates that the door at the rear of the laser is open. If this signal is active the emission of radiation will stop and signal “Laser ready” will be removed.
Front door open	Indicates that the door at the front side of the laser is open. If this signal appears the emission of radiation will be stopped and the signal laser ready will be removed.
Beam Switch: laser permission	Laser permission is only active if the water flows for the fiber connectors are in the specified range. If this signal disappears laser emission will be

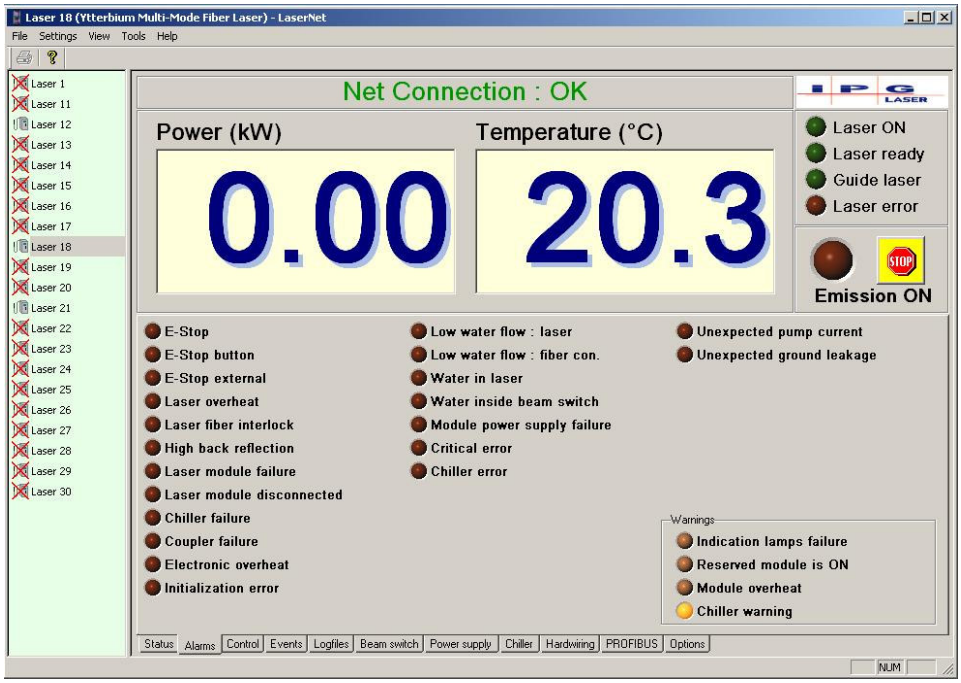
	switched off and “Laser ready” will be set to low
Beam Switch: laser enable	This signal is high if inside the coupler everything is alright. If this signal disappears laser emission will be switched off and “Laser ready” will be set to low
Laser Standby	This signal is High, if no E-Stop signal is High. This signal is independently of the mirror position.

The following laser parameters are displayed as numerical values in the status window

Parameter	Description
Set current	Pump current set in %
Set power	Selected output power in Watts.
Water flow	Current tap water flow through the laser in l/min.
Temperature (mean)	Current mean temperature of the laser modules in °C.
Temperature (max)	Current maximum temperature inside modules in °C.
Temperature (min)	Current minimum temperature inside modules in °C.
Module (Temp. max)	The number of module with the highest temperature.
Module (Temp. min)	The number of module with the lowest temperature.
Work time	Total operational time of the laser in hours, minutes and seconds.
Emission time	Total emission ON time of the laser in hours, minutes and seconds.
Work time today	Today's operational time in hours, minutes and seconds.
Emission time today	Today's emission ON time in hours, minutes and seconds.

Properties window Alarms

This window shows alarm, warning and error statuses reported by the laser and displayed as red LED Lights.



Signal name	Description of the status and its effect
E-stop	Active if the safety loops are open. Once this alarm appears the laser emission and the main power supply will be switched off, the status “Laser ready” will be removed but “Laser error” will not activate. While this signal is High power supply can not become switched on. Active, if at least one laser cell door is open (XP4: C1-C2, C3-C4). Sets itself immediately Low and "Laser Standby" High. Interlock is present again, mirror is in home position. Power supply can become switched On. After the door contacts become closed the mirror turns back to work position and the signal "Laser ready" will be set High.
E-Stop button	Active, if the E-Stop button at the laser is pressed. Additionally, the signal "E-Stop" will be set High. While this signal is High, the power supply can not be switched On.
E-Stop external	Active, if the XP2 safety circuit (C1-C4, C2-C3) has become interrupted. If XP2 safety relay becomes closed, "Laser Standby" will become active and "E-Stop external" and "E-Stop" disappears.
Laser overheat	Indicates that at least one of the laser modules is overheating (temperature exceeds +35°C). Once this alarm appears the overheating module’s emission will be switched off, the status “Laser ready” will remain and the “Laser error” will not activate. If the temperature of the module falls back under 32°C, the alarm signal will disappear and the module will be switched on. In this case an optional reserve module (if present) will not be activated.

Laser fiber interlock	Lit if the safety interlock loop of the fiber is open. Activates is the fiber connector is not correctly plugged in the optical head (fiber-fiber coupler or a beam switch, if installed) or that the fiber cable or the connector are damaged. This alarm will stop emission instantaneously and will switch the main power supply OFF removing the status “Laser ready” and activating the status “Laser error”. This alarm is lockable and will stay ON even if the reason for the alarm has been removed. The Reset button on the “Control” property page has to be used to remove this alarm.
High back reflection	This error appears if the sensor indicates excessive back reflection in the combiner module. Check with help of the pilot laser, if the beam way is aligned correctly. It is necessary to reset the laser before laser operation can be continued.
Laser module failure	Indicates an internal failure of one of the laser modules. If a reserve module is installed it will switch on and the failed module will switch off. If the laser is not equipped with the reserve module the total output power will decreased proportionally to the output power of the failed module. Possible reasons for this failure can be internal optical fault in the laser module or power supply interruption to one of the lines of the pump diodes in the module. This status can lead to immediate switching of the laser emission OFF. “Laser error” and “Laser ready” will remain unaffected.
Laser module unconnected	Indicates error in communication with one of the laser modules. It activates if the main processor inside the laser receives no information from one of the modules within specified period of time. Check that a connection cable between the laser module and mainframe is properly plugged in and if the green LED on the module’s front panel is regularly blinking. This status signal does not affect “Laser ready”, “Laser error” statuses and emission.
Coupler failure	Activates if the status signal “Critical error” activates. This status signal switches the laser emission OFF, deactivates signal “Laser ready” and sets status “Laser error” to high.
Electronic overheat	This message will appear if the thermal elements in the electronic will detect a temperature that is higher than the set value. This will not disable emission or remove the laser ready signal. It is only for information.
Initialization failure	A failure occured during LaserNet start.Please contect IPG representatives
Low water flow : laser	Indicates insufficient cooling water flow through the laser. Water flow rate specified for the laser has to become restored. This status signal switches the laser emission OFF, deactivates signal “Laser ready” and sets status “Laser error” to high.
Low water flow : fiber connector	Indicates insufficient water flow through the output connector of the feed fiber. Water flow rate specified for the connector has to become restored. This status signal switches the laser emission OFF, deactivates signal “Laser ready” and sets status “Laser error” to

	high.
Water in laser	Indicates water leak inside the laser. Open the doors of the laser cabinet and check for water leakages. This status signal switches the laser emission OFF, deactivates signal “Laser ready”, sets status “Laser error” to high and switches the power supply OFF.
Water inside beam switch	Switches off the power supply. The water flow to the beam switch becomes stopped by magnetic valves.
Module Power supply failure	Indicates interruption of the mains connection to the power supply. The reason can be checked by going to the properties page “Power supply” (signals Q1-Q4). This status signal switches the laser emission OFF, deactivates signal “Laser ready” and sets status “Laser error” to high.
Critical error	The alarm appears only together with "Coupler failure" alarms. It indicates that no further operation is possible and it is necessary to contact IPG qualified personnel.
Chiller failure	This status signal is generated by the chiller. For resetting this alarm refer to the chiller manual. This status signal switches the laser emission OFF, deactivates signal “Laser ready” and sets status “Laser error” to high.
Unexpected pump current	Appears if the power supply applies the pump current to one or all the laser modules while no emission ON signal is present. This status signal switches the laser emission OFF, deactivates signal “Laser ready”, sets status “Laser error” to high and switches the power supply OFF.
Unexpected ground leakage	Indicates a pump current leakage in the circuit between the negative terminal of the power supply and the protective earth (PE) terminal. This status signal switches the laser emission OFF, deactivates signal “Laser ready”, sets status “Laser error” to high and switches the power supply OFF.

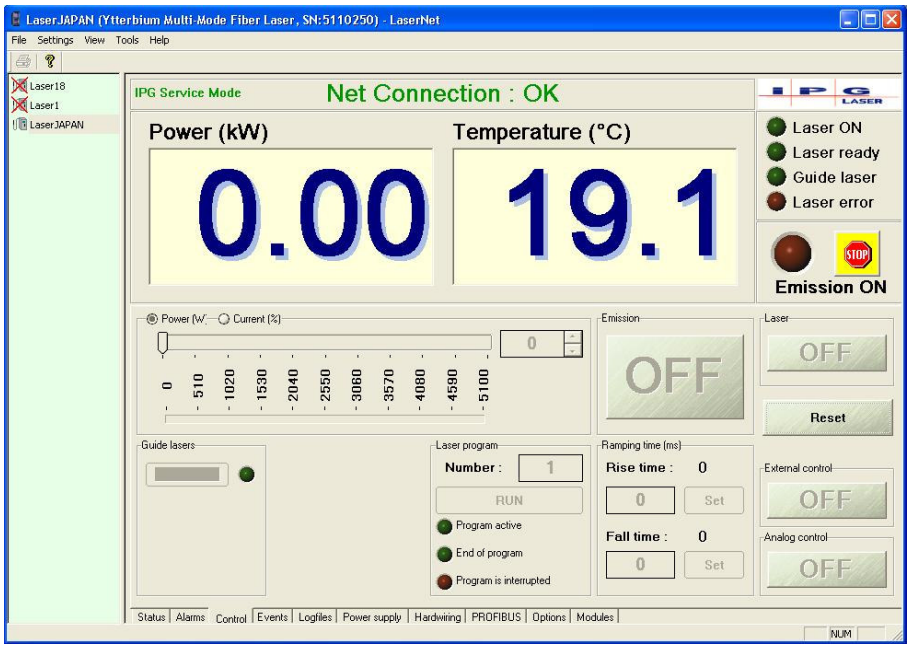
The following warnings are also included on the alarm page.

These warnings do not affect the emission capability of the laser device

Indication lamps failure	Indicates that one of the warning safety lamps that are installed in the laser is defective. This signal does not affect laser emission or statuses “Laser ready” and “Laser error”. Notwithstanding, the defective warning light can cause potential laser-safety hazardous condition especially if both warning lights go out of operation and do not provide required visible indication of presence of the laser emission.
Reserved module is ON	One of the active modules was disabled and a reserve module was switched on. Please contact IPG for clearing this problem.
Warning Chiller	This warning does not interrupt the laser operation. Conductivity is ≥ 25µS, the water temperature of the tap circuit ≥ T_{Th1} ℃ or ≤ T_{Th2} ℃, the water temperature of the DI circuit ≥ T_{Th3} ℃ or ≤ T_{Th4} ℃
Module overheat	Depending of setting of HP Config Utility this warning can lead to interruption of laser operation.

Properties window Control

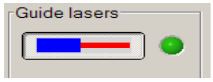
This window displays main control option.



Controls available:

"Power/Current" slide bar allows setting the output power of the laser in Watts or pump current in percents of the maximum value. Either power or current mode can be selected by clicking the corresponding check box above the slide bar. An indicator line below the slide bar and the scale shows the actual power or current value. A box with numerical value input on the right of the slide bar allows setting a specific value of the power or current. The selected value should be confirmed by pressing "Enter" on the computer's keyboard. The pump current value can be chosen between 0 and 100 % and output power between 0 and maximum value which will be rounded to the closest 100 Watts. The laser starts emission after the pump current exceeds approximately 7%.

"Guide laser" control buttons switch the installed guide laser ON or OFF. Once the guide laser is ON, the corresponding button will change its shape and green LED indicator will light.

For a YLR-6000 S the pane with active guide laser button and corresponding LED will look like	

"Beam switch" * pane controls allow to alter the positions of the beam switch mirror(s) to allow power sharing between installed output channels. With the slide bar in "home" position all mirrors are down and optical channels are inactive and the beam power is dissipated by the beam dump. Other positions of the slide bar move the mirror of the corresponding channel in "work" position enabling a particular power share output. If the green indicator LED corresponding to the beam path configuration set with the slide does not lit, this corresponds to failure of the beam switch. Refer to the beam switch properties page. In no circumstances two different mirrors can be in "work" position at the same time; presence of more than one lit green LEDs indicates failure in the beam switch.

***Note:** These controls display only if the beam switch is installed.*

"Emission" button allows switching the laser emission ON and OFF. The current state of emission (ON in red or OFF in blue) is displayed on the button. Pressing the Emission button showing OFF state will cause transition to ON and will switch the laser emission on; pressing the ON state emission button will cause transition ON to OFF state and will stop laser emission. If the laser is in external control mode, pressing the emission button will not start the emission but will only set the laser to a ready state when emission is allowed at any moment; the emission can be turned on by applying the external emission-on command via XP2 connector. If the laser is not in external control mode, pressing the emission will start the emission instantaneously. In both modes of operation, pressing the emission button (once it is in ON state) will stop the emission.

