# ERB15 Laser
# OEM Product Line

## OPERATION MANUAL
## REGISTRATION CERTIFICATE

September 2015

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Read this manual carefully before operating the device!

Check the contents of the box for transport damage and completeness. In case of irregularities contact Impex HighTech GmbH immediately!

The ERB15 is an OEM product. As such, it is intended only for integration into other equipment. The customer is responsible for certification of any kind.

Meet all necessary precautions to except damages through ESD (electrostatic discharge)!

Always wear suitable laser goggles to protect your eyes when working with lasers!

Before turning the laser on, check all parameters and settings for tolerability by the connected components!


Do not open the case of the Laser, because of high voltage! Warranty voids, if the case label was removed!

Terms and product names may be registered trademarks of the owners.

ERB15 must be installed in a laboratory or cleaned air operation environment. Dusty or dirty air environments can damage the laser system.

**Warning!** Exposure to laser radiation may be harmful. All apertures which can emit laser light in excess of levels which are considered safe are identified with appropriate labels shown later in this section. Take extreme care when working in areas where these labels are placed.

**Warning!** Always provide protective eyewear suitable for the laser's emission wavelength. The emission wavelength of your laser model is given on the DANGER sticker at the top of the laser head.

**Warning!** Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure. The use of optical instruments with these products will increase eye hazard.

# Inhalt

# 1. General

## Class 4 laser system

The following warning labels are placed on the laser system for your safety.


**Fig1. Warning lables**

**DO NOT REMOVE** them for any reason. If the labels become damaged or have been removed for any reason, **DO NOT OPERATE** the laser system and immediately contact Impex HighTech for a free replacement.

## 1.1. User safety

The ERB 15 Laser OEM Product Line is an OEM version of an IMPEX – HighTech flash lamp pumped solid-state laser. As such, it is intended only for integration into other equipment. The ERB 15 Laser OEM Product Line does not comply with Center for Devices and Radiological Health (CDRH) standards. The customer is responsible for CDRH certification of any system that incorporates the ERB 15 Laser OEM Product Line, if necessary.

### 1.1.1. Initial activation

Read this manual carefully before operating the laser system.

### 1.1.2. Removing the cover

**Warning:**
Do not remove the cover of the laser head. Dangerous radiation exists inside the laser head.
Do not remove the cover of the control electronics. Dangerous high voltages exist inside the control electronics.

### 1.1.3. Laser safety warnings

**Warning:**
Exposure to laser radiation may be harmful. All apertures which can emit laser light in excess of levels which are considered safe are identified with appropriate labels shown later in this section. Take extreme care when working in areas where these labels are placed.

**Warning:**
Always provide protective eyewear suitable for the laser's emission wavelength. The emission wavelength of your laser model is given on the DANGER sticker at the top of the laser head.

**Warning:**
Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure. The use of optical instruments with these products will increase eye hazard.

## 1.2. The ERB 15 Laser OEM Product Line

### 1.2.1. Introduction

The following operational guidelines are vital to a safe and productive environment. It is your responsibility to provide a proper operating environment.

Damage to the laser system due to an inadequate or improper operating environment is considered abuse and WILL NOT be covered under warranty. In no event will IMPEX HighTech be liable for any damages caused, in whole or in part, by customer, or for any economic loss, physical injury, lost revenue, lost profits, lost savings or other indirect, incidental, special or consequential damages incurred by any person, even if IMPEX HighTech has been advised of the possibility of such damages or claims.

### 1.2.2. Installing

- Prepare the Cooler for operation according to TermoTek manual.
- Connect the system components in the way as shown in Fig.2
- Connect the Laser Head with the Power Supply Unit - see under chapter 2.3, Fig.2, Nr.26.
- Connect the Laser Head with the Ground- see under chapter 2.3, Fig.2, Nr.15.
- Connect the Laser Head with the Cooler pushing the polypropylene pipes into the Fittings as explained in the TermoTek manual. Be sure that the connection is secure. The pipe should penetrate the fitting approximately 23 mm deep.
- In order to disconnect a pipe and the inlet (outlet) push the plastic ring surrounding the pipe and pull the pipe out.
- Make sure that the main switch-fuse is OFF.
- Screw the SMA 905 connector with fibre to the Laser Head housing (optional).
- Connect your Interlock cable to the Interlock connector on the rear wall of the Power Supply (see under chapter 2.3, Fig.2, Nr.25) or short-circuit the connector.

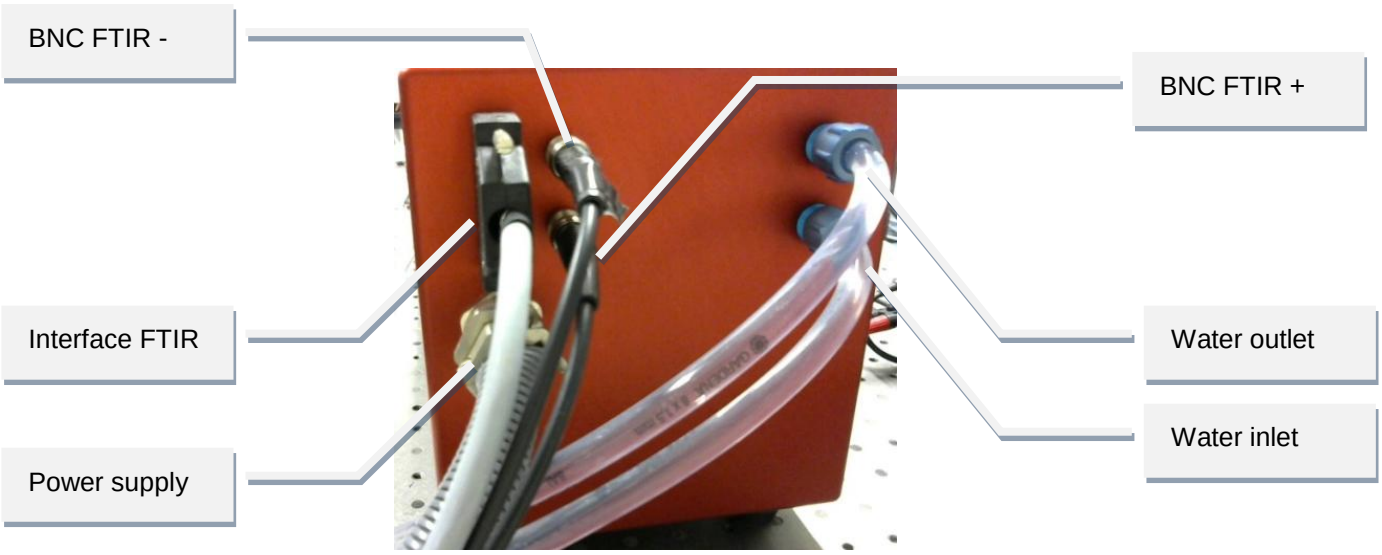



**Fig2. Laser head rear view**

### 1.2.3. Procedure of Operation

**Start-Up - Process**

1. Make sure that the emergency stop is disabled (pulled out).
2. Turn the main switch (Key-Switch) in ON position.
3. Turn the Chiller ON (If no error is shown, press Standby.)
4. Wait 10 min to let the system adjust to the set temperature.
5. Check the hoses of the system for leaks.
6. Set all parameter such as voltage of Flash lamp in the way that is explained in chapter 2.4.
7. Be sure that the chiller is on and work at set temperature
8. wear suitable laser goggles and then push the switch START

**Shutdown - Process**

1. Push the switch STOP on the power supply
2. Press the switch Power on the power supply into OFF position.
3. Keep the Chiller running for 10 min, to cool down.
4. Turn the key-switch on the mains power distributor in OFF position.


