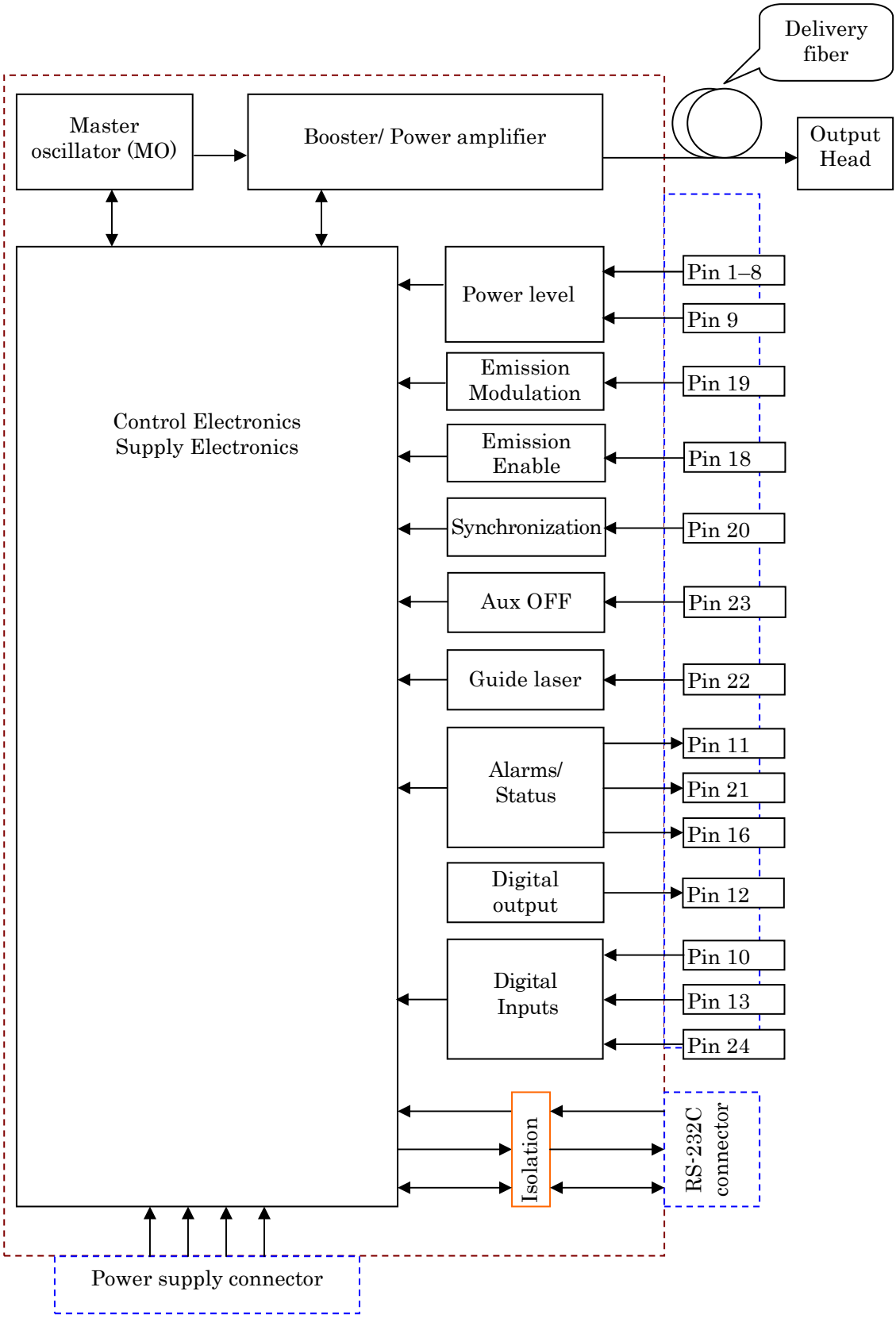
The document describes connection and control basics of pulsed lasers equipped with interface "type E" manufactured by IPG Laser GmbH and its sister companies.

Contents:

Laser Internal Structure.

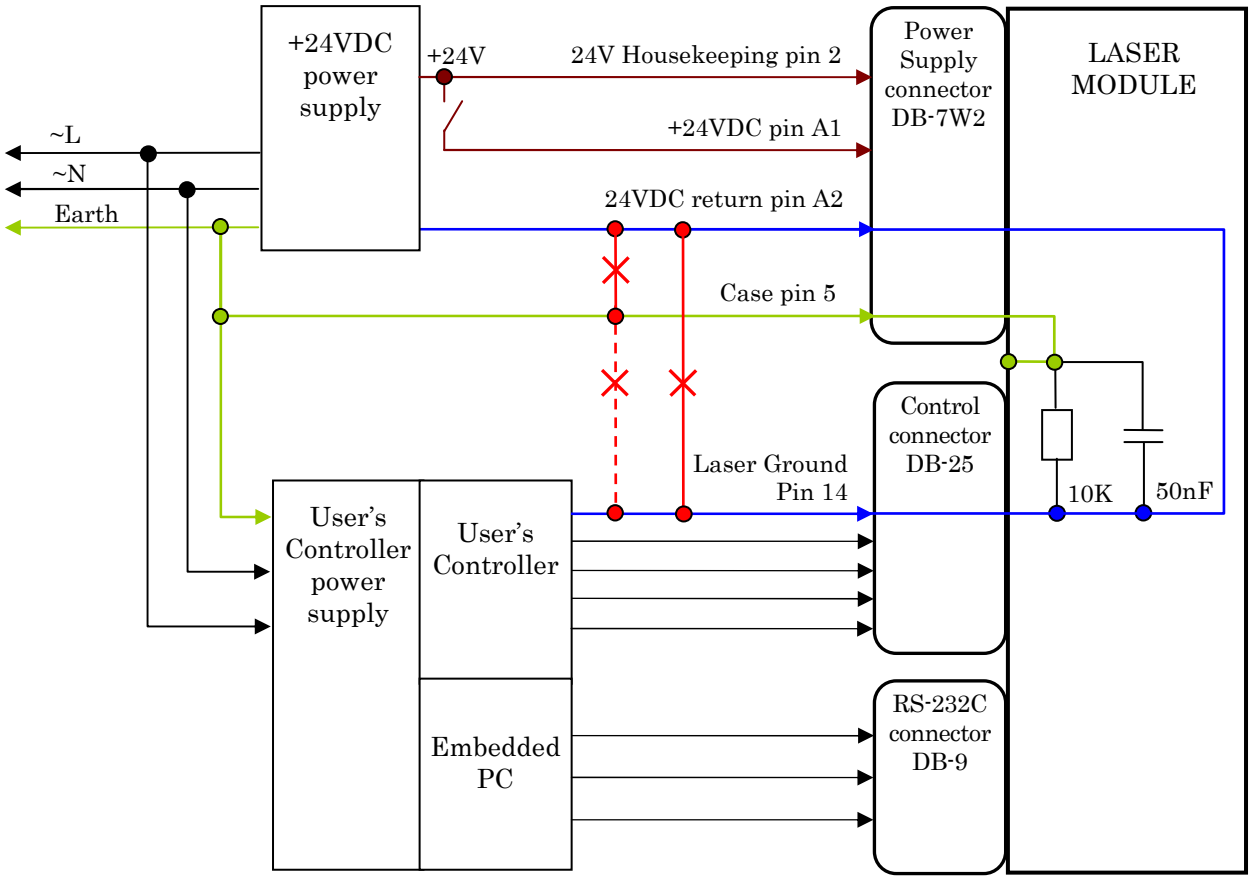


Power supply connector

The power supply connector is the DB-7W2 type plug (male). Pin assignment is shown in the table below.