"Laser" button allows switching the main power supply of the laser ON or OFF. The state of the power supply is shown on the face of the button.

"Reset" button allows resetting all failure messages (if the reason for the failure has been removed).

"External control" button allows switching the external control mode ON or OFF. The state is shown on the face of the button. To turn laser emission on in the external control mode, the button emission has to be pressed first (ON state) and then the emission on signal has to be applied via the XP2.

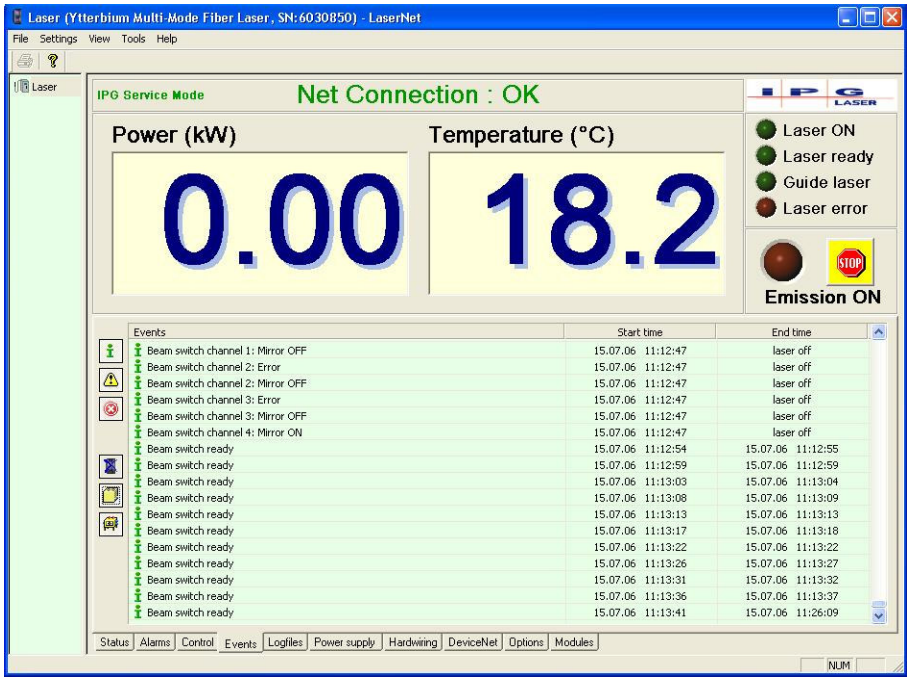
"Analog control" button allows switching the analog control mode ON or OFF. The currently selected mode is shown on the face of the button. In the analog mode the laser output power can be controlled with an analog voltage signal applied via the XP4 interface. 0V DC corresponds to 0% output power and +10V DC will set output emission power to 100%.
Note: Selection of the analog control mode automatically enables the external control mode. To switch the emission on, set "Analog control" ON, "Emission" ON, apply the analog voltage (0 to +10V DC) to the XP4 interface; apply "External ON" signal voltage (5 to +24V DC).

"Ramping time" pane has two fields for power ramping setting. The first allows setting a desired rise the second fall time. Input the time value in milli-seconds into the blank field and press "Enter" on the keyboard or click "Set" button next to the input field. The currently set values are shown above the input fields.

"Laser program" ** pane contains controls and statuses of the Laser Program (LP). The input field allows entering and selecting the LP number between 1 and 50. The Run-Stop button and three different indicators of the LP state operate as follows. If the laser is in "Ready" state, execution of a desired program will start after the LP number has been set and the button RUN pressed. Once the program is being executed, the Run button name and function will change to stop and back to RUN after the program has been completed. If Stop is pressed during execution of the program, the program will stop instantaneously. The green indicator "Program active" will remain lit from start to the end of the program. If the program has completed without errors, the indicator "End of program" will lit and will remain on until the following program starts or the "Reset" button is pressed. If the program is interrupted due to some reason, the indicator "Program is interrupted" will light and will remain on until "reset" button is pressed. The reason for interruption of the program will display in the "Events" window.
****Note:** These controls display if the laser is equipped with the option of working with the LaserProgram.*

Properties window Events

This window provides information about events recorded by the laser system. All entries have the following format: event – start time – end time. To delete event records (if no longer needed) right mouse click in the window and choose option “Delete all events”.



 Represents information about the laser system and external components.

 Gives information about warnings.

 Constitutes laser alarms.

 Denotes information concerning the laser.

 Represents information about the chiller.

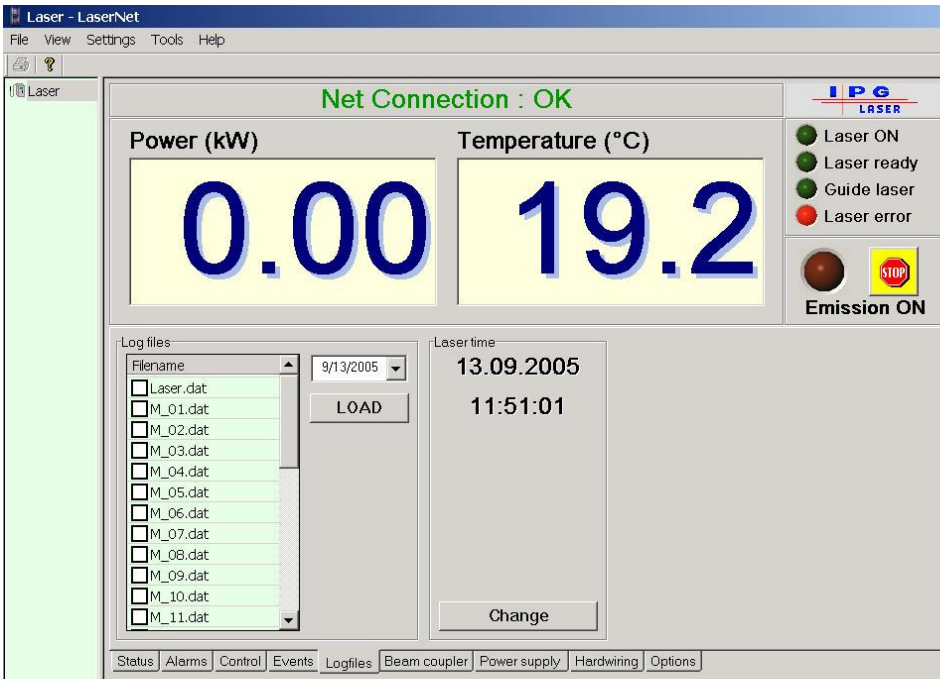
 Gives information concerning the beam switch.

These six buttons can be used to display or to hide the corresponding messages. If three symbols of one group are hidden no events remain displayed.

Note: *To increase the speed of opening this window, it is recommended to delete the records regularly.*

Properties page Logfiles

This window allows to change internal date and time in the laser and to write logfiles to the hard disk of the computer:



To save log-files to the hard disk:

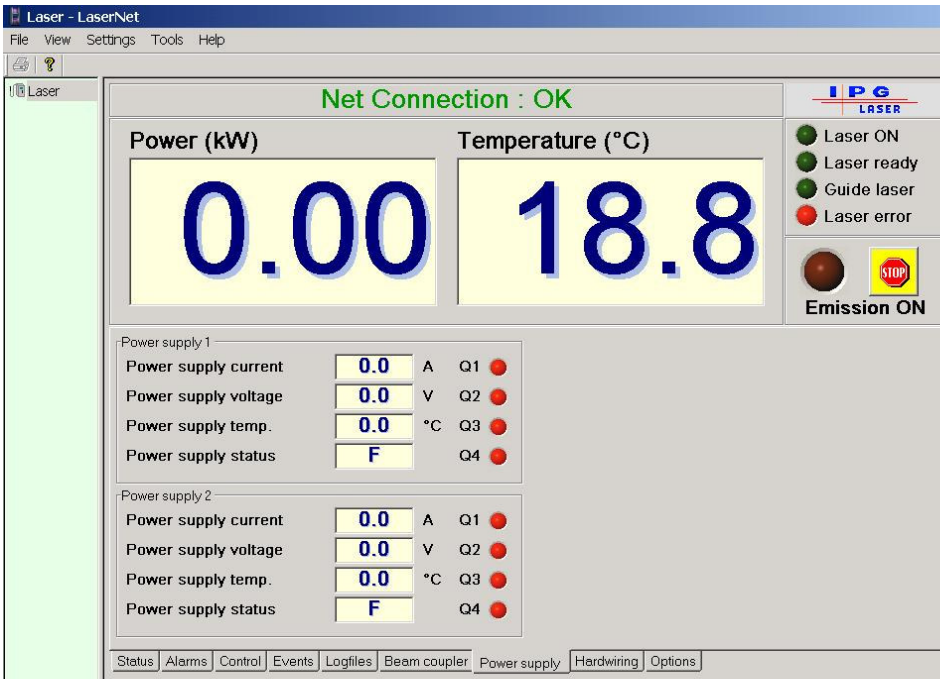
1. Select or type in the date by using the pull down menu.
2. Select required Logfiles by checking corresponding check boxes against the file names. If all files need to be selected/deselected, right mouse click on the file list and choose “Select all files” or “Clear selection”;
3. Press “Load” button and the selected files will be saved in the folder <LaserNet work folder>\<Laser name >\<Data>.

Note: *All Logfiles are in binary format and can not be viewed by the LaserNet program. In case of problems or errors reported by the laser system, the saved Logfiles should be sent to IPG-personnel for analysis.*

To change the time and date press the “Change” button and type in the new date and time. It is important to set correct time and date because this information is used by the laser for calculating laser on time and for correct recording of Logfiles

Properties window Power supply

This window displays statuses of the installed power supplies. The system can be fitted with up to four power supply units.



Following parameters are displayed in numerical format:

Power supply current	Current of the power supply (in Amps)
Power supply voltage	Voltage (in Volts)
Power supply tem	Power supply temperature (in degrees C)
Power supply status	Status of the power supply (in hexadecimal format)

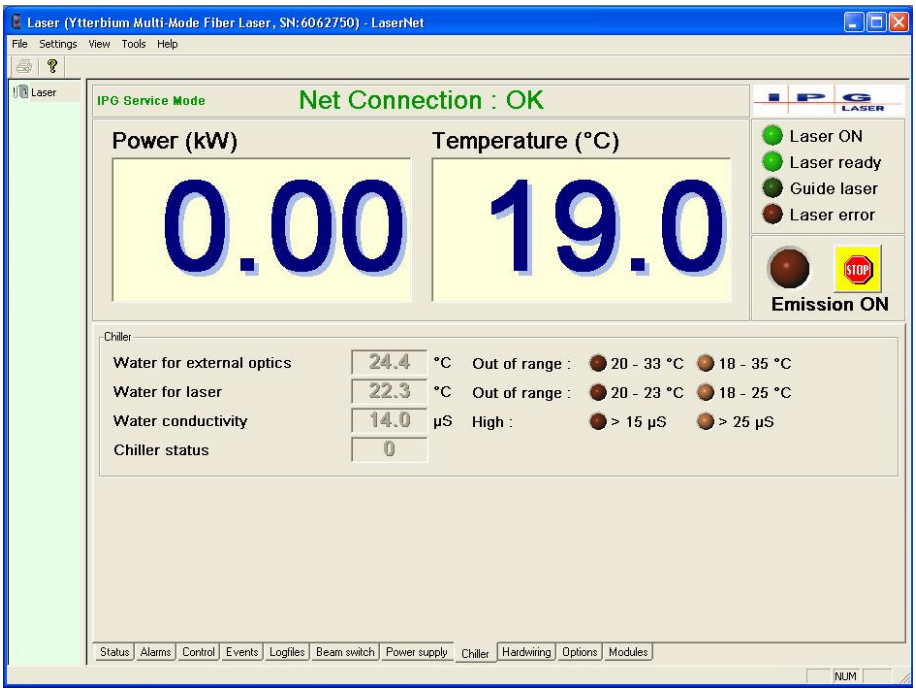
The power supply status is also represented by four red LED style indicators which will lit if the corresponding parameter is high:

Q1	Q2	Q3	Q4	Status	Comments
0	0	0	0	Proper operation	These events relate to external parameters or environment (water flow, input voltage, etc.)
0	0	0	1	Overheating	
0	0	1	0	Excessive input voltage	
0	0	1	1	Short circuit	
0	1	0	0	No-load operation	
0	1	0	1	Interlock open	
0	1	1	0	Reserved	
0	1	1	1	Reserved	
1	0	0	0	Internal failure (Code_X)	These messages relate to internal errors and assume that the power supply should be replaced.
1	0	0	1	Internal failure (Code_Y)	
1	1	1	1	Internal failure (Code_Z)	

Note: *This window is not present if a power supply without monitoring capabilities is installed*

Properties window Chiller

This window displays information about the installed chiller and its parameters



Following chiller parameters are monitored and displayed in numerical format:

Water for external optics	Current water temperature in °C for external optics (beam switch, fiber – fiber coupler, optical head, and fiber connectors)
Water for laser	Cooling water temperature in °C
Water conductivity	Cooling water conductivity fort he deionized water in µS
Chiller status	Chiller's status in hexadecimal format

The chiller status code is a three bit word

Bit number	Function	High if	Low / High values
0	DI water temperature	Temperature is out of range	0 / 1
1	Laser water temperature	Temperature is out of range	0 / 2
2	Conductivity	Conductivity is out of range	0 / 4

The chiller status is also reflected by indicators. The red LEDs will light if the temperature or conductivity exceeds the normal range. The hysteresis of the parameter values is 1 which means that if the temperature is out of +18..35 °C the error status will remove once the temperature is back in the range of +19..34 °C, and similar with respect to the threshold conductivity of 24 µS.