**Fig3. Power supply and chiller rack rear & front view**

## Laser Specifications

| Description | |
|---|---|
| Central wavelength | fixed, 2940nm |
| Repetition rate | 1Hz - 10Hz(selectable) |
| Pulse width with FTIR modulator | ~60ns |
| Operating modes | pulsed |
| Beam quality | $M^2 < 1,5$ |
| Maximal energy per pulse at fiber port | > 15mJ at 60ns |
| Fiber coupling type high power | SMA |
| Max. power drift | ± 5% of average / 2 hours |
| Polarization | random |

| Pos. in Fig.1 | Denomination | Functions |
|---|---|---|
| 1. | Kinematic mount | HR Back Mirror |
| 2. | Interface | FTIR control connection |
| 3. | High Voltage socket | Socket for Lamp wire + connection |
| 4. | High Voltage socket | Socket for Lamp wire - connection |
| 5. | Heat foil connector | Anti water condensing |
| 6. | ⏚ | Protective ground clamp |
| 7. | Kinematic mount | Fiber coupler lens (optional: for fiber coupling) |
| 8. | Kinematic mount | PR Front Mirror |
| 9. | FTIR | Pulse modulation |
| 10. | Kinematic mount | Pinhole(optional: for single mode operation) |
| 11. | cavity | Flash lamp and Er:YAG rod |
| A | inlet | Water inlet connection |
| B | outlet | Water outlet connection |

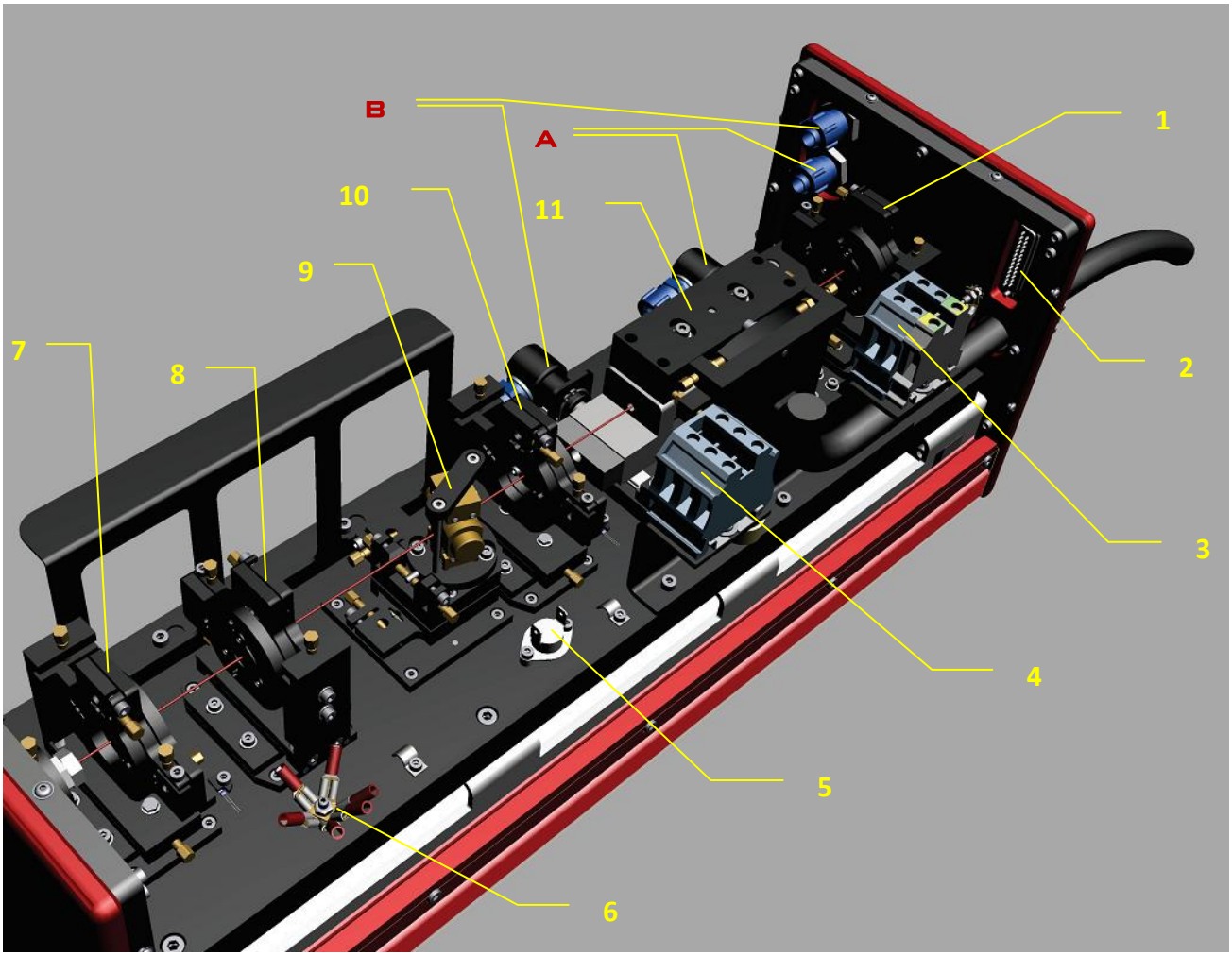



**Fig4. Laser head view**

### 1.2.3 How to clean Optics

In the laser, the optical elements are submitted to a significant energy density. Pollutants are susceptible to contaminate the optics and create hot spots. These hot spots degrade the quality of the optical surfaces and coating which may result in reduced laser efficiency. Cleaning the optics needs to be done quite often. This operation should be performed if a power loss or mode deterioration is observed.

- First clean the optics with the dry neutral gas spray. Do not put the spray into direct contact with the optics. If the optics are still dirty, proceed with the following procedure.
- Correctly clean your hands or wear clean protective gloves.
- Fold up the optical cleaning paper several times to obtain a little « cushion » of the diameter of the optical element. Do not touch the cleaning surface of the optical paper
- Humidify the cleaning paper with acetone.
- Gently drag the paper over the surface to be cleaned up.
- If it is necessary to repeat the operation, take another cleaning tissue (never use a cleaning paper twice).

**PR Mirror, plan/plan, 1/2", TR 75% @2,94µm designed by IMPEX**

**HR Mirror, Sapphire Substrate, plan/convex, r = 500 mm, 1/2" HR99,8%@2,94µm designed by IMPEX**

**(CaF2, 1/2", f = 80 mm, plan/convex, AR @2µm - 5µm)**

### 1.2.4 How to align Optics

This mirror mount's position is defined uniquely in terms of five independent coordinates, three translations and two rotations (two thin regions that serve as orthogonal hinges) with locking screws and optics adapter or adapters for pinhole.