PIN	Name	Level	Description
A1	+24V Main	+24VDC Supply Voltage	Supply voltage +24VDC ±5%. Must be supplied for the full laser operation. Floating power supply is required.
A2	24V Ret	24V Return Wire (Supply Ground)	Power supply ground. Inside the laser this ground is connected to the laser internal ground (pin 14 of DB-25 connector). Floating power supply is required.
1, 3, 4	Reserved		Customer connection is not allowed
2	HK	+5…+24VDC housekeeping	Power supply input for independent electronic board and guide laser operation only. Provides no supply to the pump laser diodes. Operating voltage range is +5…+24VDC, recommended voltage is +24VDC. Voltage should be supplied relative to pin A2. Must be supplied for the laser operation.
5	Case	Earth	Direct electrical connection to the laser housing (module)

Recommended laser connection diagram.



Electrical connection.

1. Main power supply (24VDC) should be capable to permanently supply operating current (refer to the maximum current consumption in the laser specification). Power supply should hold the voltage, measured on the laser DB-7W2 terminals, within a specified range (refer to the laser model specification) both for steady and modulated emission. Supply voltage undershoots and overshoots out of the specified range may lead to a non stable laser operation and laser damage. Power supply transient load regulation should be carefully investigated to choose a suitable power supply model.

2. Wires in the cable connecting main power supply and the laser should have an appropriate length and cross section to ensure negligible voltage drop.

3. The main 24VDC supply should have floating outputs. Its return wire should be connected only to the laser 24V return terminal (Pin A2 of DB-7W2). Wrong connections, which may create current loops (shown in the diagram above as the crossed red wires) should be avoided.

4. The main supply line +24V should be connected to +24VDC laser terminal (pin A1 of DB-7W2).

5. Laser ground (DB-25 pin 14) and laser 24V return are connected inside the laser module. No connections are allowed between these terminals outside of the laser module.

6. The laser is equipped with the housekeeping supply input- pin 2 of DB-7W2 connector. It should be kept powered for the complete laser operation cycle.

7. Laser warm-up time is calculated from the beginning of supplying a housekeeping voltage. Even if the main +24V supply is disconnected from the DB-7W2 terminal A1, while housekeeping voltage is still available, the main processor of the laser continues operation. The laser supports communication and keeps all settings made for the current session. The warm-up phase ends after 10s after supplying the housekeeping and 0.5s after supplying of main +24V Main. See the diagram in this manual.

8. Inside the module the common ground is connected to the laser housing via 10 kOhm resistor and parallel 50nF capacitor. This network equalizes potential between ground and the laser case.

9. User controller electronics ground may be connected to the earth by design (dashed red line on the diagram). If there is no such connection, it should not be made intentionally.

Control Connector Pin Assignment, DB-25 plug.

All control pins are TTL compatible, unless otherwise noted in the pin description. For the interface designs level ranges of the TTL standard should be taken into consideration. Some pins can be individually configured for control via RS-232 interface; configuration capability is given in the table.

PIN No.	Name	Description	RS-232 controllable
1-8 (D0-D7)	Power Setting	8-bit bus, range 0..FF(hex) or 0..255(dec). Least significant bit (lsb) (D0) corresponds to Pin number 1, Most significant bit (msb) (D7) corresponds to pin 8. 00h (0): Minimum output power FFh (255): Maximum output power Disconnected state corresponds to 00h.	full control
9	Latch	Latches power setting into the laser by the rising edge	enable/disable
10,13,24		Digital inputs, reserved for future use	
11,12,16,21		Laser status and digital outputs (see status codes in the table below).	
14	Ground	Ground	
15	5Vout	+5VDC output, max current consumption is 80mA.	
17	5VRG	+5±0.25VDC power supply input for independent operation of the red guide laser, maximum current consumption is 150mA	
18	EE	Emission Enable (EE) signal. HIGH: Emission Enable LOW or disconnected: Emission Disable	full control
19	EM	Emission Modulation (EM) input. HIGH: Emission ON LOW or disconnected: Emission OFF	full control
20	Sync	Pulse Repetition Rate (Synchronization) input	internal trigger generator
22	RG	Guide Laser (red diode) ON/OFF input. HIGH: ON LOW or disconnected OFF	full control
23	AuxOFF	Auxiliary Emission OFF Input HIGH: OK (Normal operation) LOW or disconnected: STOP (Laser automatically switches OFF all optical stages)	enable/disable
25		Reserved, customer connection is not allowed	

Digital Control Interface (DB-25) Description.

The laser is controlled by signals applied to the DB-25 connector. Please refer to the connector interface description table above for pin designation and operating levels.

Pin 1 to 8 D0-D7
Pin 1 to 8 is the 8 bit bus for the output power setting. Pin 1 is the least significant bit and pin 8 is the most significant bit. Codes in the range 0...255 (0...FFh) should be applied to these pins, which correspond to the power setting of 0...100% of the specified nominal value. **Note 1:** optical output power is nearly proportional to the power setting (see specification for the power adjustment range). **Note 2:** if the specified laser power adjustment range is limited (typically 10…100%), the optical output power in the unspecified range (here 0…10%) may not correspond to a set value. A power leakage at the zero power setting, as well as a nonlinear response to the power setting, is possible.

Pin 9 Latch
Pin 9 is the "Latch" control line to store power settings (pin1-8) in the laser. The data is stored in the laser by the rising edge of the signal on the pin 9. Data on the pins 1-8 should be stable for 1µs before and 1µs after the rising edge on pin 9. Stability of the data on the Pin 1-9 out of the above mentioned time frames is not required. IPG recommends supplying single positive pulse with duration longer than 2µs to latch the data into the laser. Time interval between adjacent latching pulses should be longer than 100µs (latching frequency less than 10kHz). **Note:** The line may be configured to DISABE state, in this case power setting on pins 1-8 are directly transferred into the laser.

Pin 11, 12, 16, 21 Alarms

Pin 11, 12, 16 and 21 are alarm and status outputs. Pin 12 is reserved for future use. These pins reflect the following device states:

Pin 11	Pin 16	Pin 21	Alarm description
LOW	LOW	LOW	**Temperature alarm** Laser temperature is out of the operating temperature range.
HIGH	LOW	LOW	**Power supply alarm** External supply voltage is out of the specified range.
LOW	LOW	HIGH	**Normal operation**
HIGH	LOW	HIGH	**Laser is not ready for emission**
LOW	HIGH	LOW	**Back reflection alarm** Laser automatically switches OFF due to high optical power reflected back to the laser.
HIGH	HIGH	LOW	Reserved
LOW	HIGH	HIGH	**System alarm** Laser protection system detects internal failure.
HIGH	HIGH	HIGH	Reserved

In the case of alarm activation the laser emission will be automatically switched OFF and internal Alarm flag will be set. To continue operation the internal Alarm flag should be reset.