***Note:** This window is absent if no chiller is present or if the chiller has no monitoring capability. For chillers with a single cooling loop the window appearance may change.*

After installation the chiller's settings should not be altered

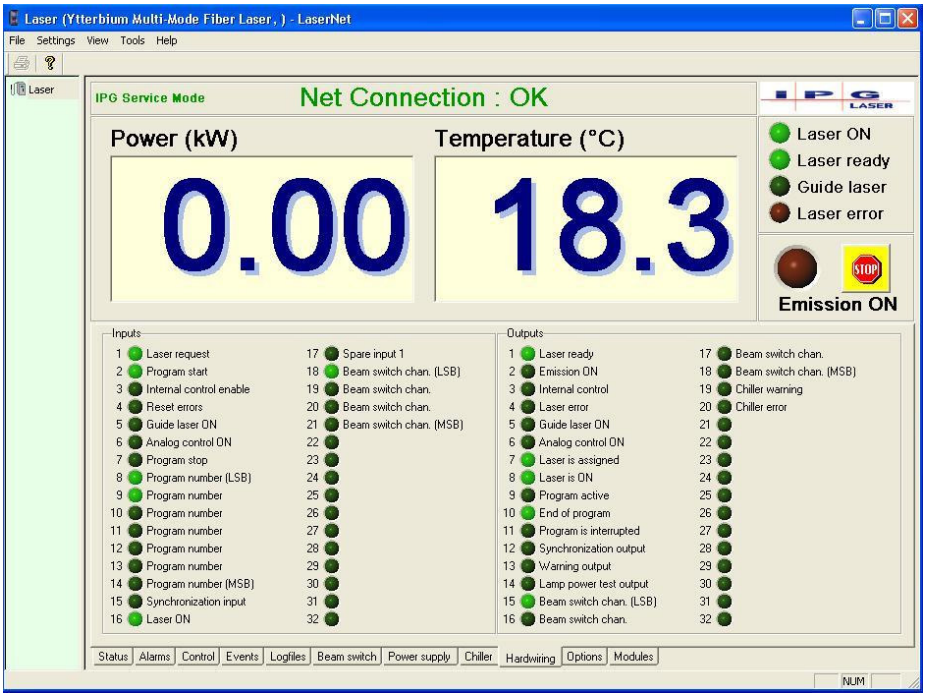
Temperature of the laser water cooling loop: 20 - 22 °C.

Temperature of water in the external optics loop: 25 - 35°C.

Settings of the internal heating (18 °C) shall not be changed in any circumstances.

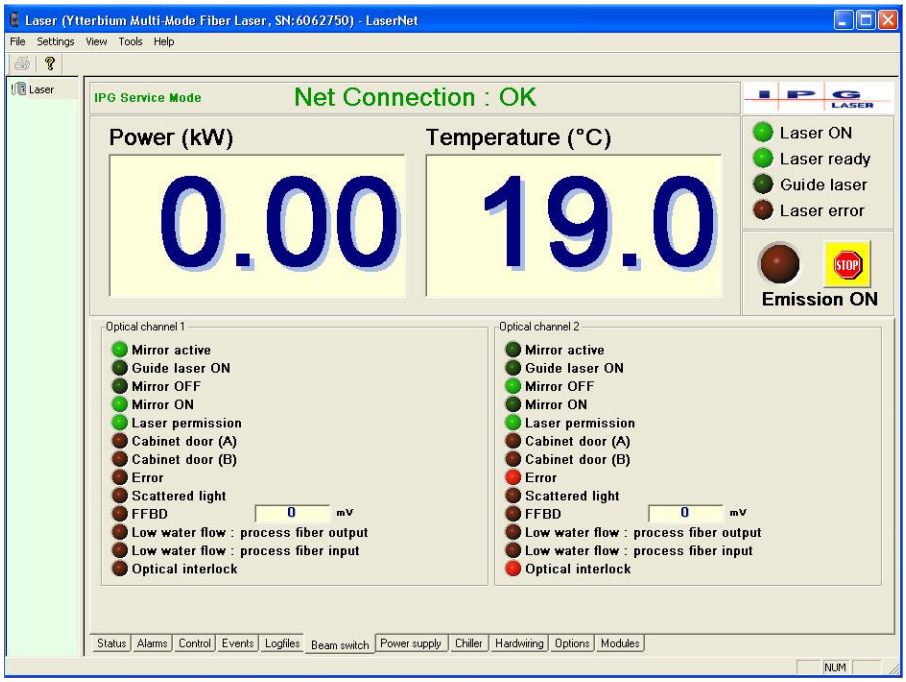
Properties window Hardwiring

This window shows information about the hardwiring interface. Statuses of all inputs and outputs of the interface are displayed. The status green LEDs will light if the corresponding status is high. For description of the statuses see the hardwiring interface chapter of this manual.



Properties window Beam Switch*

This window contains information on the beam switch channels. Below, only statuses of two channels display. If more channels are installed, a slide bar allowing selection of the channel's properties pane will appear in the bottom right corner of the window.

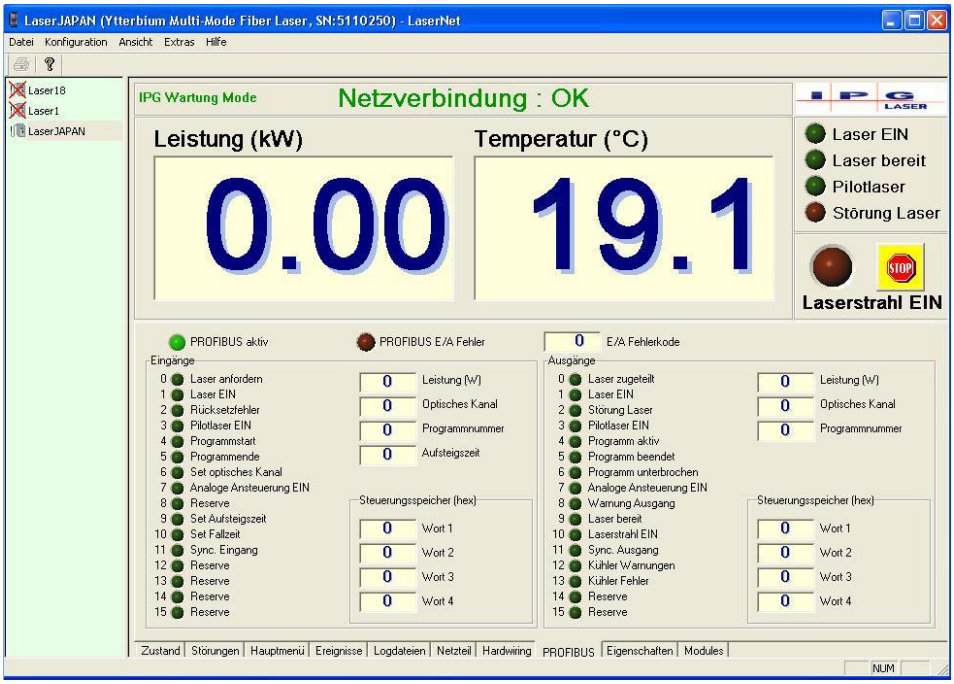


The status and signals of the beam switch channels are displayed with red and green LEDs.

Signal	Description
Mirror active	Signal from laser to set mirror in "work" position
Guide laser ON	Pilot laser of this channel is switched ON
Mirror OFF	Mirror in "home" position
Mirror ON	Signal to the laser that the mirror is in "work" position
Laser permission	Signal to the laser that the channel is ready operation
Cabinet door (A)	Laser cell door A open
Cabinet door (B)	Laser cell door B open
Scatter light	High scattered light inside the switch
Error	Signal is active if scattered light status is active or if laser permission is missing or if mirror active is received but mirror is not in "work" position
FFBD	Fast fiber breakage detection. This alert becomes activated, if extremely high scattered light at the quartz block of the process fiber is detected. This signal switches the laser emission off, sets the signal "Laser ready" low and sets the signal "Laser error" high.
Low water flow : output fiber connector	Water flow through the fiber connector of the beam switch is low
Low water flow : process fiber connector	Water flow through the fiber connector of the optical head is low

Properties window Profibus

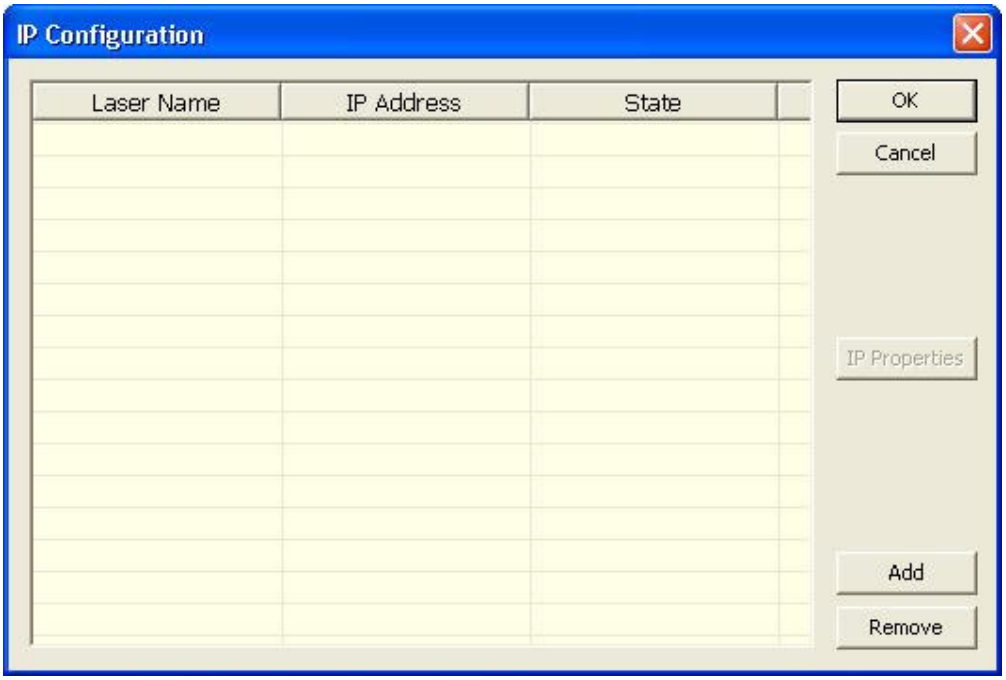
This window provides Information received via Profibus interface.



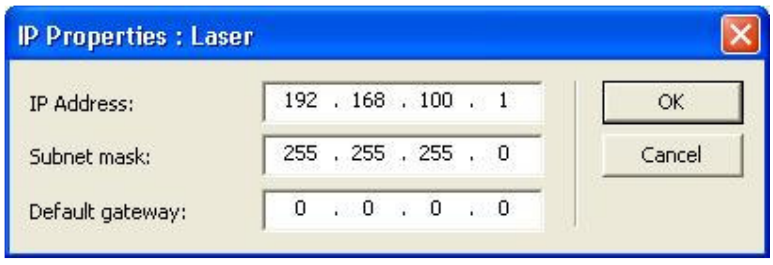
For detailed information about the Profibus protocol see chapter "Control-, Service- and Safety interfaces".

Dialog window fort he laser registration in LaserNet

This window allows connecting the laser to the LaserNet program. It opens through the menu “Settings\IP Configuration...”:

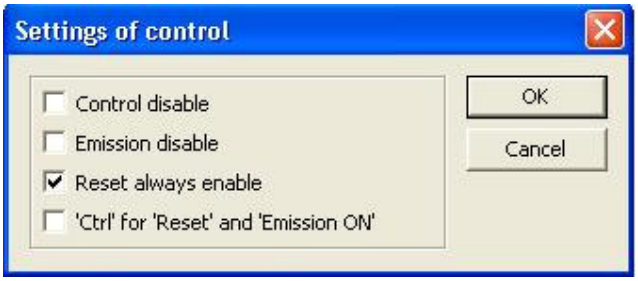


A new laser can be connected by pressing button “Add”. An entry “Laser/192.168.100.1/Disable” will appear in the list. Here, if required the laser name can be assigned (the laser will be listed under this name). Each laser needs a unique name and IP address. The IP-address and the current status (enabled / disabled) can be changed. Change of the IP-address entry will not change the real IP-address of the laser. This entry is used by the LaserNet program for communication with the laser.
Activating status “Disable” will block the exchange of data with the program while “Enable” will allow the connection. An existing entry can be removed by using the button “Remove”.
If connection to the laser has been established, the button “IP Properties” will be enabled (alternatively disabled). Pressing this button will open a dialog window for changing the IP-properties. Standard parameters: IP-Address: 192.168.100.1, Subnet mask: 255.255.255.0, Default gateway 0.0.0.0.

Pressing “OK” button in the dialog window will update the properties. If the IP Properties do not match the connection IP properties of the computer, communication between the laser and PC will be disconnected. Close the LaserNet program, change the PC IP properties, and then restart the program.	

Dialog window for setting and control parameters

This dialog window allows changing a number of parameters displayed in the "Control" sub menu. The dialog can be accessed through menu "Settings \ Control…"



Following settings can be altered:

Control disable	If this box is checked all control options of the laser are blocked.
Emission disable	If checked emission can not be turned ON or OFF with the program.
Reset always enable	If checked the "Reset" button is always enabled regardless of setting of "Control disable" or of the laser mode "Test" / "Robot".
"Ctrl" for "Reset" and "Emission ON"	If checked Emission On and Reset can only be activated when "CTRL" is pressed.

Change Password

It is possible to set a password for LaserNet under "Settings \ Change Password"

Only with the correct password it is possible to control the Laser.