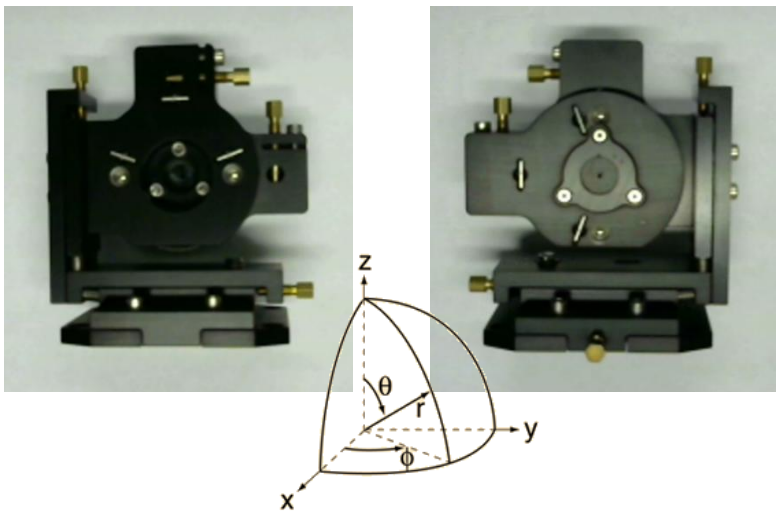



**Fig5. Kinematic optic mount**

### 1.2.5 How to replace the flash lamp

The first step is to remove the protection cover of the laser head housing. Make sure that the main switch-fuse is OFF before you start.

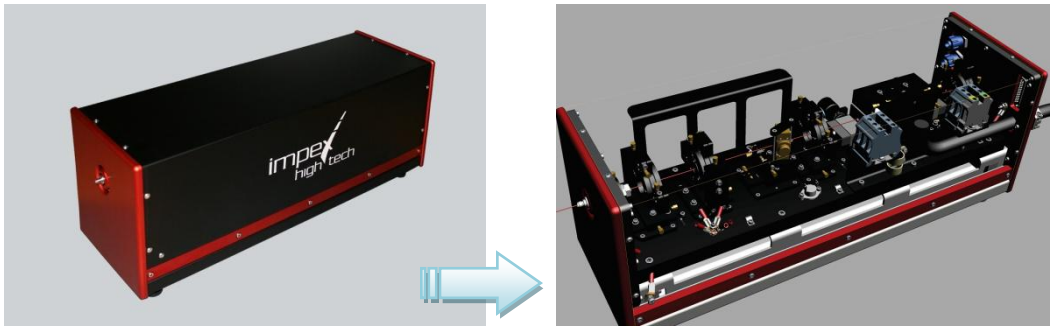



**Fig6. Laser head**

Disconnect the two power cords of the flash lamps. Observe the arrangement of the connections. The positive pole of the flash lamps (red end) is connected to the red power cord. The negative pole of the flash lamps (black end) is connected to the black power cord.

Unscrew the **two screws** as shown in Fig. 7 (right) located under the cavity and gently pull the cavity.

Remove the **four screws** holding the housing as shown in Fig. 7 (left). Once removed and before taking the housing off the optical base plate, gently swing the housing to fill it with air and drain it. Remove the housing. Do not incline to avoid water to leak into the Laser head.

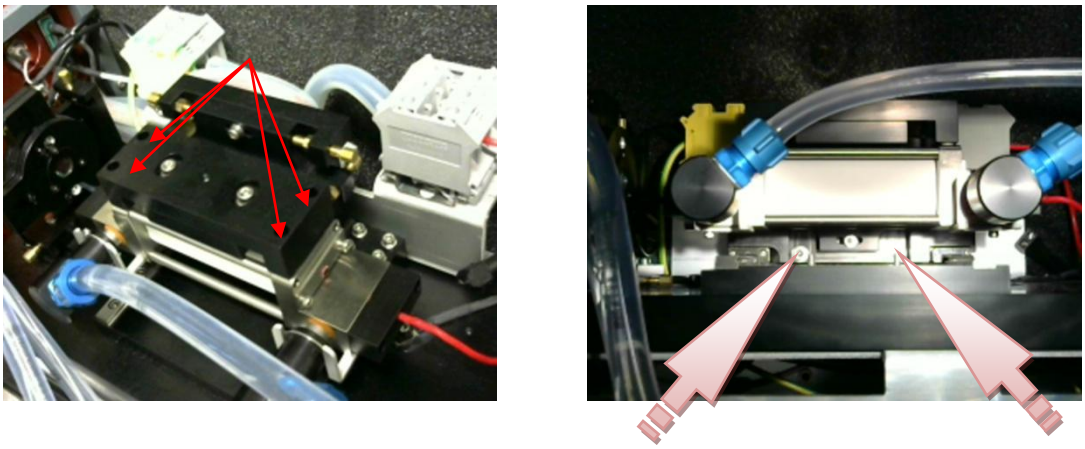


**Fig7. Laser cavity**

### 1.2.6 Taking the flash lamps out of the housing

To take the flash lamps out of the housing, use a screwdriver to unscrew two screws as shown in Fig. 8 and then gently pull the complete set of gaskets as shown on the picture. Remove the gaskets on one side of the housing first and repeat this procedure on the other side.