Reset sequence:

The "Reset Sequence" depends on the pins configuration, the table below shows possible configurations and corresponding sequences.

N	EM/EE	Control (use line or RS-232)	Reset sequence
1	EE	line	drop to LOW for at least 2µs both pins together
	EM	line	
2	EE	RS-232	send RS-232 command "Reset Alarms"
	EM	RS-232	
3	EE	line	drop to LOW pin EE and then send RS-232 command "Reset Alarms"
	EM	RS-232	
4	EM	line	drop to LOW pin EM and then send RS-232 command "Reset Alarms"
	EE	RS-232	

If the reason of alarm condition is removed, alarm outputs (pins 11, 12, 16 and 21) will be recovered to the normal state simultaneously with the reset.

Back reflection alarm: Alarm resets not earlier than in 1s after activation.

Laser is not ready for emission state: Laser is not ready to emit power. That may be a result of non correct laser operation control sequence or not correct power supply voltage. The Reset sequence is required to clear this status.

Pin 15	**5Vout**

Pin 15 provides +5VDC output with current up to 80mA that can be used for auxiliary supplying user electronics communicating with the laser DB-25 control interface.

Pin 17	**5VRG**

Pin 17 is the input for the red guide power supply. The customer may supply +5±0.25V to this pin to operate the guide laser without supplying of +24V Main or HK. Laser electronics, except the guide laser block, is completely off.

Pin 18	**EE**

Pin 18 is the Emission Enable (EE) signal. The Emission Enable input should be switched ON at least 7ms before switching ON the Emission. After switching ON Emission Enable input, the laser starts to consume more electrical power and emits residual optical power to the output even when EM pin 19 is LOW. The optical power value (pulsed and CW parts) depends on model and operating mode of the laser. High contrast (HC option) ensures low leakage optical power.

Note: the EE switches ON simultaneously with the rising edge on the pin. If the HIGH level was applied EE before supplying electrical power to PCB, the Reset sequence after the warm-up is required to start operation.

Pin 19 EM

Pin 19 is the Emission Modulation (EM) control input. Apply HIGH to switch ON the Emission and LOW to switch it OFF. The laser starts to emit optical power within specified delay after setting the pin to the HIGH level and stops to emit within specified delay after setting to the LOW level. Refer to the laser optical specification for the laser average power rise and fall times. Modulation with a period shorter than sum of the rise and fall times (the laser response time) may lead to a non adequate laser power behavior and optical over/undershoot.

Note 1: The laser will not emit power during 7ms after setting EE to HIGH. Be sure that EE is switched ON at least 7ms before switching ON EM.

Note: the EM switches ON simultaneously with the rising edge on the pin. If the HIGH level was applied EM before supplying electrical power to PCB, the Reset sequence after the warm-up is required to start operation.

Pin 20 Sync

Pin 20 is the Synchronization input (External Trigger). Pulse train with a repetition rate (PRR) within specified operating range should be applied to the pin (refer to the optical specification for PRR limits). The laser emits pulses simultaneously with the rising edge of the signal. Minimum positive pulse width should be longer than 500ns.

Note: In case the PRR supplied being out of the specified range (or no PRR signal is supplied) the laser safety circuit substitutes missing pulses or limits the PRR.

Pin 22 RG

Pin 22 is the guide laser (red diode/ pointer) control line. Apply HIGH to switch the guide laser ON and LOW to switch the guide laser OFF. If the guide laser option is not installed, pin 22 can either be connected to ground (pin14) or left floating.

Note: the laser emission is not allowed simultaneously with the guide laser operation. MO and Booster are blocked internally during the guide laser operation. If the Emission Modulation and/or Emission Enable were set to HIGH level during guide laser operation, the laser will not emit power, and will not start to emit it even after switching OFF the guide laser. It is necessary send Reset sequence to continue operation. Until the reset is done the state "Laser is not ready for emission" will be active on appropriate alarm/status pins.

Pin 23 AuxOFF

Pin 23 is the "Auxiliary stop" input. It should be set to HIGH for normal operation. In case of dropping this pin to LOW state (even for a short period) the laser automatically switches OFF optical stages (similar state when both EE and EM are OFF) independently on other control signals. To recover normal operation the Reset sequence is needed. Pin 23 should be set to HIGH at least 2µs before supplying ON signals to EE and EM pins.

Laser operation using Digital Interface.

1. Remove the protective cap from the laser output optical head and make the appropriate beam termination.

2. Connect the laser module to the control system via DB-25 connector. Drive pins according to the description above.

   Note: IPG USB based remote control may be used to simulate control lines using IPG PC utility.

3. Recommended initial state of control pins:

   Pins 18, 19, 22 are LOW

   Pin 23 HIGH (stays always HIGH, not shown on diagrams below)