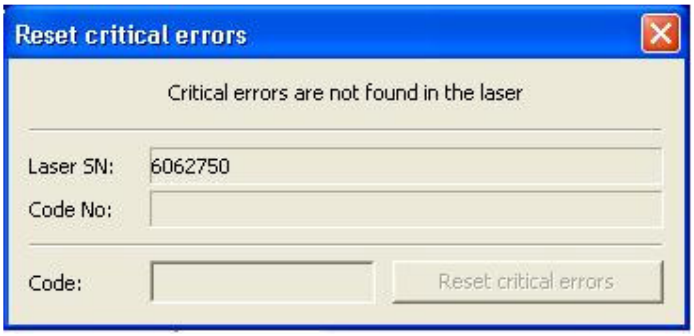
In the case of the loss of the password it is possible to delete it. For this procedure it is necessary to open the "Registry Editor". Under the following path the data "user" is saved.

HKEY_Current_User
Software
IPG Laser GMBH
LaserNet
Settings

Delete data “User” and restart LaserNet. Then it is possible to set with LaserNet a new password or run LaserNet without password.

Reset critical errors

If a critical error appears it is not possible to reset the laser with the normal reset button. To reset a critical error it is necessary to call IPG. IPG will check if it is possible to clear the failure with a special code. When the possibility is given IPG will create this code. Open Settings, Laser > Reset critical.
A window appears. Type the “code no” and the “code” and press the button “Reset critical errors”. After this procedure it is possible to use the laser again.



If no critical error is present it is not possible to type a code or press the button "Reset critical errors".

Window for editing LaserPrograms

This window allows opening a LaserProgram (LP) and enables its editing. The window can be accessed via “Tools\Program editor...”.
Loading and editing of the LP is done by filling in the corresponding table in the dialog window. For each line, a new command in the column “CMD” has to be selected and its parameters edited in the column “Param 1” and “Param 2”. The command or parameters can be selected by clicking mouse in the corresponding field and by choosing or typing in the desired values.
A new line can be added either by left mouse click over the first following empty line (default command “STOP” appears automatically in the new line, but can be changed to any other available command) or by inserting a new line in front of the existing line by right click with the mouse over the existing line and choosing option “Insert line” (the new line with the default command “Stop” will appear above this line).
To erase the existing command line, right click on the line and select “Delete line”. If the program consists of a single line, the line can not be deleted.
To save the LP into the laser, press “Write” button. A dialog for assigning the program number will appear and a number between 1 and 50 can be assigned to the program. If connection with the laser is not established, a warning will appear.
To load a saved program press “Read”, select the program number to load (between 1 and 50). After loading the current program number will be displayed in the title of the table dialog window. If connection with the laser is not established, a warning will appear.
The LP can be saved as a file on the computer by selecting “File\Save...” and inputting the path and file names. The program file will be stored as a text file with extension “.inp” and can be viewed or altered by a standard text editor. Loading a program file stored on the computer can be done by selecting “File\Load...” and choosing the desired file.

IPG Laser program

Structure of the laser program (LP)

Each LaserProgram consists of a three-column table. The codes of commands are specified in the first column, parameters of the commands in the second and third columns. Total number of lines in each LP is limited by 100 (defined by internal FLASH memory). The maximum number of LPs is limited by 50.
The action of the Laser in response to the command “Start LP number 0” is described in the Specification/Hardwiring Interface section.

Description of commands available for the LaserProgram:

1. *Stop*
   Switches the emission OFF, switches analogue control OFF, stops execution of the LaserProgram and sets the status “End of the program” to high.

2. *Set output power in a certain time*
   (Linear interpolation between two points) - sets output power (in Watts) as specified by the second parameter of this command, in time duration (in ms) as specified by the first parameter. The initial value of the power is taken from the previous command if applicable, or set to 0 if previously unspecified. If the initial power setting equals the new value, the command will only perform a specified time delay. This command switches analogue control OFF if it was switched ON before.

3. *Set output power with ramping time*
   Acts similar to the previous command except for the first parameter where a ramping ratio (in W/ms) should be specified instead.

Note: *Commands 2 and 3 are the only commands allowing setting the power.*

4. *Wait for event*
   Allows waiting for one of the following events:
   - Transition high/low at Synchronization Input,
   - Transition low/high at Synchronization Input,
   - Low level at Synchronization Input,
   - High level at Synchronization Input,
   - Timer (ms).

Active synchronization input or timer selection is done by specifying the first parameter, a type of the event is specified by the second parameter.

5. *Go to another command line*
   This command performs “GOTO” the command line whose number specified by the first parameter, and if the number specified by the second parameter (counter) is not zero. After having gone to the specified line, the counter value (second parameter) decreases by one. If the initial state of the counter is zero, the GOTO command performs unconditionally. In addition to the GOTO with the counter, GOTO IF can be used.
   - Low level at Synchronization Input,
   - High level at Synchronization Input.

GOTO specified line will be performed, if one of the specified conditions is detected.

6. *Set signal on "Synchronization Output"*
   Sets low or a high level at Synchronization Output. Number of "Synchronization Outputs" (one in this version) is specified by the first parameter, the level (high or low) by the second parameter.

7. *Switch-over to external mode*
   After performing this command the value of the output power is red from the external interface. The external interface is specified by the first parameter of the command. Execution of this command can be stopped by commands 1, 2, 3 (and 7, but with the different external interface specified).
   Note: The current version of LaserProgram supports only one type of external interface, the External analogue control.

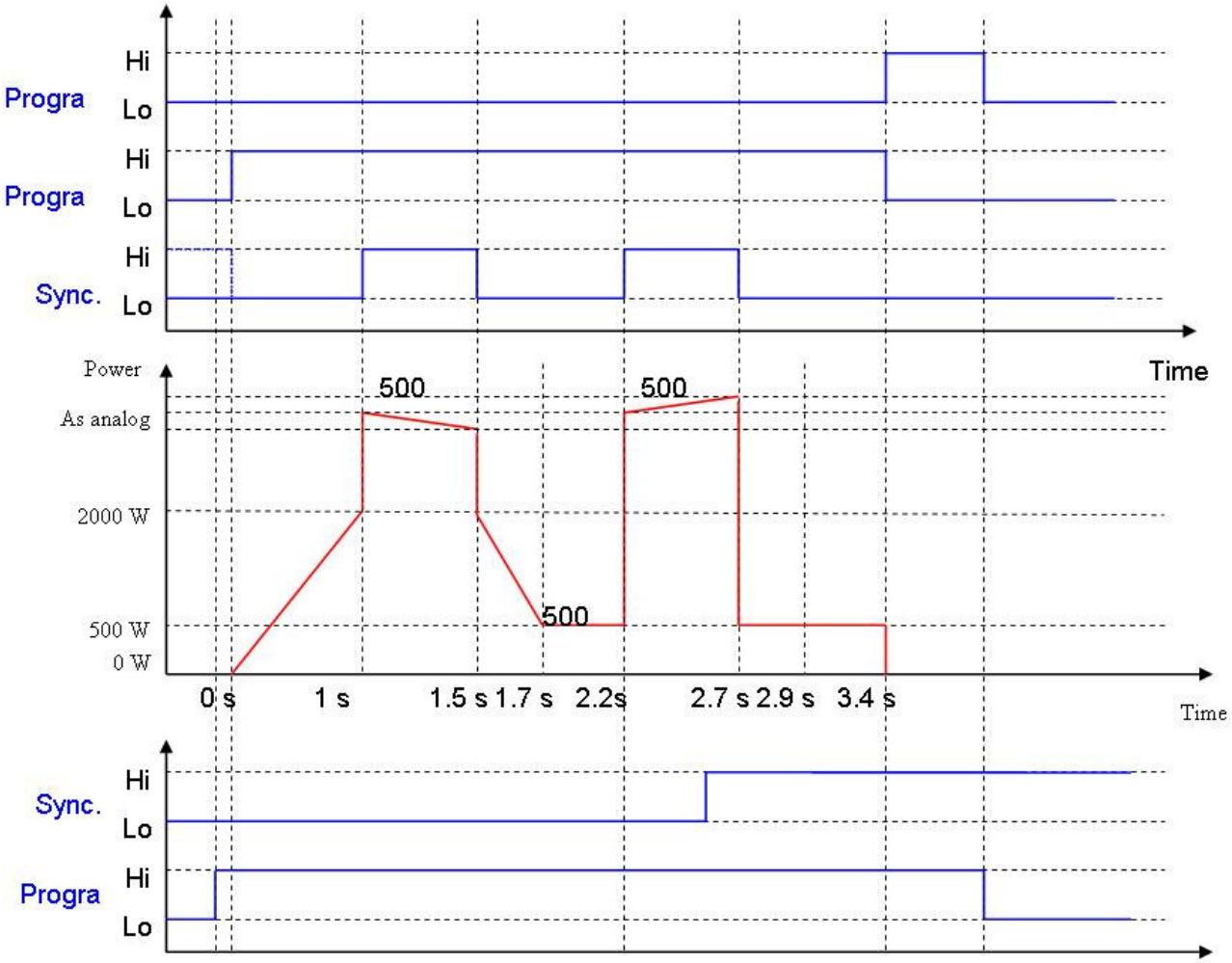
Note: *The current version of LaserProgram supports only one type of external interface, the External analogue control.*

Table of commands used by the LaserProgram (LP)

Command		Parameter 1	Parameter 2	Remarks
#	Name			
1	STOP	-	-	No parameters
2	SPT	0 - 65535	0 – max power	Parameter 1 – time in ms Parameter 2 – power in W
3	SPR	0 - 65535	0 – max power	Parameter 1 – ramping ratio in W/ms Parameter 2 – power in W
4	WAIT	SI	LOW	Wait for low level on Sync. In.
		SI	HIGH	Wait for high level on Sync. In.
		SI	LH	Wait for transition from low to high level on Sync. In
		SI	HL	Wait for transition from high to low level on Sync. In
		Time	0 - 65535	Delay in ms
5	GOTO	Line 0 – 99	SI LOW	Go to the specified line of LP if low level is detected on Sync. In
		Line 0 – 99	SI HIGH	Go to the specified line of LP if high level is detected on Sync. In
		Line 0 – 99	0 - 32767	Go to specified line by counter
6	OUT	SO	LOW	Set Sync. In to low level
		SO	HIGH	Set Sync. In to high level
7	EXTPWR	ANALOG	-	Switch over to analog interface

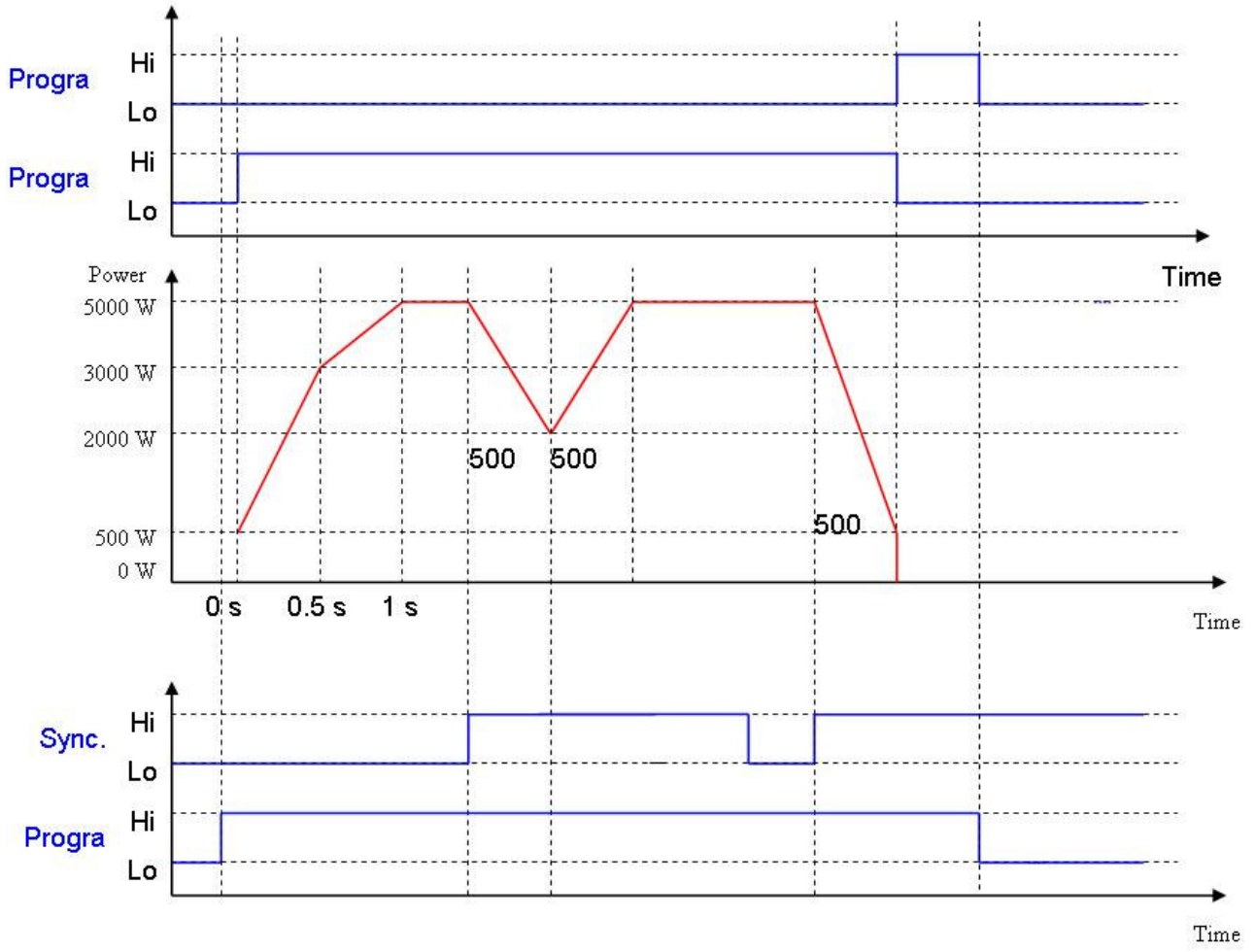
Example 1. LP producing a sequence of pulses.