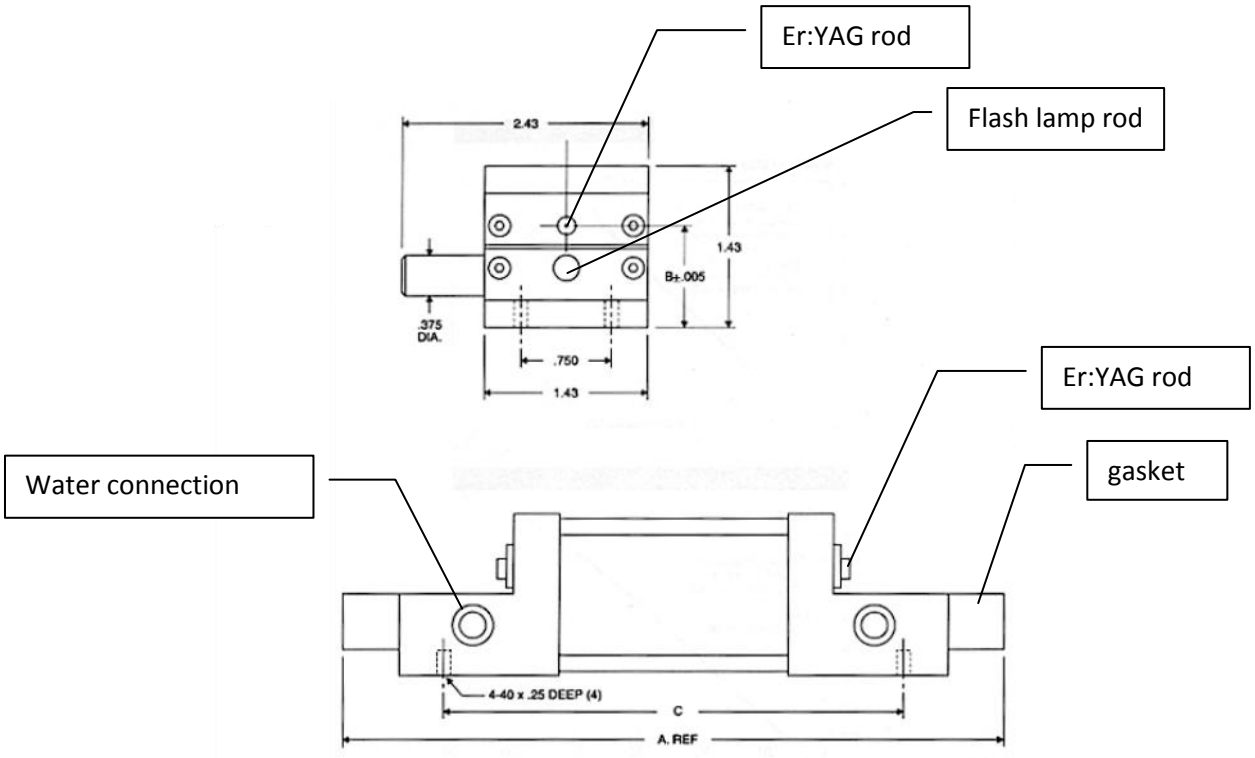



**Fig8. Cavity drawing**

To take the flash lamps out of the housing: push the electrode with a pushrod. You need to be very careful during this procedure to avoid the housing because the flash lamps can come out suddenly.

Warning: Do not manipulate the flash lamps with naked hands. The pollutants let by fingers on the flash lamps may burn when heated up and damage the lamps. If needed, clean the flash lamps with ethanol. Manipulate the flash lamps with clean protective gloves and preferably holding them by the electrodes.

Once the flash lamps are released, gently pull them out. Remain on the housing axis as much as possible.

### 1.2.6 Installing new flash lamps

Gently slide the flash lamps into the housing. Make sure the gaskets are well in place and properly blocked.

Now you can put together again the housing of the laser head while checking the gaskets between them are in place. Tighten the four screws.

Warning: Before connecting the flash lamps back, make sure there is no water leak next to the flash lamps or the housing base plate. Run the cooling unit for at least 15 minutes and check for water leaks. Presence of a drop of water on the rod may focus the beam down and damage the laser. Moreover, make sure there is no air in the light trap. If there is, pinch the water hose several times.

Once everything is checked, connect the flash lamps again while respecting polarities (red cord on red electrode and black cord on black electrode).

WARNING: INVERTING THE POLARITIES WILL RESULT IN SERIOUS DAMAGES FOR THE FLASHLAMPS.

After replacing a pair of flash lamps, note the number of shots it has been used for. You can read the number of shots in the menu of each power supplies. Moreover, the flash lamps should be burned in before use at full power. This consists in running the laser for at least an hour, with minimum voltage (1000V) and shutter closed.

Once this procedure is performed, the laser is ready to operate again.

WARNING: REPLACING THE FLASHLAMPS MAY SLIGHTLY CHANGE THE LASER ENERGY CALIBRATION. IT IS RECOMMENDED TO CHECK THE CALIBRATION BEFORE OPERATING THE LASER. NOTE THE NEW VALUE OF THE ENERGY FOR NOMINAL VOLTAGES.

- Adjustment of the laser power is done by regulating the high voltage applied to the flash lamps.
- The operating temperature is factory set at 20 °C. It is not recommended to modify it. To synchronize the flash lamps externally, connect the synchronization signal to the OSCILLATOR SYNC IN on the T connector located on the rear panel of the cabinet.
- It is recommended to leave the cooling system ON for few minutes after the system has been switched off, to allow for gradual cooling of the laser rod.

# 2. Power Supply

## *PS 5021*

Operation manual
Registration certificate

The power supply unit for pulse lasers **PS5021** is designed for flash lamp-pumped lasers and presents a device consisting of capacitor charging, simmer/trigger and pulse forming modules and control circuits.

## 2.1. MAIN TECHNICAL SPECIFICATIONS

### *2.1.1 Technical parameters*

| No. p/p | Parameter denomination | | Standard for channel | Test data |
|---|---|---|---|---|
| 2.1.1.1. | Max. average charge rate at max. output voltage; J/s | | 4000 | 1320 |
| 2.1.1.2. | Smooth adjustment range of capacitor bank charging voltage $U_c$ ; V | | 0 - 450 | 0 - 450 |
| 2.1.1.3. | Error of capacitor bank charging voltage (at $U_c = U_{max}$); less than, % | | ± 0.15 | 0.15 |
| 2.1.1.4. | Capacitance of capacitor bank; µF | | 13200 | 13200 |
| 2.1.1.5. | Inductance; µH | | 15 | 20 |
| 2.1.1.6. | Simmer current; A | | 0.6 | 0.68 |
| 2.1.1.7. | Triggering modes | | Internal, external | Internal, external |
| 2.1.1.8. | Operation control mode | | control panel, CAN, RS232 | control panel, CAN, RS232 |
| 2.1.1.9. | Requirements for external sync. pulse (sockets SYNC. IN; input resistance 300 Ω):<br>◆ duration, µs<br>◆ amplitude, V | | <br>10 - 15<br>6 - 15 | <br>7.5<br>3.1 |
| 2.1.1.10. | Characteristics of output sync. pulse at load resistance of 100 Ω (sockets on rear panel):<br>◆ duration, µs<br>◆ amplitude, V | | <br>≥10<br>≥10 | <br>14.0<br>12.2 |
| 2.1.1.11. | Power consumption at maximum output power; kVA | average | ≤2.4 | 1.6 |
| | | peak | ≤4.4 | 3 |

* Customer's specification

### *2.1.2. Operation requirements*

| | | | |
|---|---|---|---|
| 2.1.2.1 | Mains voltage; V | | 220 |
| 2.1.2.2. | Mains frequency; Hz | | 50/60 |
| 2.1.2.3. | Ambient temperature; °C | storage | +5 - +50 |
| | | operation | +15 - +40 |
| 2.1.2.4. | Humidity; below, % | | 80 |
| 2.1.2.5. | Forced air cooling with mounted-in air fan | | ok |

### *2.1.3. Other data*

| | | |
|---|---|---|
| 2.1.3.1. | Average lifetime; hours (when operated in compliance with p.1.1) | 5000 |
| 2.1.3.2. | Dimensions; mm | 19" x 7" front panel; 460(D) x 440(W) case |
| 2.1.3.3. | Weight; not exceeding, kg | 31 |

## 2.2. COMPONENTS

| No. p/p | Denomination | Quantity |
|---|---|---|
| 2.2.1. | Power supply *PS 5021* | 1 |
| 2.2.2. | High voltage junctions | 2 |
| 2.2.3. | Powering cable | 1 |
| 2.2.4. | Operation manual | 1 |