   Sync input with repetition rate within specified range

4. Connect power supply sources (housekeeping and main) to the laser.

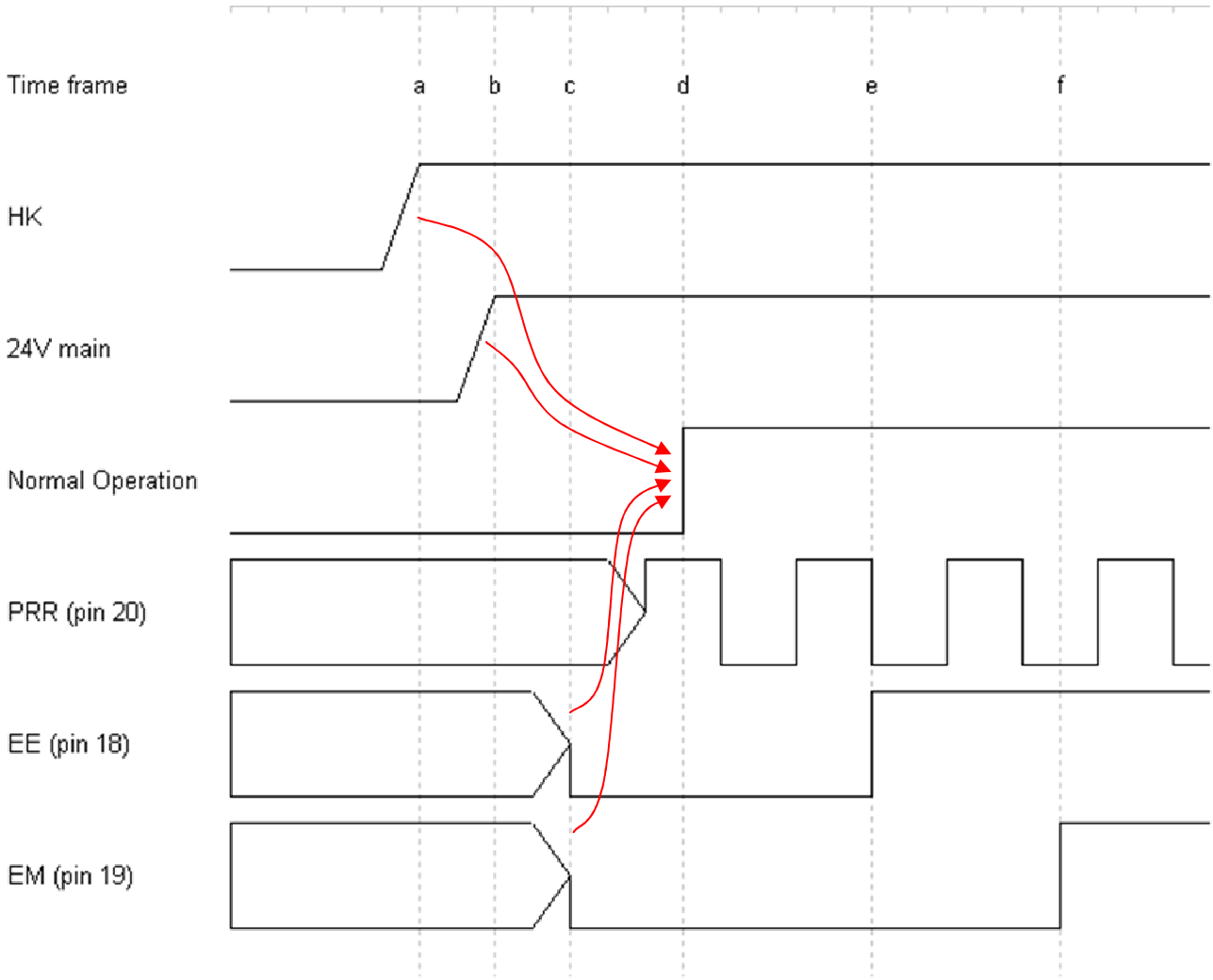
5. In 10 seconds after supplying HK and after 0.5s after supplying +24V Main the warm up phase is complete and the laser is ready for operation.

   Note: HK may be supplied after or before powering lines of the DB-25 interface.

6. Set desired power via pin 1-8, latch it using pin 9 to store the power settings into the laser.

7. Switch the EE ON applying HIGH to the EE input.

8. Wait for 7ms, power ON sequence diagram is below.



Timing requirements:

a (HK) to d (Normal Operation status) max 10s

a (HK) to b (24V main) should zero or positive

b (24V main) to d (Normal Operation status) max 0.5s

c (EE input) to d (Normal Operation status) max 2µs

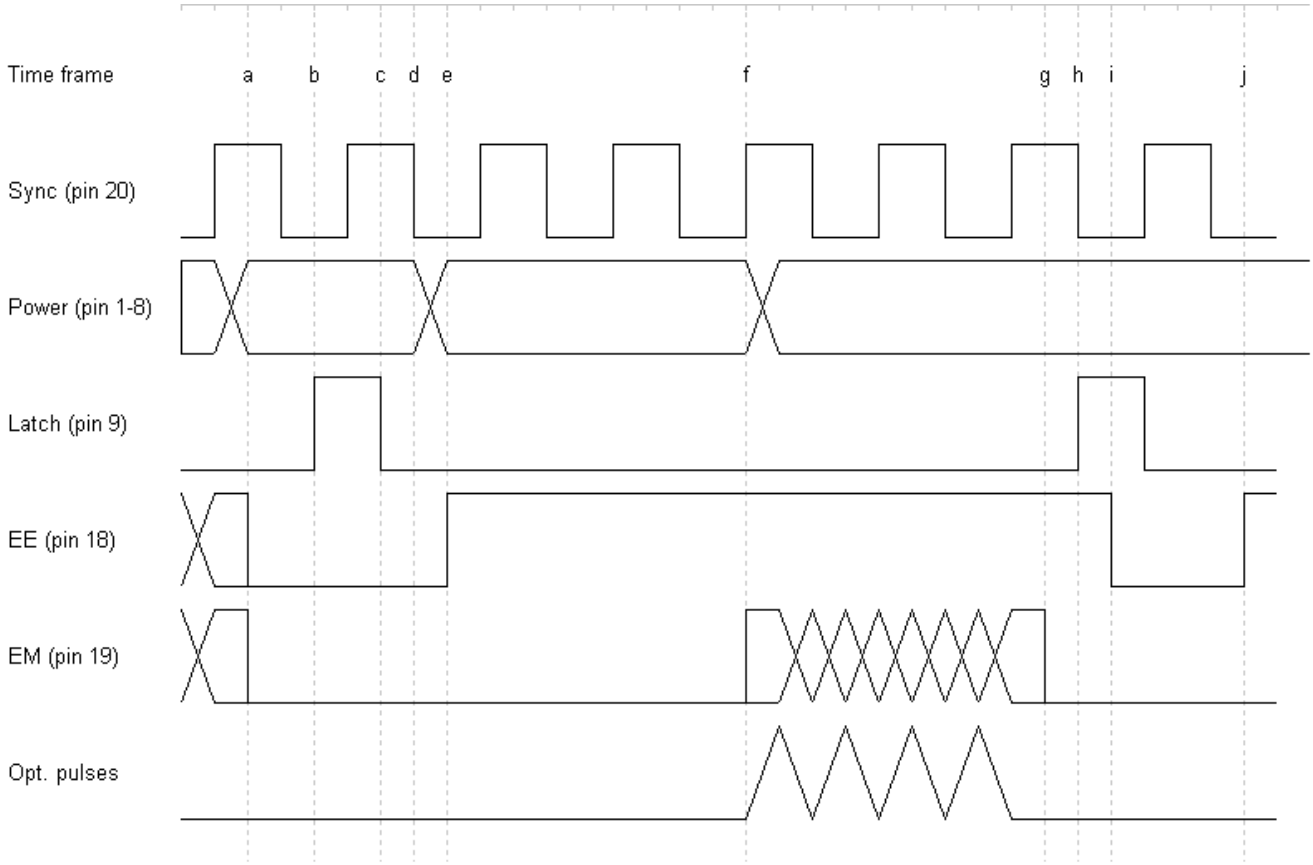
c (EM input) to d (Normal Operation status) max 2µs

c (EE input) to e (EE input) should be min 2µs, initialization reset

c (EM input) to e (EM input) should be min 2µs, initialization reset

c (EM input) to f (EM input) and c (EE input) to e (EE input) overlapping of LOW state should be min 2µs, initialization reset

9. The Laser is ready for a fast modulation via EM input. Set HIGH and LOW sequence to switch the laser ON and OFF correspondingly. The laser has finite ON/OFF response rise/fall times (refer to the specification for the particular model). The speed of the modulation should not be faster than sum of rise and fall times, otherwise laser optical response may not be as expected. Sequence diagram is shown below.