Line	Command	Parameter 1	Parameter 2	Remarks
1	OUT	SO	LOW	Sets the Synchronization Output to low level.
2	SPT	1000	2000	Reaches output power of 2 kW in 1 sec.
3	EXTPWR	ANALOG	-	Switches-over to analogue interface
4	OUT	SO	HI	Sets the Synchronization Output to high level.
5	WAIT	TIME	500	Wait 500 ms.
6	OUT	SO	LOW	Sets the Synchronization Output to low level.
7	SPT	200	500	Reaches output power of 500 W in 200 ms.
8	WAIT	TIME	500	Wait 500 ms.
9	GOTO	LINE3	SI LOW	Go to line 3 if Sync. In. has low level
10	STOP	-	-	End of the program



Example 2 of the LP

Line	Command	Parameter 1	Parameter 2	Remarks
1	SPT	500	3000	Reaches output power of 3 kW in 0.5 sec.
2	SPT	500	5000	Reaches output power of 5 kW in 0.5 sec.
3	WAIT	SI	LH	Wait for transition from low to high level on *Synchronization Input*
4	SPT	500	2000	Reaches output power of 2 kW in 0.5 sec.
5	WAIT	SI	HI	Wait for high level on *Synchronization Input*.
6	SPT	500	5000	Reaches output power of 5 kW in 0.5 sec.
7	WAIT	SI	LH	Wait for transition from low to high level on *Synchronization Input*
8	SPT	500	500	Reaches output power of 0.5 kW in 0.5 sec.
9	STOP	-	-	End of the program



11. Operation

The Laser can be operated in Manual mode, External modulation mode, Analog control mode, LaserProgram mode and Hardwiring driving mode.

It is very important that the laser is operated in the range of 10-100%. Operating the laser in a power range of less than 10 % is out of the specifications and is not allowed by IPG. If a power less than 10 % from the total power is needed the one module mode should be activated. But also with one module the minimum power is 10%.

Note: *After switching the laser controller ON, the laser switch to test or robot mode can take up to two minutes due to the time required for booting the internal computer.*

Operation in Manual mode

In this mode only external computer is needed to drive the laser. The computer has to be connected to the laser via an Ethernet interface.

1. Connect the Laser to an external computer. Put the laser's switch to "test". Start LaserNet program. Laser parameters and statuses will be displayed in the multi window screen.
2. Press Laser ON button, the main power supply of the laser will switch on. Laser ON and Laser ready statuses will activate in the LaserNet window.
3. Switch the guide laser ON by pressing the "guide laser" button. Verify the beam aiming position or proper termination by using the visible guide laser. The Guide laser status will be active in the LaserNet.
4. Set the required power or pump diodes current by using the slide control in the LaserNet. Settings of the output power (in Watts) or pump diodes current (in percent) will show in the LaserNet window.
5. Press Emission button. Laser will start emitting power; and emitted power will be displayed.
6. Once Emission is ON, the output power level can be varied from 0 to 100%.
7. Switch the laser emission OFF by pressing Emission ON button.
8. Different rise and fall times can be set for switching emission ON and OFF. This option is available only in the Manual mode.

Operation in External Modulation mode

For operation in this mode, an external voltage signal of +4... 25V DC is required (High level – emission ON, low level – emission OFF).

1. Connect the Laser to the computer via the Ethernet (LaserNet program). Connect the external power supply to the laser (positive to pin A1, XP2 (safety interface), negative to pin A2, XP2).
2. Start LaserNet program. Open the "Control" window.
3. Press "External control" button (ON) to enable the External modulation mode.
4. Set the required laser power (in percent or in Watts).
5. Press "Emission" button (ON). Warning lights on the laser will start blinking, but no emission will appear at this stage, before supplying the external modulation signal.
6. Switch external signal to high – emission will turn ON.
7. It is possible to change the output power level once emission is ON.
8. Switch emission OFF by removing (setting to low) the external signal.

The external modulation input can also be used for external modulation of the output of the laser. Connect a wave front electrical generator producing square positive voltage signal (0 to +4...25V amplitude) to the modulation input. The laser output power can be modulated with up to 5,000 Hz maximum frequency

Operation in Analog Control mode

For operation in this mode, an external modulation and analog signals are required. The analog signal should be used for setting a desired output power level; 0V DC correspond to the 0W output power, 10V DC correspond to the maximum output power.

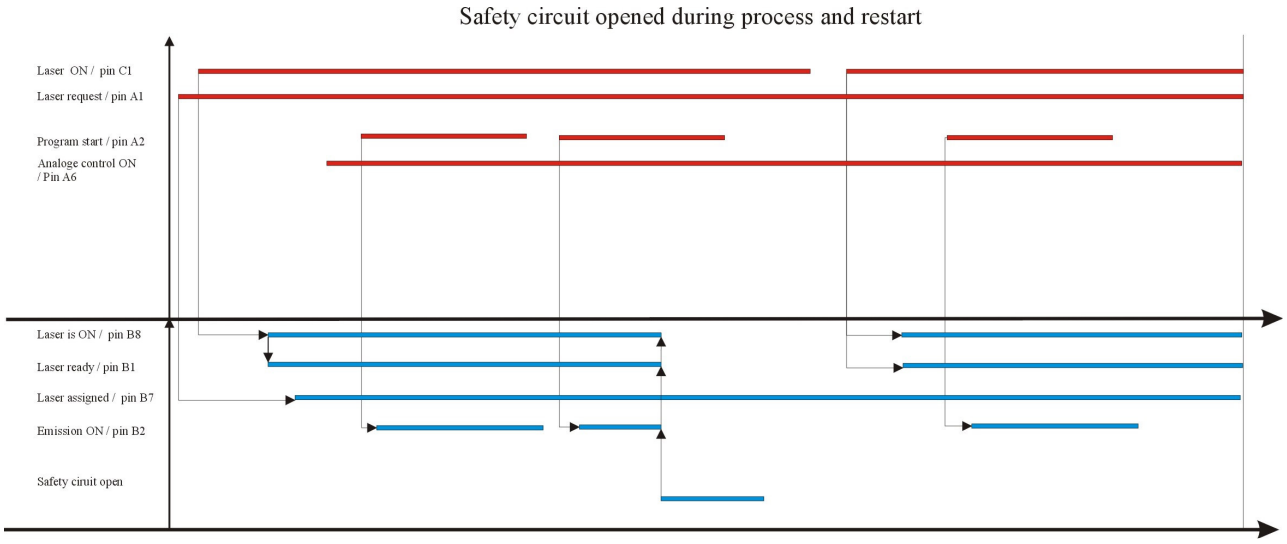
1. Connect the Laser to the computer via Ethernet link (LaserNet program). Connect an external power supply to the laser (positive - to pin A1 on XP2 (safety interface), negative - to pin A2 on XP2). Connect a power supply 0…10 V DC to the laser analog input.
2. Start LaserNet program. Open “Control” window.
3. Press Analog control button (ON) to enable the “Analog control” mode. “External modulation” mode will activate automatically.
4. Press Emission button (ON). Warning lamps will start blinking but no emission will appear without supplying the analog control and external modulation signals.
5. Set the desired power level by applying a voltage within 0…10 V DC to the analog input.
6. Switch the external modulation signal ON – emission will turn ON.
7. It is possible to change output power level during emission ON by changing the analog signal voltage.

Operation via Hardwiring interface

This is the main operation mode of the laser. The laser has to be connected to the robot’s controller according to XP1- Hardwiring interface (see description for additional information).

Once “Laser request signal” (pinA1) is supplied, the computer with running LaserNet program can be used for monitoring only.

For laser with beam switch we highly recommend:
In case of interruption of a laser or robot program, set all signals except "Laser request" to Low and remove the failure before restarting the program.
After a laser or robot program has finished move the beam switch mirrors back to home position before you open the laser cell doors.

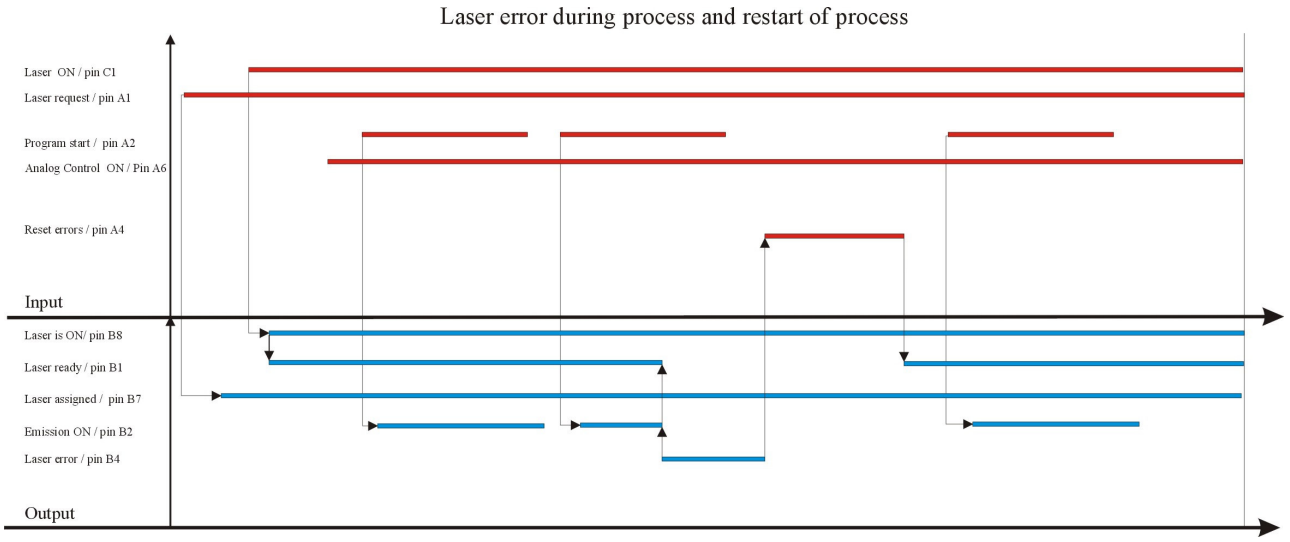


Possible Reasons

General	Beam Switch
External E-Stop circuit is open (XP2-Safety interface channel 1 (Pins C1 – C4), channel 2 (Pins C2 – C3) → Interlock circuit is open	The interlock of the cabinet doors of the active channel became opened during operation
Internal E-Stop circuit is open	E-Stop button at beam switch became opened
Laser doors open → Interlock circuit open	Doors at beam switch became opened → Interlock circuit open

Fiber – Fiber Coupler	Other reasons *
E-Stop at Beam Switch became opened	"Unexpected pump current"
Doors at Fiber – Fiber Coupler became opened → Interlock circuit open	"Unexpected ground leakage"
	"Laser fiber interlock" → Interlock circuit open
	"Water in laser" → Interlock circuit open

* lead to switching off the power supply and set the output signal "Laser error" High.

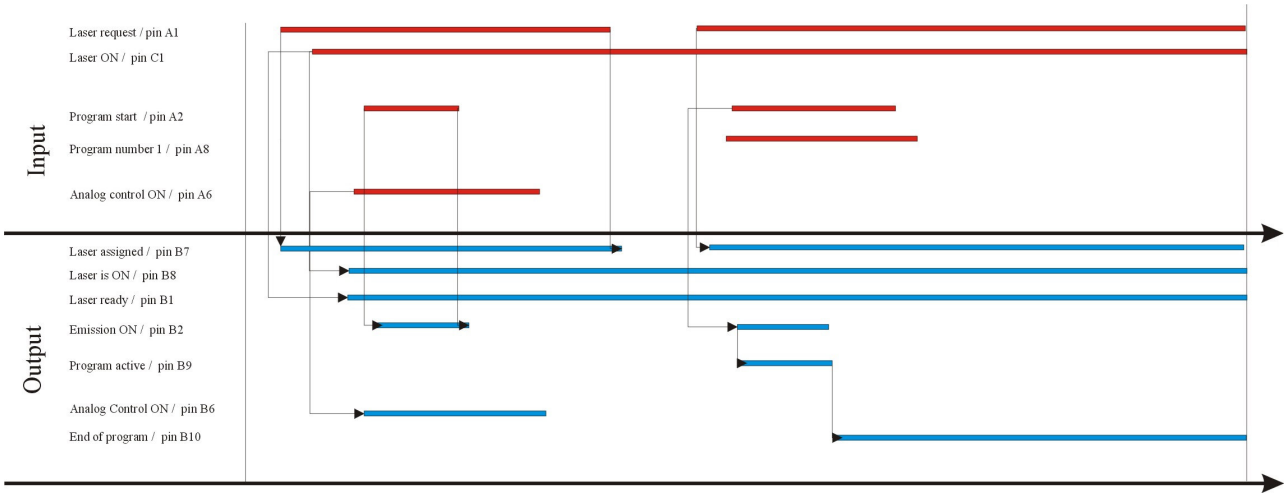


Possible reasons for "Laser error during operation

Laser *	Chiller
"High back reflection"	"Chiller error"
"Low water flow: laser"	Temperature for external optic and laser or conductivity is beyond specified range
"Low water flow: fiber connector"	
"Power supply failure"	
"Laser overheat"	
"Laser module disconnected"	