## 2.3. CONTROLSUPPORT

### 2.3.1. Power supply front and rear panel view

**(See Fig.9)**

### Front panel

| Pos. in Fig.2 | Denomination | Functions |
|---|---|---|
| 1. | STOP | STOP button |
| 2. | MENU | MENU button |
| 3. | ERROR | Indicators of feasible emergency states |
| 4. | < | Selection button |
| 5. | RUN indicator | RUN indicator |

| | | |
|---|---|---|
| 6. | > | Selection button |
| 7. | | Alphanumeric display |
| 8. | READY | capacitor banks charging indicator (lights when capacitors voltage attains pre-defined value) |
| 9. | ESC | Escape button |
| 10. | | Selection knob |
| 11. | RUN | RUN button |
| 12. | LASER EMISSION | 'LASER EMISSION' LED |
| 13. | POWER | Mains on/off switch |

## Rear panel

| Pos. in Fiq.2 | Denomination | Functions |
|---|---|---|
| 14. | MAINS | Socket for mains cable connection |
| 15. | ⏚ | Protective ground clamp |
| 16. | 16 A SLOW | Fuse sockets. Fuses 16A Slow, Ø6.3mm x 32mm |
| 17. | SYNC IN | Input for external synchronization pulse |
| 18. | READY | |
| 19,20. | CAN | CAN connectors |
| 21. | RS232 | RS232 connector |
| 22. | SYNC OUT | Sync. pulse outlet |
| 23. | DELAYED SYNC.OUT | Sync. pulse outlet. Sync. pulse is shifted in time with respect to one in SYNC OUT socket and coincidence to the beginning of discharge pulse in a channel. |
| 24. | EXT TRIGG ON/OFF | Releases or stops output pulse triggering: Trigg. On; Trigg. Off. Simmer and high voltage are ON. |
| 25. | INTERLOCK | Socket for connection of external safety circuits for blocking of supply's power part operation |
| 26. | HV OUT -+ | High voltage sockets for flash lamp connection |
| 27. | *POWER SUPPLY PS5O21* | Sample identification label |

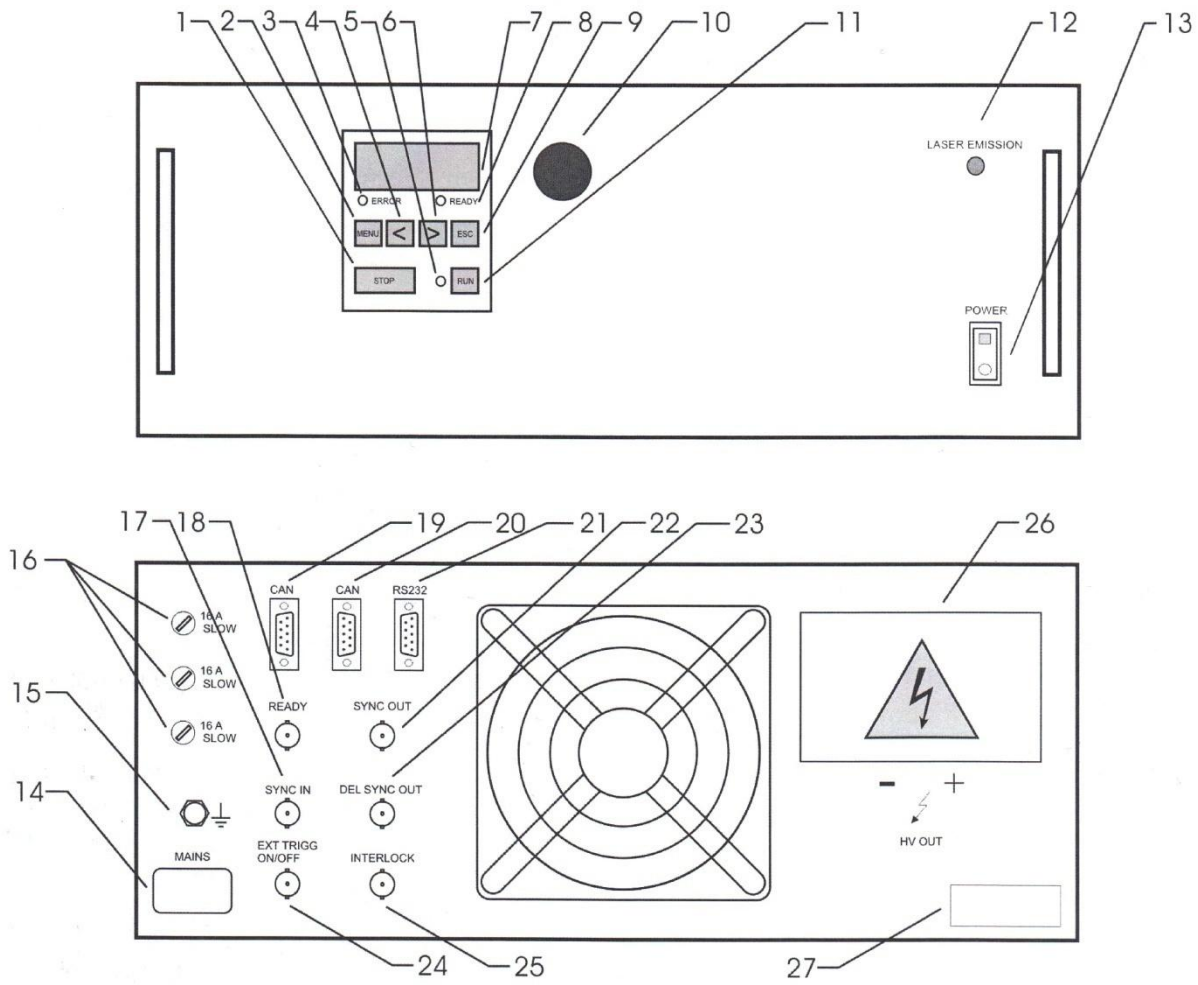



**Fig9. Front and rear panel view**

## 2.4. SAFETY PRECAUTIONS

2.4.1. Equipment is designed to be safe under normal environmental conditions according 2.1.4.1. 61010-1@IEC:2001 (Safety requirements for electrical equipment, control and laboratory use):

a) indoor use;
b) altitude up to 2000m;
c) temperature 5°C to 40°C;
d) maximum relative humidity 80% for temperatures up to 31°C decreasing linearly to 50%relative humidity at 40°C;
e) MAINS supply voltage fluctuations up to +- of the nominal voltage;
f) transient overvoltage typically present on the MAINS supply;
g) POLLUTION degree 1: no POLLUTION or only dry, non-conductive POLLUTION occur

2.4.2. Working with power supply is allowed to persons acquainted with operation manual and having permission to deal with voltages over 1000 V.

2.4.3. Do not remove unit covers while power cable is connected to the mains.

2.4.4. Do not operate the unit when it is not **grounded** and the load is not connected as well as when flash lamp housing is not grounded.