Timing requirements:

a (D0-D7) to b (Latch) should be min 1µs

b (Latch) to d (D0-D7) should be min 1µs

b (Latch) to c (Latch) should be min 2µs, data are latched with rising edge

e (EE input) to f (EM input) should be >7 µs

b (Latch) to h (Latch) should be min 10µs

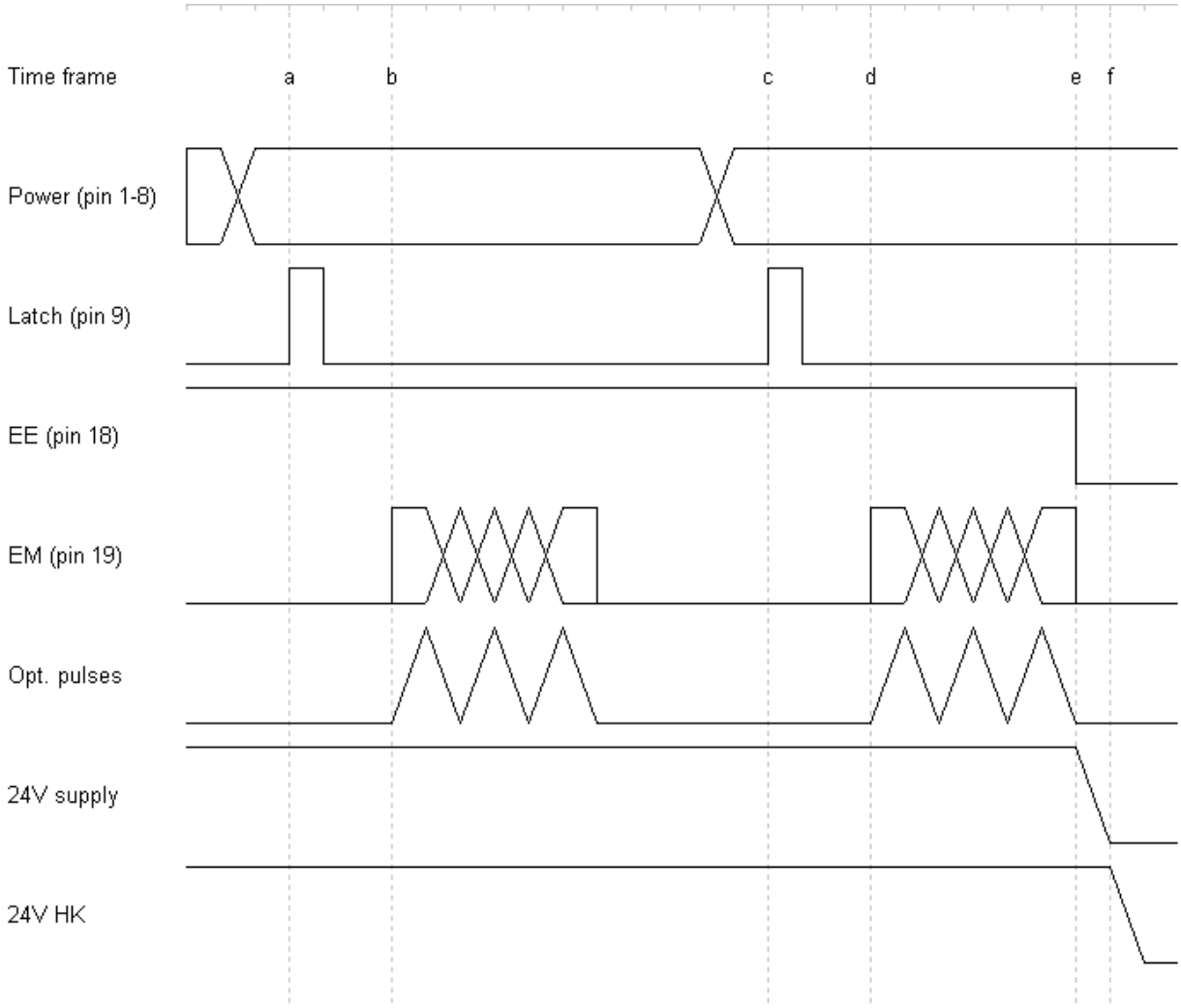
g (EM input) to i (EE input) should be min 1µs

i (EE input) to j (EE input) should be >5ms

10. If the EM OFF time between subsequent ON/OFF batches (jobs) is more than 500ms, it is recommended to switch OFF EE. It will spare power consumption, avoid unnecessary wear out of the laser and exclude residual MO power at the laser output.

11. After finishing the laser operation, switch OFF the EM and EE.

12. Remove all supply voltages. It is recommended to remove HK together or later that 24V main. Below is a timing diagram for switching OFF sequence and setting the power.



Timing requirements:

a (Latch) to b (EM input) should be min 5ms for guaranteed transition between any power set levels. Power transitions for smaller steps is faster (step 240< - >200 is faster than 240< - >180)

Switching OFF sequence: set e (EE and EM) to LOW, then switch OFF 24V main power supply

f (HK) should be switched OFF not earlier than e (24V main)

Operation Features.

1. In case PRR at Sync is higher than the maximum allowed PRR, the laser will operate at the maximum specified PRR. If the "master" PRR (Sync input) is lower than the minimum allowed PRR, the laser will operate at the minimum specified PRR.

   The power setting can be changed during the laser operation by applying updated levels to D0-D7 and writing them into the laser using Latch.

2. If pins EM and EE are LOW, there is no laser radiation at the operating wavelength.

3. If the EE is ON and EM is OFF, there is a residual power at the laser output. The value depends on the laser model and the operating mode.

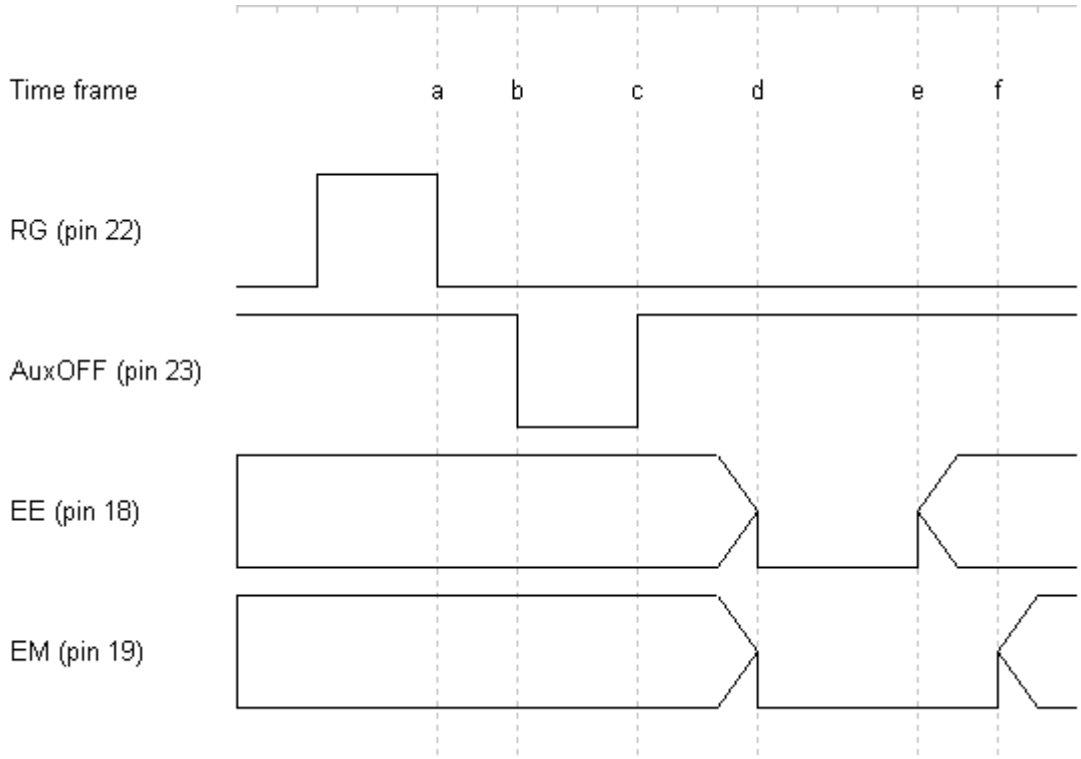
4. If the EE is ON, EM is ON and latched D0-D7 is 00h there is a residual power at the laser output. The value depends on the laser model and the operating mode.