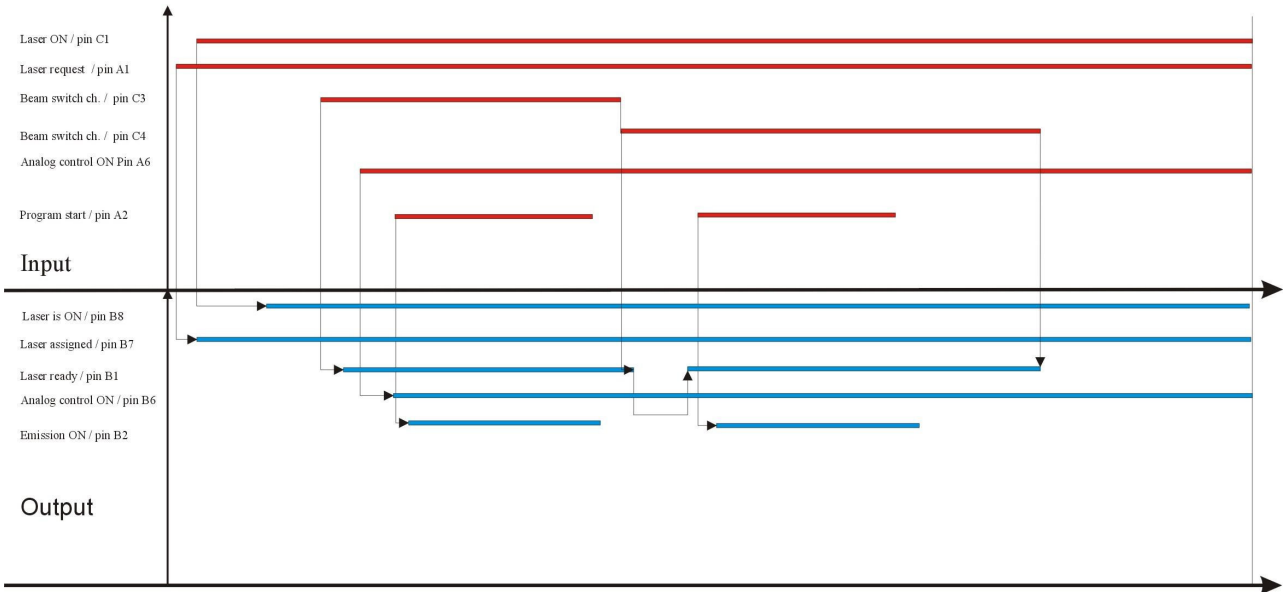
Beam Switch	Fiber – Fiber Coupler
"Error	"Scattered light"
"Scattered Light"	"Low water flow: process fiber output"
"FFBD"	"Low water flow: process fiber input"
"Low water flow: process fiber output"	Fiber – Fiber Coupler signal dropout: "Coupler: request" "Coupler: enable"
"Low water flow: process fiber input"	
"Optical interlock"	
Beam Switch signal dropout: "Beam Switch: laser permission", "Beam Switch: laser enable"	

* If the output "Laser error" will be set High depends on laser configuration



Within both loops shown above the laser becomes requested two times. In loop one Analog control is used. In loop two, program number 1 is used.
After first loop has been finished, input signal "Laser ON" does not disappear before "Laser request" has disappeared. The power supply remains switched on,
While applying the next input signal "Laser request" the output signals "Laser ON" and "Laser ready" are directly set together with the signal "Laser assigned.

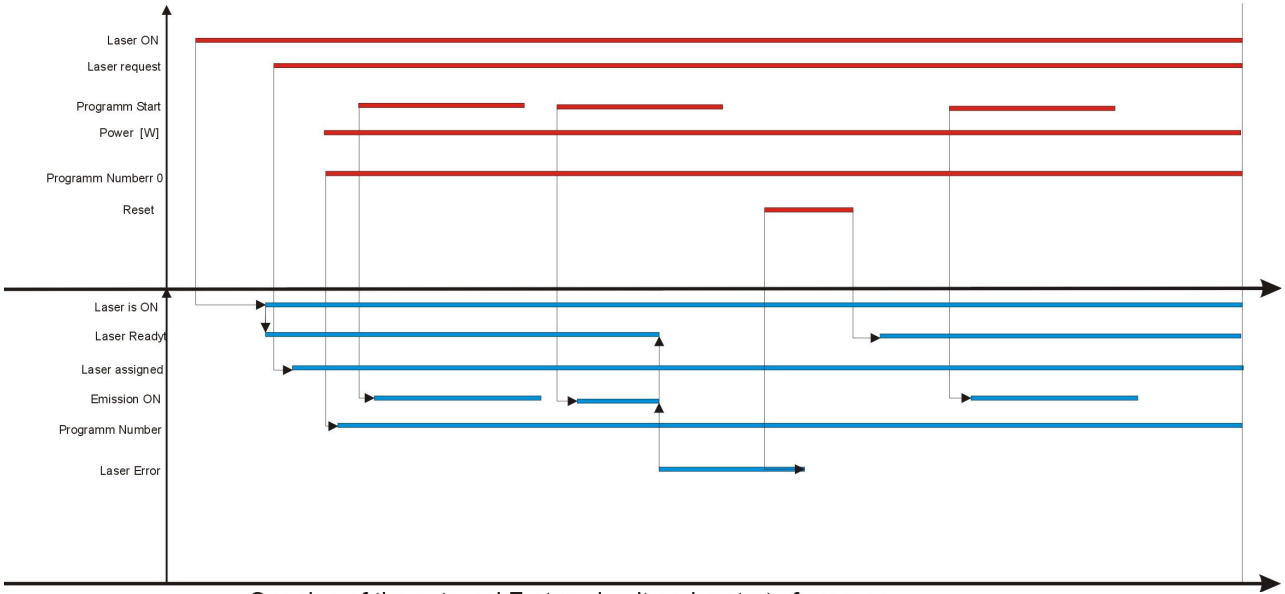
Start of process using analog control power control and switching process between two channel of a beamswitch



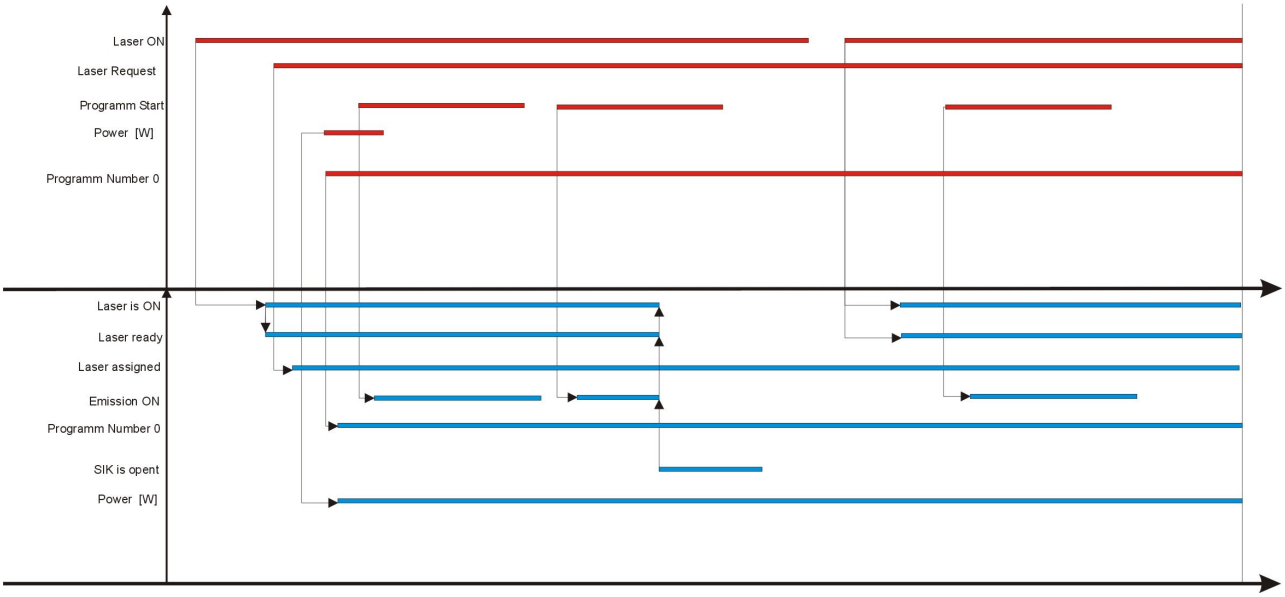
During the switching the output signal "Laser ready" will be cleared and set High again when the requested mirror is in work position.

Operation via Profibus

Laser error during process and restart of process



Opening of the external E-stop circuit and restart of process



12. Interlock and E-Stop system of the laser

Interlock and E-Stop system of the laser consist of two safety relays (MSR127TP, MSR127RP) and power contactors K1, K2 as represented in the figure below:

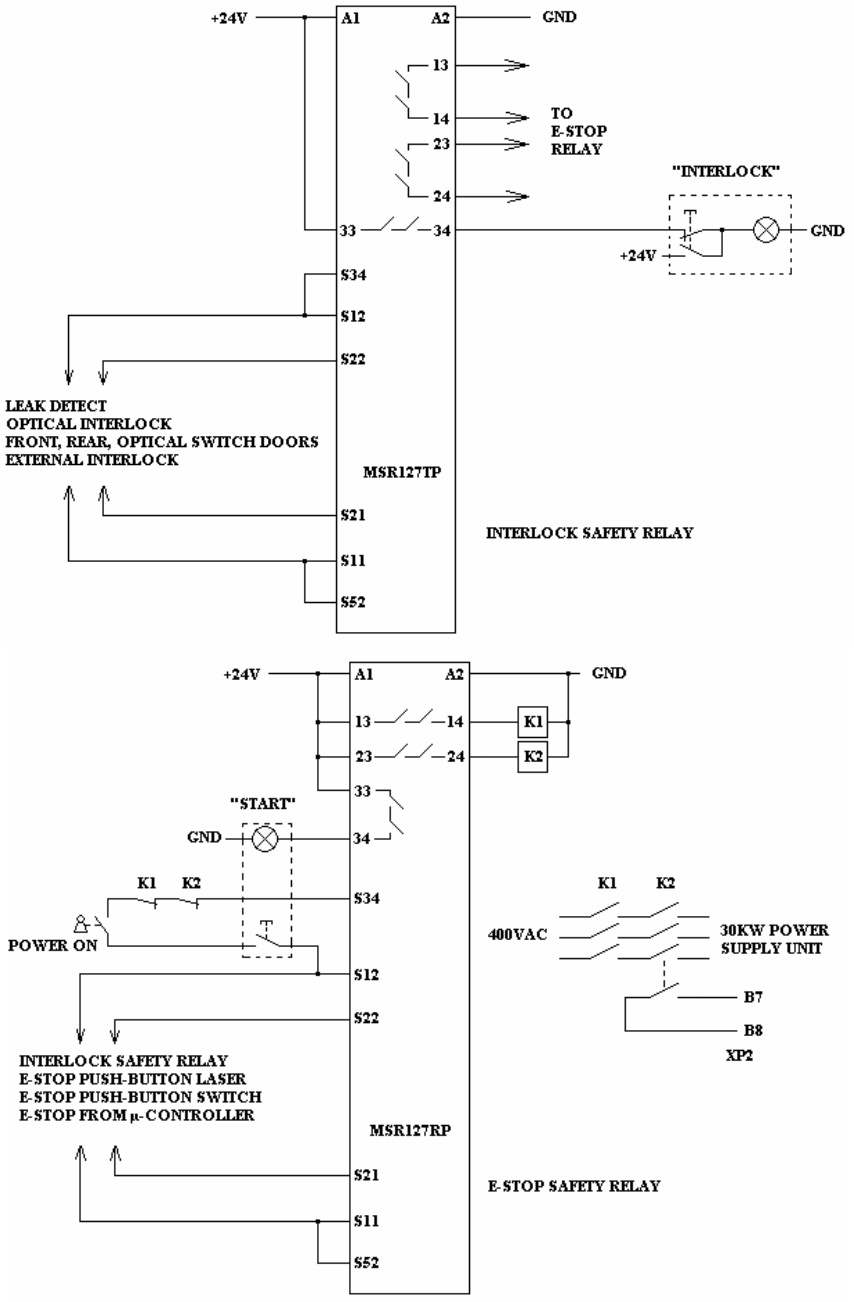


Figure 1: Functional schematic of the interlock and E-Stop Safety system

Interlock safety relay is configured to operate with automatic reset: when all interlock circuits are closed, this relay is automatically turns ON and yellow LED will lit on the “Interlock” button on the Laser. By pressing the “Interlock” button at any time the operator can check that LED and 24VDC are OK.

The Interlock circuits connected to the input of the Interlock Safety Relay are as follow:

- Optical interlock (Feeding fiber from the laser to the optical switch unit)
- Leak detect* (Sensors on the floor inside the laser cabinet).
- Front and rear doors of the laser cabinet and doors of optical switch cabinet
- External interlock (E-Stop input: pins C2-C3 and C1-C4 of XP2 Safety Interface Connector – see Figure 3).

***Note:** Water leakage sensors require warming up delay of approximately 30 sec after powering up.*

Statuses of the optical interlock, leak detect, front and rear doors of the laser are additionally monitored and displayed by the LaserNet. External interlock and optical switch doors are not monitored by the LaserNet software.