2.4.5. Do not use the unit if some defects have been detected.

## 2.5. CONTROLPANEL

### 2.5.1. General description

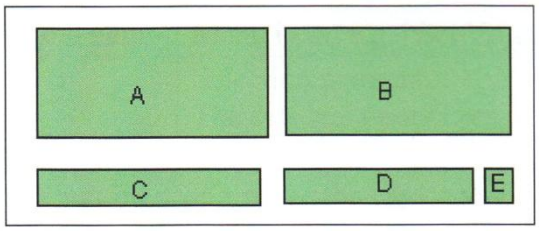
#### 2.5.1.1. Control Panel modes

| Mode | Description |
|---|---|
| LOCK | Disables changing of PS5021 parameters via CAN or RS232 connection and the control Panel menu access.<br>To lock/unlock PS5021 push buttons < and > together and keep depressed for few seconds. |
| EDITING | In this mode turning of the encoder knob changes the selected parameter. Editing mode can't be used for all parameters (e.g. Pulses counter). |
| "Store?" window | Asks for Confirmation to save parameter in EEPROM memory. If the selected parameter can't be saved "Store?" window doesn't appear. |

#### 2.5.1.2. Operation controls

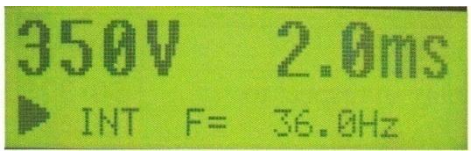
| Button | Description |
|---|---|
| MENU | Switches on the "Menu" window (if LOCK is not on). |
| < | Moves the cursor one Position left if in EDITING mode digital parameter is selected. |
| > | Moves the cursor one Position right if in EDITING mode digital parameter is selected. |
| OK(encoder button) | Switches on the "Menu" window.<br>Switches on the EDITING mode.<br>Saves Parameters in EEPROM. |
| ESC | Returns to the previous state (action opposite to OK button). |
| STOP | Stops operation of PS5021. |
| RUN | Starts operation of PS5021. |

### 2.5.2. Working window

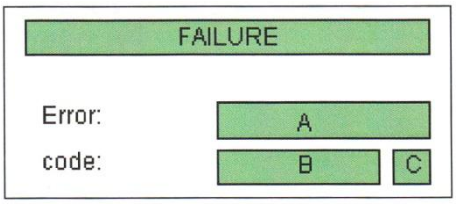



| Field | Description | Indications |
|---|---|---|
| A | Output voltage | From 0 V to 450 V. |
| B | Pulse duration | From 0.1 ms to 40ms |
| C | State indicator | STANDBY – simmer is off<br>IGNITION – simmer is being switched on,<br>STOP – simmer is on,<br>RUN ► – simmer is on and the power supply is pulsing. |
| D | Pulse repetition rate | Frequency in internal triggering mode,<br>EXT SYNC – in external triggering mode. |
| E | LOCK indicator | |

Example of the working window:

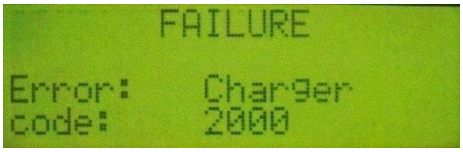



### 2.5.3. Failure window



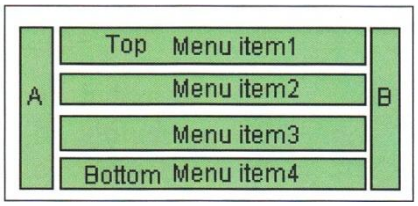

| Field | Description | Indications |
|---|---|---|
| A | Failure source | Short information about failure source, e.g. Charge, Flash lamps, Interlock, Connector. |
| B | Failure code | Unambiguously shows all detected failures. |
| C | LOCK indicator | |

Example of the failure window:




### 2.5.4. Menu

#### 2.5.4.1. **Selection of the menu item**

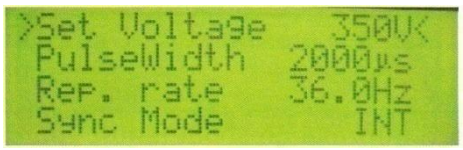



| Field | Description |
|---|---|
| Menu item | Menu item, e.g. “Set Voltage” |
| A, B | Selection Markers.<br>The selected menu item is marked by symbols > and <. |

Menu items:

| Menu item | Description | Possible values |
|---|---|---|
| Set Voltage | Channel voltage | 0 - 2000 V |
| PulseWidth | Set output pulse duration | 0.1 - 40 ms |
| Rep. rate | Frequency of the internal synchronization | 0.1 - 1000.0 Hz |
| Sync mode | Synchronization mode | Internal, External |
| Trig delay | Output pulse delay in respect to SyncIn pulse | 50 - 30000 µs |
| Sync delay | SyncOut pulse delay in respect to the output pulse | 0 - 30000 µs |
| Lamp Impedance | Set flash-lamp impedance | 15 - 50 Ω |
| Counter | Pulses counter | 0 - 9999999999 |

Example of menu item selection:




- Select desired menu item by turning the encoder.
- Push the OK button for selected item editing.

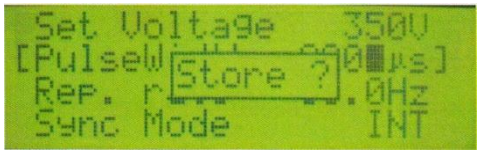
#### 2.5.4.2. Editing of the menu item

| Field | Description |
|---|---|
| Menu item | Menu item, e.g. “Set Voltage” |
| A, B | Selection markers.<br>The selected menu item is marked by symbols [ and ]. |

- By buttons < or > move the cursor to the position that needs to be changed.
- Change the Parameter value by turning the encoder.
- Push the OK button to save selected value. “Store?” window opens.

#### 2.5.4.3. Saving the menu changes

Example of “Store?” window:




- Push the OK button to save selected in the EEPROM

## 2.6. REMOTE CONTROL

### 2.6.1. P55021 remote control functions

PS5021 may be controlled by:

- Remote control pad connected to power supply (optional).
- RS232 port. The connector 'RS232' is located on the rear of power supply PS5021.
- CAN port. The connector 'CAN' is located on the rear of power supply PS5021.

Following functions are accessible remotely:

| Laser function | Control pad | RS232 |
|---|---|---|
| **Basic function** | | |
| Laser START/STOP | + | + |
| Software version | - | RO |
| Serial number | - | RO |
| Pulse repetition rate | RW | RW |
| Internal/external synchronization | + | + |
| **Diagnostics** | | |
| Basic error message | + | + |
| Complete laser and power supply setup parameters | - | - |

| | | |
|---|---|---|
| Logging of setup and parameters to file | - | - |

| | |
|---|---|
| RO | read only |
| RW | read/modify/program |
| + | function accessible |
| - | function not accessible |

### 2.6.2. Diagnostics

**Basic error messages**

- Basic error messages allow to determine the primary cause of PS5021 malfunction
- Basic messages are accessible to user through remote control pad or RS232 port
- See 'Basic error messages' in 'RS232 commands summary' for details

**Software**

- LabVIEW application for RS232 connection.
- Test utility 'CanBrowser' for CAN connection.

### 2.6.3. RS232 protocol description

RS232 communication protocol is used to link Ekspla devices: power supplies, lasers, OPG and PC.

Communication between devices and the PC is ASCII message-based. Every device can send messages at any time; there is no handshake. Therefore, the devices including PC have buffers to keep raw (unprocessed) messages. This protocol is intended for use in short distance control. It is assumed that data transfer is loss-free and no data confirmation and error correction are provided.

(Hint: There are plenty of samples of commands below. See strings in bold.)

**General Message Form**

Every message is enclosed in brackets [ *Message* ]. Symbol ' [ ' clears the message buffer, ' ] ' starts the command interpreter.