5. Make sure that pin 22 is connected to the ground or left floating if the guide laser is not in use. Connection to the HIGH level disables laser emission.

6. The laser automatically switches OFF emission, if the module temperature rises above or drops below specified maximum/minimum operating temperatures (for operating temperature range refer to the laser specification). The internal Alarm flags set and appropriate alarm signal combination appears on the alarm pin 11, 12, 16 and 21. The laser does not recover the emission and holds the alarm pins unchanged until the Reset sequence is sent. For devices with a remote Booster (power amplifier), this also relates to the remote head temperature.

7. The laser may have an internal back reflection sensor. It switches emission OFF if the reflected level is potentially dangerous for the laser. The internal Alarm flag is set and the appropriate alarm signal combination appears on the alarm pins 11, 12, 16 and 21. The laser does not recover the emission and holds the alarm pins unchanged until the Reset sequence is sent. Emission is possible in one second after the alarm was emerged.

8. The laser requires reset sequence to clear "alarm" state. See Reset sequence section for sequence description. Below is the diagram for demonstrating reset sequence after the RG and AuxOFF operation.



Timing requirements for reset after the guide laser operation:

a (pin 22) to e (EE input) should be min 2µs

a (pin 22) to f (EE input) should be min 2µs

d (EE input) to e (EM input) and d (EM input) to f (EM input) LOW state should overlap for min 2µs

Timing requirements for reset after AuxOFF (pin 23) activation:

c (pin 23) to e (EE input) should be min 2µs

c (pin 23) to f (EE input) should be min 2µs

d (EE input) to e (EM input) and d (EM input) to f (EM input) LOW state should overlap for min 2µs

Operating modes and options

1. The laser may be equipped with options and control modes, which extend and/or change laser operation. List of installed options may be read by RS-232C interface using appropriate command. Below is the list of options.

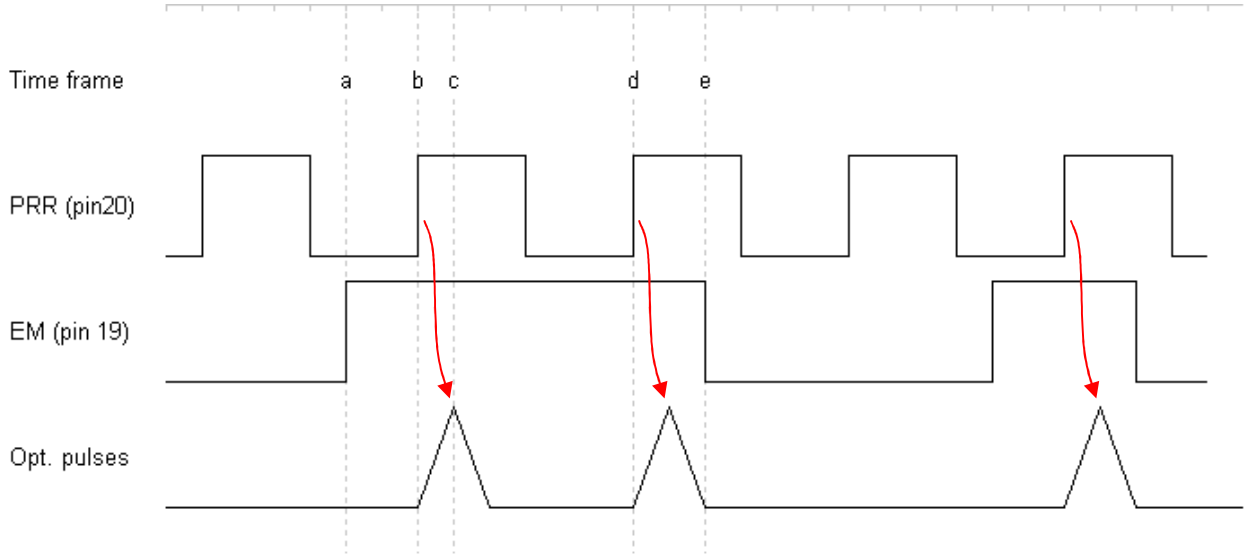
Option/ Mode	Description	Customer configurable
RS-232	RS-232 control	no
HC	High Contrast	no
ExtPRR	Extended Pulse Repetition Rate	no
BS1	Bitstream 1 mode	yes
AdjPulse	Adjustable Pulse Duration mode	no

2. **"RS-232C"** interface allows controlling the laser via RS-232 port. The control lines may be configured for control via RS-232 one independently. Also extended laser monitoring is available through this interface.

3. **"HC"** high contrast option ensures low power leakage if the Emission Modulation signal is LOW and Emission Enable signal is HIGH. For a laser not equipped with this option there is a power leakage at the output, with the value depending on the laser model. If BS1 operating mode is activated, a CW residual power may be emitted in HC mode.

4. **"ExtPRR"** Extended PRR option allows to operate with the PRR lower than nominal (refer to the specification for details). Average power is proportionally reduced while operating at PRR is less than nominal, so that the pulse energy is kept constant.

5. **"BS1"** Bitstream 1 operating mode allows fast emission modulation down to emission of single pulses. Assuming that the laser operates at a constant PRR, the EM signal can be used as a mask. Set EM to HIGH for the pulse emission and LOW to suppress the emission. BS1 option requires pre-pumping to prepare the laser for instant emission. This results in a leakage of a of CW power in case EE is HIGH. An example of a control diagram for BS1 is shown below.



Timing requirements:

a (EM) to b (PRR Sync) should be min 0.5µs for stable pulse clocking

d (PRR Sync) to e (EM input) should be min 0.5µs for stable pulse clocking

b (PRR Sync) to c (Opt Pulses) is typically less than 2µs

6. **"AdjPulse"** Adjustable pulse duration option allows user to choose shape and duration of the optical pulse from the preinstalled discrete set. The set of preset optical pulse shapes is defined in the device specification and is calibrated at the factory. Please note that operating parameters of the laser like maximum energy and average power may change with the pulse duration (refer to the device specification for detail).