Outputs (safety contacts) of the interlock safety relay are connected to the input of the second E-Stop safety relay. The E-Stop safety relay is configured to operate with monitored manual reset: when all input circuits of the relay are closed, reset is required to turn this relay ON. Illuminated “Start” push button on the Laser performs reset function of the E-Stop safety relay. When relay is ON, green LED will light on the “Start” push-button. Additionally following circuits are connected in series to the input of E-Stop safety relay:

- E-Stop push button on the laser
- E-Stop push button on the optical switch unit
- E-Stop from internal logic (additional relay driven by the micro controller)

In addition to the “Start” push-button, E-Stop Safety relay can also be reset by the software command (“Laser ON” software button in the LaserNet window) and by the external potential-free contacts connected between pins C5 and C6 of XP2 Safety interface connector (see figure 4). E-Stop safety relay turns ON power contactors K1 and K2, thus connecting main power supply of the laser to 400VAC line. The status signal of contactors can be monitored between pins B7 and B8 of XP2 Safety interface connector (see figure 1). These pins can be used to control, for example, an external safety warning lamp.

E-Stop output

In order to facilitate connection of all E-Stop buttons of the system (including robot controller) in one loop, additional contact blocks on the internal E-Stop push-buttons are connected to pins B4-B5; B3-B6 of XP2 Safety interface connector to provide E-Stop output for the customer’s use.

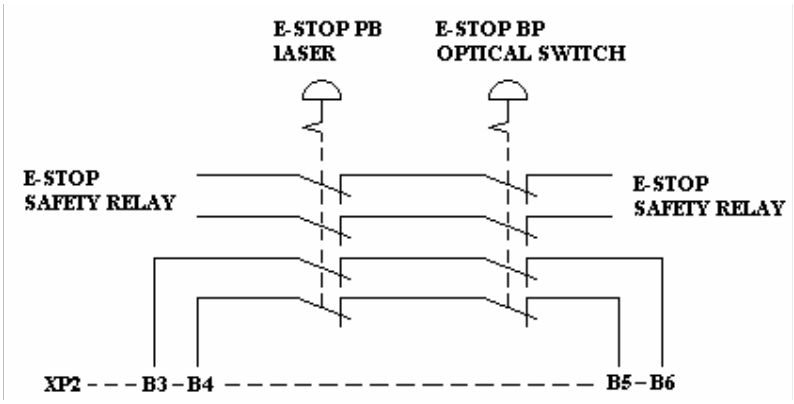


Figure 2: Functional schematic of E-Stop output

E-Stop input

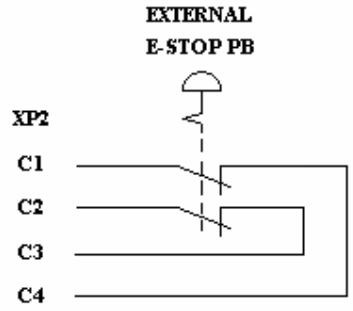


Figure 3: External safety contacts or external E-Stop Push-Button can be connected to E-Stop input of the laser as shown. If not used, jumpers/links should be installed between appropriate pins of XP2 safety connector.

External start

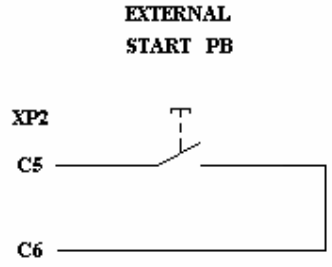


Figure 4: External contacts or external Push-Button can be connected as shown. Function of this input is the same as the function of “Start” Push-Button on the laser.

13. Connection between robot controller and laser

All optocoupled inputs of XP1 interface connector (Hardwiring) have common pin (A16). Optocouplers have two infrared LEDs connected in inverse parallel, so that the common pin (A16) can be either positive or negative (figure 1).

Input current at nominal input voltage (24VDC)	5 mA
Maximum input voltage range	±35VDC
Recommended input voltage range	±30VDC
Low level input voltage	-3.5…+3.5VDC
High level input voltage	-30…-15VDC 15…+30VDC

All optocoupled outputs have common supply voltage which has to be provided externally by the customer. Each output returns the supplied voltage to the customer if set to “high” and have high impedance if set to “low”. These are current outputs and an external load between output terminals and negative supply terminal (B16) are required for proper operation. Common pin for the inputs (A16) and common pin for the outputs (B16) are not linked internally and can have different potential on the customer side if required (Figure1).

Minimum output current (recommended)	3mA
Maximum output current	0.625A
Supply voltage range	11…45VDC

Smart Power High-Side-Switch in each output channel can also be used for driving an inductive load, and has all necessary protection features required by industrial applications.

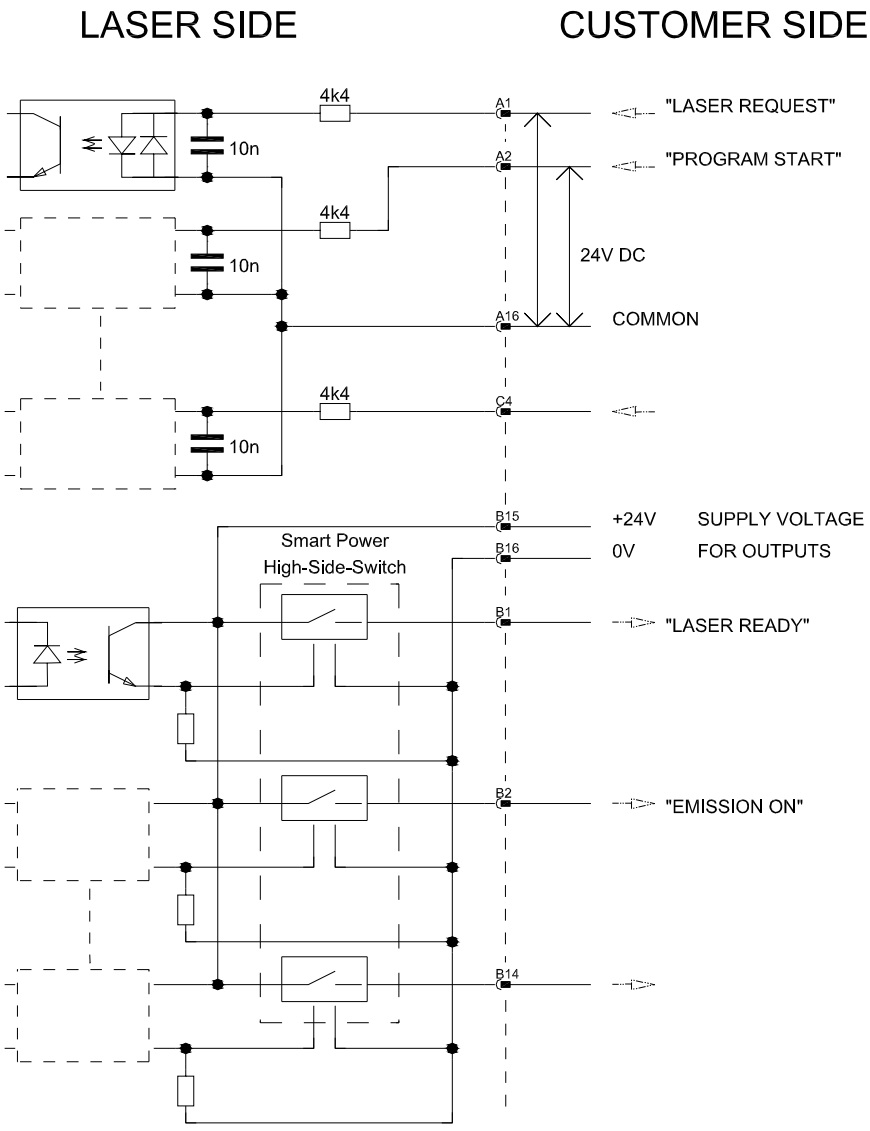


Figure 1: Functional schematic around XP1 interface connector

14. Cleaning of fiber connector

It is highly essential that a fiber connector is checked for dust and dirt every time before it is connected with an optical head or beam coupler.

CAUTION Serious hazard of damage to laser.

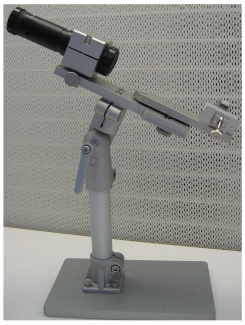
Through dust and insufficient cleaning the fiber connectors can become contaminated.

- Clean the fiber connectors only according to the instructions in this manual.

For cleaning a fiber connector you need the following materials:

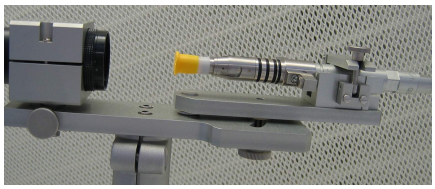
1. Kodak lens cleaning paper
2. Optical cleaning sticks
3. Isopropanol (water free)
4. Acetone (water free)
5. Compressed air (oil free, water free)
6. Microscope (IPG Model)
7. Light source

Lens cleaning paper and sticks


IPG Microscope

The following procedure has to be followed for cleaning fiber connectors

1. Open beam switch cabinet and start the fan
2. Wait approximately 15 min so that the air inside of the cabinet is free of dust
3. Put microscope inside the cabinet and switch on both lamps
4. Spray some Isopropanol at the fiber connector and blow it away with compressed air.
5. Put the connector in the holder of the microscope


Connector in the microscope

6. Put the connector in the holder of the microscope

CAUTION Internal deposit of dust and dirt in protective cap.

In the cap internal deposit of dust and dirt can contaminate the quartz block.

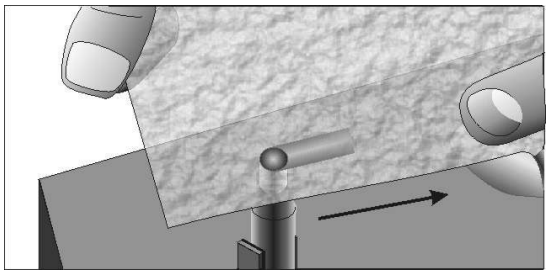
- Always place the cap face-down to prevent deposit of dust and dirt.

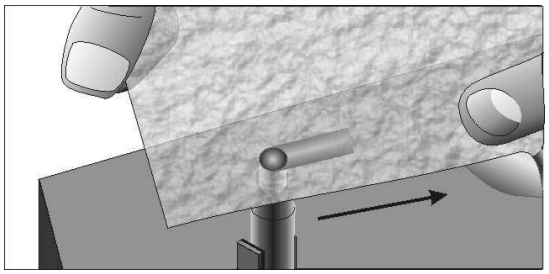
Protective cap

7. Focus the microscope onto connectors surface

IMPORTANT Look at the surface at a slight angle to improve visibility.

8. If the light inside cabinet is not sufficient for checking the connector, use an additional light source. It has to be installed so that the light is reflected from the surface into the microscope.
9. Check the surface carefully. If some contamination is visible on the quartz block, cleaning is necessary
   9.1. Try to blow away the dust with compressed air **from the side**
   9.2. Put a drop of Isopropanol onto a Kodak lens cleaning paper and wipe the wet spot laterally over the surface of the connector until it is dry.
   9.3. Put some Isopropanol on the cleaning bud and gently wipe over the quartz block with circular moves, do not scratch

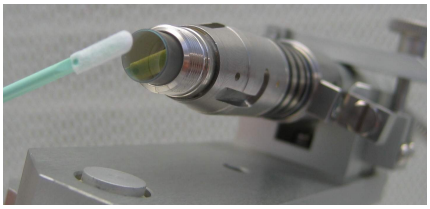




CAUTION Danger of contamination of the quartz block due to dirty cleaning paper.

Touching the quartz block with dirty cleaning paper can contaminate the laser and lead to serious damage to the laser or to the fibers.

- Never let the face of the cleaning paper you touched get into contact with the surface of the quartz block.



Cleaning with cleaning buds

CAUTION Never touch the top of the cleaning bud with fingers and use every bud only one time.

9.4. Repeat the cleaning process (p12 – 9.3) with acetone instead of Isopropanol. The cleaning procedure can always be stopped if a good result has already been achieved.
9.5. It is recommended to clean the surface with Isopropanol again after a cleaning with acetone was done.

CAUTION

Risk of damage at the fiber connectors.

Misuse, inaccurate cleaning, use of not intended chemicals can lead to damage at the fiber connector. These damages are not covered by the warranty

- Activities at the fiber connectors are only to be executed according to the manual. The allowed cleaning materials and procedure of cleaning are explained in the according chapter.

10. Install the cleaned connector in the bayonet fixing or an optical head or the beam switch and close the fixing.
11. If the fiber is not to be connected instantly with a suitable optical component recap it with the protection cap. Do not forget to clean the cap before use.

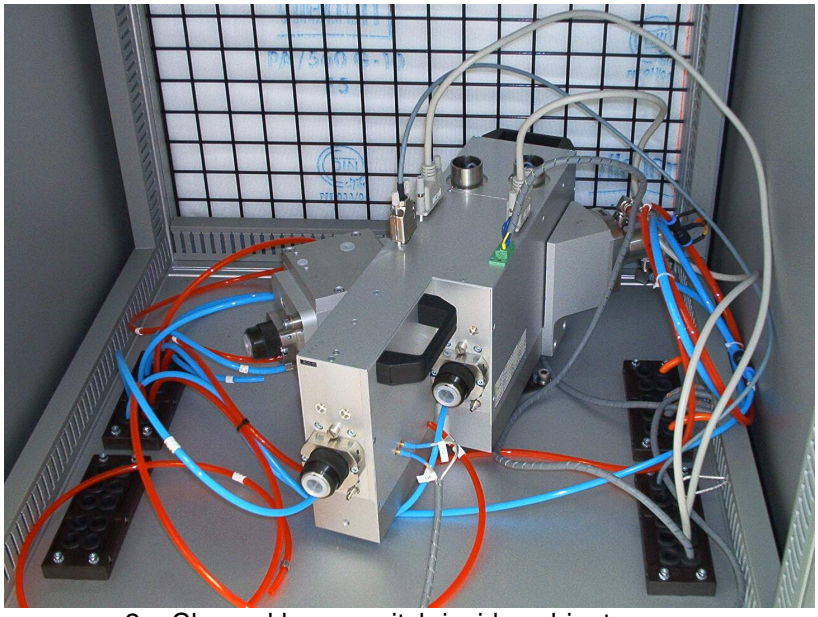
15. Beam switch alignment

CAUTION

Serious danger of damage to beam switch, optical head, fibers and Laser due to inaccurate alignment.