LF and CR symbols are ignored if received.

The receiver never repeats the received symbols. If a terminal program (such as HyperTerminal) is used for manual operation, turn on the option 'echo typed characters locally' to view the symbols.

The general format of a message is: [ *ReceiverName* : *MessageBody* \ *SenderName* ]

Samples of commands:

**[PS:START\PC]** start the power supply;
**[PS:STOP\PC]** stop the power supply;

The command interpreter is case-sensitive.

Spaces in message are not allowed, except as separators between commands.

Sender and receiver names may be omitted for a single device connection, so you may enter [SAY] instead of **[PS:SAY\PC]** . The device will reply to default address: [MS:READY\XX]. XX is the device name.

**Receiver and Sender names**

The RS232 port allows controlling several devices simultaneously (for example, the laser, data unit and parametric generator). Each device has a unique name composed of two or three symbols (A-Z and 0-9). This unique name is used as the address when sending

commands. To answer a message, the sender must also have a name. The name of a sender is composed of two or three symbols as well.
Default names are:

PL - PL2143, PL2200, PL2201, PL2210
NL - NL30X, NL220
SL- SL312, SL321
D1 - PGXXX
PS - PS5021

The name MS is reserved for the main control program. This is a default address for energy meters data, error messages and others.

The device answers to an inquiry by exchanging sender and receiver names. See sample: Inquiry: **[PS:E0/S?\PC]**, answer: **[PC:E0/S50\PS]** .

**Message Body**

The message can contain one or several commands.

Commands are divided by a space symbol.

The length of a message cannot exceed 127 characters including addresses and symbol characters.

Messages exceeding 127 symbols are ignored.

The device does not decode an incoming message until terminator is received. Commands are executed in the order they are transmitted.

A sample of messages with several commands:

**[PL:F0/S10 E1/S20\PC]** starts the laser

**Commands**

Two types of commands are available: system commands and general commands. The system command set varies only slightly from device to device.

**System Commands**

The system command is a single word composed of letters A-Za-z and numbers 0-9: [*Command*]

The system command has a very simple syntax. Here is a basic set of commands for lasers:

*SAY* Full message looks like: **[PL:SAY/PC]** Laser reports its current state;

*START* Full message looks like: **[PL:START/PC]** Starts the laser;

*STOP* Full message looks like: **[PL:STOP/PC]** Stops the laser.

The system command can have a single parameter: [ *Command* = *Parameter* ]

The parameter is separated from the command by an equals sign = or enclosed within double quotes. For example, **[NAME=D1]** and **[NAME"D1"]** are the same command, i.e. NAME with parameter D1. If quotes ("") are used, the forward and backward slashes, brackets, equals sign, colon ( / \ [ ] = : ) and the space symbol are not allowed for a parameter. If the equals sign = is used, the back slash (\) and brackets ([]) are not allowed for a parameter, and the message must contain only a single command. The **[NAME"D1"]** form exists only for compatibility purposes.

The parameter can be numerical or a string.

The device replies to most commands by an answer of the same syntax. For several commands there is no response. Sample of a command and response:

Command: **[PL:SAY/PC]** ; response: **[PC:READY=0\PL]**. Here 0 is a parameter – an integer number meaning the laser is ready to run.

See system command summary for more information.

**General Commands**

General commands are used to control device sub-sections. The device sub-section is a single-dimension array of numbers or string constants. Elements of an array can be read, written, increased or decreased.

The following example explains the syntax (a command to set the laser amplification level to 50):

**E0/S50**

**E** - the array name. It is a single letter from A-Z
**0** - the index. A number from 0-65535
**/** - a separator.
**S** - the action key. Might be the following: S A P ?. See description below.
**50** - the parameter. The parameter can be a real or integer number.

The action key **S** (SET) writes the parameter.
The action key **A** (ADD) increases or decreases the parameter.
The action key **P** (PROGRAM) makes the parameter NONVOLATILE; used in devices where constants are saved in EEPROM.
A question mark (?) indicates an inquiry. The device replies to an inquiry by an answer of the same syntax. For example, if the amplification level is set to 50, device answers **E0/S50** to inquiry **E0/?**.

Not all action keys are valid for every sub-section.

See the general command summary for more information.

### Connection several devices to a single serial port

There is possibility to connect several devices in series. For this command **ECHO** is reserved. After command ECHO is received, device starts to echo received symbols to transmit channel.

### Communication testing

Because the communication is text string based, it is easy to test remote connection and commands by help of any terminal program. Windows users may use HyperTerminal. Go Start→Accessories→Communications→HyperTerminal.

The simplest way to test the connection is to enter command **[SAY]** in terminal window.

Sender and receiver names may be omitted for a single device connection, so you may enter **[SAY]** instead of **[PL:SAY\PC]**. The device will reply with **[MS:READY\XX]**.
XX is the device name.

### Hardware

#### *Serial connection cable*

The following connections must be made:

9 pin connector

| Connector "RS232" of PLXXXX, PGXXX, NLXXX, PS5021 | RS232 port of PC |
|---|---|
| pin 5 | pin 5 (GND) |
| pin 2 | pin 2 (RxD) |
| pin 3 | pin 3 (TxD) |

25 pin connector

| Connector "RS232" of PLXXXX, PGXXX, NLXXX, PS5021 | RS232 port of PC |
|---|---|

| | |
|---|---|
| pin 5 | pin 7 (GND) |
| pin 2 | pin 3 (RxD) |
| pin 3 | pin 2 (TxD) |

***Serial port settings***

The data exchange parameters must be set in the following way:

- baud rate: 19200 bd
- data bits: 8
- parity: none
- stop bits: 1

### 2.6.4. RS232 Commands summary

- Consult the topic 'RS232 protocol description' for command syntax.

**System commands**

PC commands:

| Command | Response | Description |
|---|---|---|
| VER | VER=string | Returns a string containing software version information |
| SN | SN=string | Returns a string containing hardware version information |
| START | START=int | Tries to set the PS5021 to RUN mode; int - a bit mask showing possible errors; see description below |
| STOP | | Stops the PS5021 |
| SAY | READY=int | Checks the laser state; int - a bit mask showing possible errors; see description below. Zero means readiness to RUN |

int - integer number in ASCII string form

PS5021 reports:

| Command | Description |
|---|---|
| PowerON | PowerON procedure is started |
| READY=xx | Laser status |

**General commands**

| Parameter | Keys | Type | Bounds | Description | Dimension |
|---|---|---|---|---|---|
| U0 | SA?P | int | 0..500 | Set voltage | [V] |
| U2 | ? | int | 0..2200 | Measured | [V] |
| W0 | SA?P | int | 100..40000 | Pulse width oscillator | [µs] |
| D0 | SA?P | int | 0..30000 | Trig delay | [µs] |
| D2 | SA?P | int | 0..30000 | Sync out delay | [µs] |
| D3 | SA?P | int | 0..30000 | Delayed sync out delay | [µs] |

| | | | | | |
|---|---|---|---|---|---|
| C0 | SA?P | int | 0..1 | Sync mode | [internal, external] |
| C1 | SA?P | int | 0..1 | Enable | [disabled, enabled] |
| S0 | SA?P | int | 0..2 | Command | [STANDBY,STOP,RUN] |
| S1 | ? | int | 0..4 | State | [standby, ignition, stop, run, failure] |
| F0 | SA?P | int | 1..10000 | Pulse repetition rate | 0.1 Hz |
| P0 | SA? | int | 0..4294967295 | Pulses counter | |