RS-232C electrical connector

RS-232C connector is the DB9 type plug (male). The RS-232C interface is galvanically isolated from the internal laser ground and digital interface. This helps to avoid major problems associated with current loops in complex interface interconnections.

Pin assignment is shown in the table below and is standard for communication with a PC COM port. Use crossed RS-232C cable to link the laser and a PC.

PIN No.	Description
1, 4, 6-9	Not connected
2	RxD, receive
3	TxD, transmit
5	Interface ground, galvanically isolated from the laser internal ground

RS-232C Command Structure Description

1. Initialization of RS-232:

   baud rate: 57600 bits per second

   parity / flow control: none

   start / stop bits: 8 data bits, 1 start bit and 1 stop bit

2. Firmware command structure (ASCII codes for symbols):

$	Command code	; (semicolon)	Optional parameters separated by semicolon	CR symbol (hexadecimal OD)

3. Laser reply structure:

Command code	; (semicolon)	Return values separated by semicolon	CR symbol (hexadecimal OD)

4. The command code is a decimal ASCII representation of a number individual for each command. The list of command numbers is shown in the table below.

5. Command parameter is a text string. If the parameter is a numerical value, it should be converted into a decimal ASCII string.

6. The returned value is also a text string. If the requested value is numerical, the opposite conversion from text string to the numerical value is required.

7. All commands should be terminated by "Carriage Return" symbol, hexadecimal value "0D". The RS-232C buffer of the laser receives bytes until the CR symbol occurs. All bytes before this symbol are interpreted as a command. Bytes after CR until next CR will be interpreted as a next command.

8. For all "set" commands device returns as the parameter "Y" if the command was successfully executed and "N" if the command was not executed.

9. For all strings sent to the laser, which were not recognized as valid commands, the laser sends "E" as parameter.

10. After switching on electrical power device state is the following:

    Pulse repetition rate: nominal PRR

    EE and EM are in OFF state

    Set power is zero

RS-232C Command Codes.

List of commands for laser monitoring and configuration.

Type	Command	Command code	Parameters or return values	Description/Parameters
Read	Device ID	1	string, up to 24 char	Read device identifier written to the laser in the factory
Read	Device SN	2	string, up to 24 char	Read device serial number
Read	FW revision	3	string, up to 255 char	Read device firmware revision
Read	Vendor	99	string, up to 255 char	Read device vendor written to the laser in the factory
Read	Device Status	4	up to 32 bit integer	Read device status, decimal to binary decoding is required
Read	Device temperature	5	float, 1 digit after point	Read module temperature in degree Celsius
Read	Digital interface Status	10	up to 32 bit integer	Reads digital interface status, decimal to binary decoding is required
Read	Extended Status	11	up to 32 bit integer	Read device extended status, decimal to binary decoding is required
Read	BR Counter	12	up to 32 bit integer	Read back reflection counter
Read	Session BR Counter	13	up to 32 bit integer	Read back reflection counter for the current session. The session starts with supplying voltage to the laser module.
Read	Nominal average Power	14	float, 1 digit after point	Read nominal average power of the laser in [W] Return value is float in [W].
Read	Nominal Pulse Duration	15	up to 32 bit integer	Read nominal pulse duration of the laser [ns]
Read	Nominal Pulse Energy	16	float, 2 digit after point	Read nominal pulse energy of the laser [mJ]
Read	Nominal Peak Power	17	float, 1 digit after point	Read nominal peak power of the laser in [kW]. Value is calculated from the nominal energy and the nominal pulse duration.
Read	PRR Range	18	see description	Read pulse repetition rates range. Return value is two floats separated by a semicolon, corresponding to minimum and maximum PRR [kHz].

Type	Command	Command code	Parameters or return values	Description/Parameters
Read	Head Temperature	19	float, 1 digit after point	Read remote head temperature in degree Celsius, if the head is installed
Read	Main Supply Voltage	21	float, 1 digit after point	Read main 24V supply voltage in [V]
Read	24V Housekeeping Voltage	22	float, 1 digit after point	Read 24V housekeeping supply voltage in [V]
Read	Operating Mode	23	32 bit integer	Read active control interface operating mode, decimal to binary decoding is required.
Set	Operating Mode	24	32 bit integer	Set active control interface operating mode, binary to decimal encoding is required.
Read	Installed Options	25	32 bit integer	Read list of installed options and operating modes, decimal to binary decoding is required
Set	Start Operating Mode	26	32 bit integer	Set initial control interface operating mode, binary to decimal encoding is required. This mode becomes active after supplying the laser with electrical power. Value is stored permanently in the laser EEPROM.
Read	Start Operating Mode	27	32 bit integer	Read control interface operating mode, which activates after connecting the laser to the supply voltage. The value is stored permanently in the laser EEPROM, decimal to binary decoding is required
Read	Operating Power [W]	33	float, 1 digit after point	Read back operating power in [W] set by command 32 (in RS-232 mode) or via digital interface (in DB-25 mode), but recalculated into Watts using nominal laser parameters.
Read	Operating Power [%]	34	float, 1 digit after point	Read back operating power in [%] set by command 32 (in RS-232 mode) or via digital interface (in DB-25 mode), but recalculated into [%] using nominal laser parameters.
Read	Operating Pulse Energy	36	float, 2 digit after point	Read operating pulse energy in [mJ]. Value is calculated using nominal laser parameters and power settings.
Read	PRR monitor	38	float, 1 digit after point	Read back operating PRR in [kHz] set by command 28 (in RS-232 mode) or applied via Sync input of digital interface (in DB-25 mode)
Read	24V alarm counter	70	16 bit integer	Read counter for +24V main alarms
Read	HK alarm counter	71	16 bit integer	Read counter for HK alarms
Read	System alarm counter	72	16 bit integer	Read counter for System alarms
Read	Temp alarm counter	73	16 bit integer	Read counter for Temperature alarms

List of commands for RS-232C control interface.

Type	Command	Command code	Parameters or return values	Description/Parameters	Equivalent DB25 control line
Set	PRR	28	float, 1 digit after point	Set operating pulse repetition rate in [kHz]	Pin 20
Read	PRR	29	float, 1 digit after point	Read back operating pulse repetition rate in [kHz] set by command 28	
Set	Laser Emission ON	30		Switch ON laser emission	Pin 19
Set	Laser Emission OFF	31		Switch OFF laser emission.	
Set	Operating Power	32	float, 1 digit after point	Set operating power in [%]. Range 0…100, resolution 255 levels for the full scale	Pins 1-8 & 9
Set	Guide Laser ON	40		Switch ON guide laser	Pin 22
Set	Guide Laser OFF	41		Switch OFF guide laser.	
Set	EE ON	42		Switch ON Emission Enable	Pin 19
Set	EE OFF	43		Switch OFF Emission Enable	
Set	Reset Alarms	50		Reset alarms, see alarms description for details	
Set	Save Parameters	54		Permanently save parameters to EEPROM: 1) preset pulse duration 2) operating mode configuration	

Most of DB25 connector pins can be individually configured to be controlled by an equivalent RS-232 command. Every "ON" command sent by RS232 is equal to the HIGH state of corresponding control pin and "OFF" command is equivalent to the LOW state. Taking this into consideration, all control logic described for the interface control pins remains unchanged in terms of RS232 commands.