The beam switch is a highly sensitive product.
Inaccurate alignment can result serious damages.

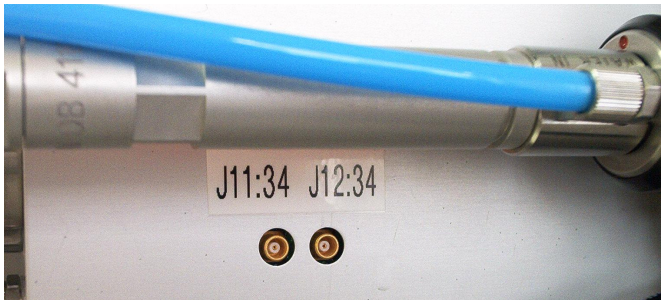
- Every change or alignment of the beam switch is only permitted after an instruction through qualified IPG personnel.



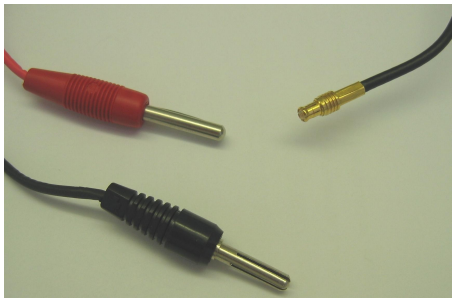
2 – Channel beam switch inside cabinet

Beam switch preparations:

- Insert a fiber with **cleaned quartz surface** into the beam switch and close the bayonet fixing.
- Plug the other end of the fiber into an optical head, close the bayonet.
- Install the cooling water tubes both at the beam switch and the optical head.
- Connect the connection cable to the photodiode in the socket of the channel that should be aligned.



Socket for the channel 1 and 2



photodiode cable

There are two different spots where the cable can be attached.

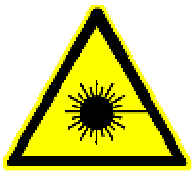
Connection number	Channel number
J11:12	1
J12:12	2

- The other side of the cable is to connect with a multimeter. (Red = positive / black = negative or COM) The diodes will deliver a DC voltage signal in the range of mV.
- Now switch ON the laser with main switch at the laser.

The beam switch is now ready for alignment.

IMPORTANT The beam switch can only be aligned if fiber cables are connected to entrance and exit of the switch:

DANGER



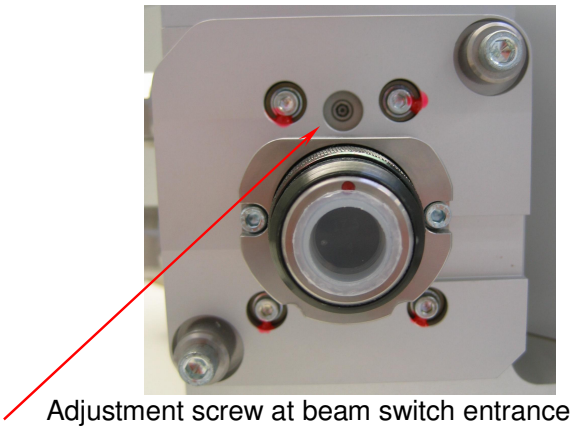
Danger of life through Laser radiation.

The beam way of the laser becomes absorbed in an adequate device, e.g. a beam trap.

- Ensure that the beam way is determined before starting adjustment.

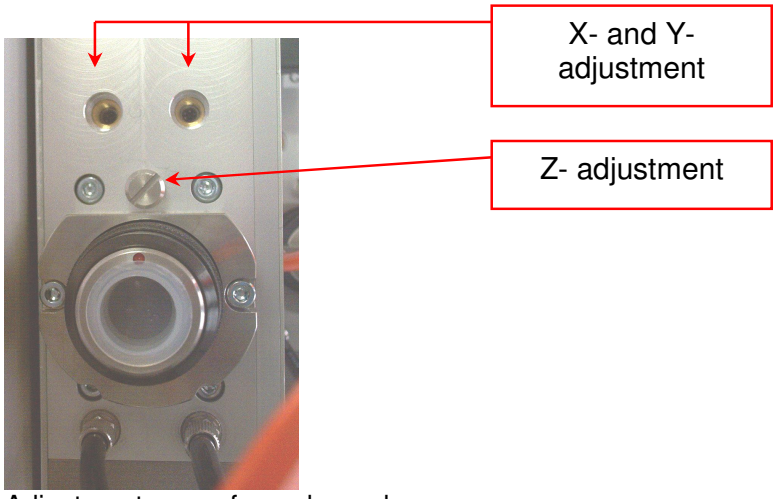
The beam switch lenses can be moved in three different directions. X- and Y- movements are perpendicular to beam propagation and Z-movement is parallel to beam propagation. On the beam switch there are seven different spots where changes can be made.

- You can move the collimating lens at the beam switch entrance (fiber from the laser) in Z-direction.



Adjustment screw at beam switch entrance (collimating lens)

IMPORTANT Any changes of the collimating lens position will affect the beam path of all channels. We highly recommend that the lens position on the collimator will not be changed.



Adjustment screw for a channel

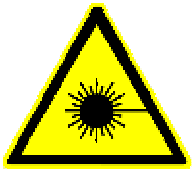
- You have also the possibility to change beam path for each channel by moving the focusing lens of each exit in X- , Y- and Z-direction.

- The shift of the lens along the beam path (Z-) is realized by the adjustment screw above the bayonet fixing of each channel. With a flat screwdriver the lens can be moved. A clockwise turn will move the lens to the bayonet fixing and a counter clockwise turn away from it. The screws for X- and Y-movement can be moved with a hexagonal screwdriver size 3mm.

Alignment of a channel:

1. Make sure that fibers and cables are attached to the beam switch Make sure that fibers and cables are attached to the beam switch and that the beam becomes absorbed in an adequate absorber.
2. Activate the channel that should be aligned in the control program. (LaserNet – Beam Switch). Check if the mirror is in the beam path.
3. Switch ON guide laser for the activated channel and check if the beam is visible after optical head.

DANGER



Danger of life through Laser radiation.

Radiation can lead to burns, blindness and death.

- Never look directly into the beam.
- Laser radiation-safe eye protection has always to be worn when laser is active.

4. If the guide laser is not or only partly visible the focusing lens has to be aligned.
5. For this move the lens in X-, Y- and Z-direction until the guide laser is good visible and the focal point is at the anticipated distance from optical head.

IMPORTANT

For the X- and Y- and Z-screws there are no scales. That's why you always have to remember how many turns in which direction the adjustment screws are twisted. If you do not follow this instruction it is possible to misalign the lenses so strong that the beam is lost. After that it is very difficult to find the beam again. We highly recommend only make small movements.

6. After base adjustment of beam switch with the guide laser the fine alignment with the fiber laser has to follow.
7. Switch guide laser OFF and start the multimeter. There should be a voltage signal in the range of -10 to 0mV DC. (This value may vary due to different diodes). This signal has to be constant until the fiber laser starts emission. Make a note of all measured values do that you can make comparisons in the future.
8. Start with a power of 10% (current). Move the lens in all three directions until a local minimum of the indicated voltage is reached. (This means that the voltage value increases no matter in which direction the adjustment screw is turned)
9. Increase the power by 10% and redo the alignment.
10. Repeat increasing and aligning until a power of 100% is reached.
11. Switch OFF laser.
12. Repeat steps 1 – 11 for all other channels.

The beam switch is now ready for use.

16. Industry Standards Compliance

EMC Test:

Emission:

EN 55011: 1998 + A1: 1999 + A2: 2002 Gr. 1 Class A,

Immunity:

EN 61000-6-2: 2001
EN 61000-4-6: 1996 + A1: 2001
EN 61000-4-4: 1995 + A1: 2001
EN 61000-4-5: 1995 + A1: 2001
EN 61000-4-2: 1995 + A1: 1998 + A2: 2001

Laser Safety:

EN 60825-1

Safety of Machinery – Electrical Equipment of Machines

EN 60204-1: 1997

Emergency Shutdown:

EN 954-1 cat. III: switching of time less than 1 sec

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18. Warranty

General Warranty

All products are warranted by IPG against defects in materials and workmanship for the period of time as set forth on the applicable purchase order or in the specifications starting with the date of shipment. IPG also warrants that this product will meet applicable specifications under normal use.

IPG shall, at its option, repair or replace any product that proves, in the reasonable opinion of IPG, to be defective in materials or workmanship during the warranty period. All products repaired or replaced under warranty are only warranted for the remaining un-expired period of time in the original warranty for the particular defective product. IPG reserves the right to issue a credit note for any defective products that have proved defective through normal usage.

Warranty Limitations

This warranty excludes products, parts (including fiber connectors) or equipment which have been tampered with, opened, disassembled, opened, or modified by persons other than IPG personnel, misused, neglected, or damaged by accident, used in applications which exceeds their specifications or ratings, used outside of environmental specifications for the product, used with buyer software or interfacing, improperly installed, maintained or otherwise abused or used other than in accordance with the information and precautions contained in this User's Manual. It is the customer's responsibility to understand and follow operating instructions in this User's Guide and specifications prior to operation—failure to do so may result in voiding this warranty. Accessories and fiber connectors are not covered by this warranty.

Buyer must claim under the warranty in writing no later than 31 days after the claimed defect is discovered. This warranty does not extend to any third party, including without limitation Buyer's end-users or customers, and does not apply to any parts, equipment or other products not manufactured by IPG.

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Service and Repairs

CAUTION:

Never send any product back to IPG without a Return Merchandise Authorization (RMA). Please refer to the Sample RMA Clearance Form in this User's Manual for additional information. The customer will be charged for the cost of repairing the product if the product is not under warranty or if the repair is not covered under the warranty.

Any damage noted upon receipt of the unit must be documented for appropriate claim against the carrier.

IMPORTANT:

Never send any product back to IPG without a Return Merchandise Authorization (RMA). Please refer to the Sample RMA Clearance Form in this User's Manual for additional information. The customer will be charged for the cost of repairing the product if the product is not under warranty or if the repair is not covered under the warranty:

Changes

We reserve the right to make changes in design or constructions of any of our products at any time without incurring any obligation to make changes or install the same on units previously purchased.

19. Declaration of Conformity

Declaration of Conformity

Konformitätserklärung

IPG Laser GmbH
Siemensstr. 7
D-57299 Burbach
Germany

IPG Laser GmbH declares that all fiber laser products are produced under ISO 9001:2000.

Product Name: High Power Fiber Laser, Model Series YLR (Ytterbium-Fiber Laser)

Model Number (s)

YLR-1000 (Basic, Premium, Special) *)	1kW Fiber Laser, cw, 1070 +/-10nm **)
YLR-2000 (Basic, Premium, Special) *)	2kW Fiber Laser, cw, 1070 +/-10nm **)
YLR-3000 (Basic, Premium, Special) *)	3kW Fiber Laser, cw, 1070 +/-10nm **)
YLR-4000 (Basic, Premium, Special) *)	4kW Fiber Laser, cw, 1070 +/-10nm **)
YLR-5000 (Basic, Premium, Special) *)	5kW Fiber Laser, cw, 1070 +/-10nm **)
YLR-6000 (Basic, Premium, Special) *)	6kW Fiber Laser, cw, 1070 +/-10nm **)
YLR-8000 (Basic, Premium, Special) *)	8kW Fiber Laser, cw, 1070 +/-10nm **)
YLR-10000 (Basic, Premium, Special) *)	10kW Fiber Laser, cw, 1070 +/-10nm **)
YLR-15000 (Basic, Premium, Special) *)	15kW Fiber Laser, cw, 1070 +/-10nm **)
YLR-20000 (Basic, Premium, Special) *)	20kW Fiber Laser, cw, 1070 +/-10nm **)

*) Basic, Premium, Special standing for changed beam qualities; all power levels between fulfill same standards as indicated below

**) included into this declaration are external or internal fiber-fiber-coupler and beam switches optionally delivered with the corresponding laser system.

IPG Laser GmbH conforms to the following standards:

IEC EN 60825-1:2001-08 Lasersafety
EN 61010: 2001 (2nd edition) Safety requirements for electrical equipment, control and Laboratory use
EN 954-1 Kat. III Lasersafety, Emergency Stop Safety
EN 55011 A Emission, interference voltage, E-field
EN 61000-3-2 (1995) + A!, A2, A14 Emission Harmonics
EN 61000-6-2 noise immunity after EN 61000-3, EN 61000-5, EN 61000-6
EN 61000-11
EN 61000-3-3 (1995) + A1 Flicker

All lasers (including source and fiber exit) are Class 4 products as designated by IEC EN 60825-1. The products are specifically developed for the integration into other equipments or machines. It is the responsibility of the user, to make sure, that the fiber output or the optical processing head shall have a protective housing to ensure Class 1 according to IEC 60825:2001-08. The laser itself (without fiber output) is classified as Class 1.

Eugen Shcherbakov
Managing Director

Valerij Starschenko
ISO Quality Manager

Burbach im Juni 2006