**Basic error messages**

Error messages allow to determine the cause of PS5021 malfunction. A message in form [MS:*message*\PS] is sent to RS232 in case of some failure detected. For *message*, see the table column 'Message'. The same messages also appear in control pad. If several failures are detected at once, the control pad shows only the primary one. To check the laser remotely, use START and SAY commands. A response from device contains status information. See column 'Mask' for message decoding.

| Mask/Code | Message | Source | Description |
|---|---|---|---|
| 0x0004 | BadPar | | Bad pulse parameters: Pulse width / Voltage / Frequency... |
| 0x0010 | PowerDown | Power supply comparator | Pulse counters saved, PS5021 is going into STANDBY state |
| 0x0020 | OvervoltOsc | Charger | Overvoltage on capacitor detected |
| 0x0080 | ThermoOsc | Charger | Overheat |
| 0x0200 | CurrentOsc | Flash lamp | No simmer current is detected in channel |
| 0x0800 | Interlock | Interlock | Interlock circuit is open |
| 0x1000 | Connector | HV connector block | HV connector not secured |
| 0x2000 | NoChargeOsc | Charger | Low charge current |

## 2.7. OPERATION

### 2.7.1. Installation

2.7.1.1. Ground the Power Supply.

2.7.1.2. Connect flash lamp to high voltage sockets "+" and "-" matching the polarity in each channel. *Tighten ferrule nuts on HV connectors and adjust small screwbolts for disabling HV connectors' blocking. Consider triggering of blocking micro switches mounted between high voltage sockets.*

2.7.1.3. Connect external blocking circuit to "INTERLOCK" and "EXT TRIGG ON/OFF" sockets. *Normally open contacts of the cooling system can be used. The power supply unit can be turned on only when the "INTERLOCK" and "EXT TRIGG ON/OFF" circuit has been shortened throw external circuit.*

2.7.1.4. Connect power cable to the socket "~380 V" and plug to the mains

### 2.7.2. Getting ready

2.7.2.1. Switch the power supply on and turn the switch POWER at the front panel in the "ON" position.

2.7.2.2. Set required charging voltage (pulse duration and repetition rate) of OSCILLATOR channel using control panel or via remote control.

2.7.2.3. The safety interlocks - INTERLOCK and EXT TRIGG ON/OFF should be shortened for normal operation.

2.7.2.4. Enter flash-lamp impedance from front panel. The impedance should be calculated according to following equation:

$$k = 1{,}28 \cdot \left(\frac{l}{d}\right) \cdot \left(\frac{p}{x}\right)^{0.2};$$

$l$ - arc length;

$d$ - bore diameter;

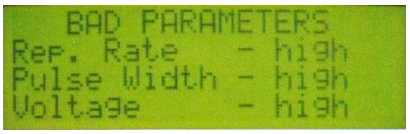
$p$ - flashlamp fill pressure, Torr;

$x$ = 450 for Xe, 800 for Kr.

### 2.7.3. Operation in internal triggering mode

2.7.3.1. Push button RUN in order to start pulsing.

2.7.3.2. In the case of incorrect settings, the following screen will be indicated:




"Rep. Rate" - decrease pulse repetition rate.
"Pulse Width'- decrease pulse duration.
"Voltage" - decrease set output voltage.

2.7.3.3. In order to stop pulsing, press button STOP.

### 2.7.4. Operation in external triggering mode

2.7.4.1. Connect external source of sync. pulses to "SYNC.IN" socket. Parameters of sync. pulses have to comply with requirements listed on the first page.

*Power supply starts pulsing when triggering pulse is applied at the repetition rate set by external source.*

2.7.4.2. To switch the power supply off, turn the switch POWER on the front panel to position "OFF".

*After switching the unit off, all the circuits get current-free and during the following 2 min as capacitor bank discharges through internal shunt (relay-triggered process).*

If frequency of synchronization pulses appears too high for capacitor bank to manage reaching the pre-defined voltage, synchronization pulse is ignored. Charge is initiated by the first next pulse after capacitor bank completes charging.

### 2.7.5. Activation of safety circuits & blockings set

Power supply PS5021 is provided with safety circuits & blockings set ensuring safe and consistent performance of the device. Emergency occurrences are displayed on the control panel. At safety activation, both simmer glowing and capacitor bank charging is canceled, and a relay initiates the latter discharging. In such cases, the device must necessarily be re-switched on manually or by mean of remote control "Power On/Off"

*Power supply features forced air cooling of heated nodes. Operation of power supply with covers lifted is **not advisable**: as air stream changes direction, thermal sensor becomes overheated and initiates turning all the power parts off.*

# 3. Laser Specifications

| Description | |
|---|---|
| Central wavelength | fixed, 2940nm |
| Repetition rate | 1Hz - 10Hz(selectable) |
| Pulse width | ~140ns |
| Operating modes | pulsed |
| Pulse timing stability | To be specified |
| Beam quality | $M^2 < 1,5$ |
| Maximal energy per pulse at fiber port | > 15mJ |
| Fiber coupling type high power | SMA |
| Max. power drift | ± 5% of average / 2 hours |
| Polarization | random |
| Beam waist location | to be specified |
| Automatic energy control | available (resolution to be specified) |
| Optical module | 600mm x 200mm x 200mm |
| Mechanical design | designed for indoor operation (can be installed in a mobile rack) |
| Operating temperature | 15°C to 26°C |
| Cooling method | close loop, distilled water / water |
| Mounting method | state of the design and manufacturing |
| Pump source lifetime | > 75M pulses |
| Q-switch lifetime | >> 100M shots expected |
| Coolant treatment interval | > 6 month |

All required safety means shall be implemented in order to resemble to class 4 laser system.

# 4. Warranty

IMPEX – HighTech ERB 15 Laser OEM Product Line are warranted to be free of defects in materially and workmanship for 12 month from date of shipment. The warranty shall not cover any damage incurred during shipping. When the product is received by the customers, the shipping container and its content should be inspected for any damage incurred during shipping. In order to obtain service under this warranty, the customer must notify IMPEX – HighTech of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. In all cases the customer will be responsible for properly packing and shipping the product back to IMPEX – HighTech, with shipping charges prepaid. If the product is not properly packed, it will be damaged in shipping and the warranty will be avoided.
This warranty shall not apply to any defect, failure, or damage caused by improper use, failure to observe proper operating procedures per the product specifications, or improper / inadequate maintenance. IMPEX – HighTech shall not be obligated to furnish service under this warranty 1) to repair damage resulting from attempts by personnel (other than IMPEX – HighTech representatives) to repair or service the product; 2) to repair damage resulting from improper use or connection to incompatible equipment; 3) to repair damage resulting from operation outside of the operating environmental specifications of the product; 4) to repair damage resulting from improper packaging of the product in order to return it to
IMPEX – HighTech.