Note 1: Command $42 "EE ON" cannot activate laser if the status bit "Laser is ready for emission" is not HIGH. In this case the reason of the not ready state (like active state of guide laser, etc.) should be eliminated and reset sequence should be applied to clear "not ready" state.

Note 2: Optical output power is nearly proportional to the set operating power (see specification for the power adjustment range). In case the specified laser power adjustment range is limited (typically 10…100%), the optical output power in the unspecified range (typically 0…10%) may not correspond to a set power value. A power leakage with zero power settings as well as a nonlinear response to set power is possible.

List of commands for Adjustable Pulse Duration mode.

Type	Command	Command code	Parameters or return values	Description/Parameters
Read	Pulse Duration	48	16 bit integer	Read back pulse duration in [ns] set by command 49
Set	Pulse Duration	49	16 bit integer	Set optical pulse duration in [ns]. The set value should correspond to one from the list returned by the command 51
Read	List of Pulse Durations	51	<int1>;<int2>; …;<intN>	Read list of preset pulse durations in [ns]. List of 16 bit integers separated by semicolon

Command "$4" "Read device status"- return value interpretation.

Bit	State	Description
0	1 0	Rack reflection Alarm active No BR alarm
1	1 0	Temperature Alarm active. Laser module temperature is out of specified range. No temperature alarm
2	1 0	Temperature Alarm active. Laser remote head temperature is out of specified range. No temperature alarm
3	1 0	System Alarm active No system alarm
4	1 0	+24V main supply Alarm active. Overvoltage or Undervoltage of the main electrical supply occurred during the laser emission. No supply alarm
5	1 0	HK supply Alarm active. Overvoltage or Undervoltage of the 24V housekeeping electrical supply occurred during the laser emission. No supply alarm
6	1 0	Laser is ready for emission Laser is not ready for emission
7	1 0	At least one of the warnings is activated No warning is activated

Command "$10" "Read digital interface DB-25 status"- return value interpretation.

Return bits reflect status of the corresponding pins or internal data.
"1" means that pin/data is HIGH, "0" means LOW.

Bit	Pin/Data	Description of Pin/Data
0	Latched D0	D0 latched power setting
1	Latched D1	D1 latched power setting
2	Latched D2	D2 latched power setting
3	Latched D3	D3 latched power setting
4	Latched D4	D4 latched power setting
5	Latched D5	D5 latched power setting
6	Latched D6	D6 latched power setting
7	Latched D7	D7 latched power setting
8	pin 1	D0 power setting
9	pin 2	D1 power setting
10	pin 3	D2 power setting
11	pin 4	D3 power setting
12	pin 5	D4 power setting
13	pin 6	D5 power setting
14	pin 7	D6 power setting
15	pin 8	D7 power setting
16	pin 9	Latch
17	pin 23	AuxOFF
18	pin 19	Emission Modulation
19	pin 22	Guide laser control
20	pin 20	External Synchronization
21	pin 18	Emission enable
22	pin 10	Bit is reserved for future use
23	pin 13	Bit is reserved for future use
24	pin 16	Alarm0
25	pin 21	Alarm1
26	pin 11	Alarm2
27	pin 12	Bit is reserved for future use
28	pin 24	Bit is reserved for future use
29	Reserved	Bit is reserved for future use
30	Reserved	Bit is reserved for future use
31	Reserved	Bit is reserved for future use

Command "$11" "Read device extended status"- return value interpretation.

Bit	State	Description	Message Type
0	1 0	Emergency stop was activated Emergency stop was not activated	Warning
1	1 0	External synchronization frequency on 20pin is above specification Not above specification	Warning
2	1 0	External synchronization frequency on 20pin is below specification Not below specification	Warning
3		Reserved	
4		Reserved	
5	1 0	Guide laser was activated Guide laser was not activated	Warning
6		Reserved	Warning
7		Reserved	Warning
8	1 0	Laser emission is ON (laser is pumped) Laser emission is OFF (laser is not pumped)	Information
9		Reserved	
10		Reserved	
11	1 0	Laser emission ON command was received by RS232C Laser emission OFF command was received by RS232C This bit is valid in RS-232C control mode only	Information
12	1 0	Guide laser ON command was received by RS232C Guide laser OFF command was received by RS232C This bit is valid in RS-232C control mode only	Information
13	1 0	24V Main supply voltage is in specified range 24V Main supply voltage is not in specified range	Warning
14	1 0	HK supply voltage is in specified range HK supply voltage is not in specified range	Warning/ Information
15	1 0	Emission Enable is switched ON by RS-232 Emission Enable is switched OFF by RS-232	Warning Information

Operating modes commands

Command "$23" "Read operation mode"- return value interpretation

Command "$27" "Read start operation mode"- return value interpretation

Command "$24" "Set operation mode"- value for setting

Command "$26" "Set start operation mode"- value for setting

Bit	State	Description	Equivalent DB25 control line
0	1 0	Power control (D0-D7) by DB-25 Power control (D0-D7) by RS-232	1-8
1		Reserved	
2	1 0	AuxOFF control by DB-25 AuxOFF disabled	23
3	1 0	Guide laser control by DB-25 Guide laser control by RS-232	22
4		Reserved	
5		Reserved	
6		Reserved	
7	1 0	Emission Modulation control by DB-25 Emission Modulation control by RS-232	19
8		Reserved	
9		Reserved	
10	1 0	Bitstream 1 (BS1) mode is active (to activate) Not active (to deactivate)	N/A
11		Reserved	
12	1 0	Sync PRR control by DB-25 Internal trigger generator by RS-232	20
13	1 0	Emission Enable control by DB-25 Emission Enable control by RS-232	18
14		Reserved	
15		Latch control by DB-25 Automatic latch	9
16		Reserved	
17		Reserved	
18		Reserved	

The bits marked as "Reserved" in the structure above are used for internal laser control purpose and are not allowed to be changed by a customer. To preserve these bits first read the status from the laser and then change only required bits keeping other without modification.

Read options command

Command "$25" "Read installed options and operating modes"- return value interpretation.

Bit	State	Description
0		Reserved
1		Reserved
2		Reserved
3		Reserved
4	1 0	Adjustable pulse duration mode is installed Not installed
5		Reserved
6	1 0	Extended PRR mode is installed Not installed
7		Reserved
8		Reserved
9		Reserved
10	1 0	Bitstream 1 (BS1) option is installed Not installed
11		Reserved
12		Reserved
13		Reserved
14		Reserved
15		Reserved
16	1 0	Guide laser is installed Not installed
17	1 0	HC (high contrast) is installed Not installed
18	1 0	Remote amplifier is installed Not installed