PHAROS
Modular-Design Femtosecond Lasers for Industry and Science

FEATURES
- 100 fs – 20 ps tunable pulse duration
- 4 mJ maximum pulse energy
- 20 W maximum output power
- Single-shot – 1 MHz repetition rate
- Pulse picker for pulse-on-demand mode
- BiBurst
- Automated harmonic generators (up to 5th harmonic)
- CEP stabilization option
- Repetition rate locking to an external source

PHAROS is a series of femtosecond lasers combining multi-millijoule pulse energy and high average power. PHAROS features a mechanical and optical design optimized for both scientific and industrial applications. A compact, thermally-stabilized, and sealed design enables PHAROS integration into various optical setups and machining workstations. Diode-pumped Yb medium significantly reduces maintenance costs and provides a long laser lifetime, while the robust optomechanical design enables stable operation in varying environments.

The tunability of PHAROS allows the system to cover applications normally requiring multiple different laser systems. Tunable parameters include pulse duration (100 fs – 20 ps), repetition rate (single-shot – 1 MHz), pulse energy (up to 4 mJ), and average power (up to 20 W). A pulse-on-demand mode is available using the built-in pulse picker. The versatility of PHAROS can be extended by a variety of options, including carrier-envelope phase (CEP) stabilization, repetition rate locking to an external source, and automated harmonic modules.

PHAROS PH2-SP-1mJ / 6 W, 1 mJ
PHAROS PH2-SP-2mJ / 20 W, 2 mJ
PHAROS PH2-1mJ / 20 W, 1 mJ
PHAROS PH2-20W / 20 W, 400 µJ
PHAROS PH2-10W / 10 W, 200 µJ

Pulse energy vs fundamental repetition rate of PHAROS

Typical pulse duration of PHAROS-PH2-UP

Typical spectrum of PHAROS-PH2-UP
## SPECIFICATIONS

### OUTPUT CHARACTERISTIC

<table>
<thead>
<tr>
<th>Model</th>
<th>PH2-10W</th>
<th>PH2-20W</th>
<th>PH2-4mJ</th>
<th>PH2-1mJ-SP</th>
<th>PH2-2mJ-SP</th>
<th>PH2-UP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum output power</td>
<td>10 W</td>
<td>20 W</td>
<td>10 W</td>
<td>20 W</td>
<td>10 W / 20 W</td>
<td></td>
</tr>
<tr>
<td>Pulse duration</td>
<td>&lt; 290 fs</td>
<td>&lt; 450 fs</td>
<td>&lt; 190 fs</td>
<td>&lt; 100 fs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulse duration tuning range</td>
<td>290 fs – 10 ps (20 ps on request)</td>
<td>450 fs – 10 ps (20 ps on request)</td>
<td>190 fs – 10 ps (20 ps on request)</td>
<td>100 fs – 10 ps</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum pulse energy</td>
<td>0.2 mJ / 0.4 mJ</td>
<td>4 mJ</td>
<td>1 mJ</td>
<td>2 mJ</td>
<td>0.2 mJ / 0.4 mJ</td>
<td></td>
</tr>
</tbody>
</table>

### Repletion rate
- Single-shot – 1 MHz

### Pulse selection
- Single-shot, pulse-on-demand, any fundamental repetition rate division

### Center wavelength
- 1030 ± 10 nm

### Polarization
- Linear, horizontal

### Beam quality, $M^2$

<table>
<thead>
<tr>
<th></th>
<th>&lt; 1.2</th>
<th>&lt; 1.3</th>
<th>&lt; 1.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam diameter</td>
<td>3.2 ± 0.3 mm / 3.9 ± 0.4 mm</td>
<td>6.6 ± 0.6 mm</td>
<td>4.5 ± 0.4 mm</td>
</tr>
</tbody>
</table>

### Beam pointing stability
- < 20 µrad/°C

### Pre-pulse contrast
- < 1 : 1000

### Post-pulse contrast
- < 1 : 200

### Pulse-to-pulse energy stability
- < 0.5% RMS deviation over 24 h

### Long-term power stability
- < 0.5% RMS deviation over 100 h

## OPTIONAL EXTENSIONS

### Oscillator output
Optional. Contact sales@lightcon.com for more details

### Typical output
- 1 – 6 W, 50 – 250 fs, ≈ 1035 nm, ≈ 76 MHz; available simultaneously

### Harmonic generator
- Integrated, optional (see page 8)

### Optical parametric amplifier
- Integrated, optional (see page 15)

### BiBurst option
- Tunable GHz and MHz burst with burst-in-burst capability, optional (see page 9)

#### GHz-Burst
- Intra burst pulse period | 200 ± 40 ps |
- Number of pulses, $P$ | 1 – 25 |

#### MHz-Burst
- Intra burst pulse period | ≈ 15 ns |
- Number of pulses, $N$ | 1 – 9 (7 with FEC) |

## PHYSICAL DIMENSIONS

- Laser head (L x W x H) | 730 × 419 × 230 mm | 843 × 492 × 250 mm | 730 × 419 × 230 mm |
- Chiller (L x W x H) | 590 × 484 × 267 mm |
- 24 V DC power supply (L x W x H) | 280 × 144 × 49 mm |

## ENVIRONMENTAL & UTILITY REQUIREMENTS

- Operating temperature | 15 – 30 °C (air conditioning recommended) |
- Relative humidity | < 80% (non-condensing) |
- Electrical requirements | 100 V AC, 12 A – 240 V AC, 5 A; 50 – 60 Hz |
- Rated power | 1000 W |
- Power consumption | 600 W |
- Electrical requirements (chiller) | 100 – 230 V AC; 50 – 60 Hz |
- Rated power (chiller) | 1400 W |
- Power consumption (chiller) | 1000 W |

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¹⁾ More models are available on request.
²⁾ Assuming Gaussian pulse shape.
³⁾ Pulse duration can be reduced to < 250 fs if pulse peak intensity of > 50 GW/cm² is tolerated by customer setup.
⁴⁾ Precise wavelength for specific models are available on request.
⁵⁾ FW 1/e², measured at laser output, using maximum pulse energy.
⁶⁾ Under stable environmental conditions.

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DANGER: VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT, REFLECTED OR SCATTERED RADIATION CLASS 4 LASER PRODUCT

³⁾ Normalized to average pulse energy, NRMSD.
⁴⁾ Maximum number of pulses in a burst depends on the laser repetition rate. Custom number of pulses are available on request.
⁶⁾ Dimensions depend on laser configuration and integrated options.
**STABILITY MEASUREMENTS**

**Long-term power stability of PHAROS**

**Output power of industrial-grade PHAROS lasers operating 24/7 and current of pump diodes during the years**

**PHAROS output power and beam direction with power lock enabled, under harsh environmental conditions**
CEP STABILIZATION

PHAROS lasers can be equipped with feedback electronics for carrier-envelope phase (CEP) stabilization of the output pulses. The carrier-envelope offset (CEO) of the PHAROS oscillator is actively locked to 1/4th of the repetition rate with a < 100 mrad standard deviation. The CEP stable pulses from the synchronized amplifier have a < 350 mrad standard deviation. The CEP drift occurring inside the amplifier and the user’s setup can be compensated with an out of loop f-2f interferometer, which is a part of the complete PHAROS active CEP stabilization package.

REPETITION RATE LOCKING

The oscillator of PHAROS laser can be customized for repetition rate locking applications. Coupled with the necessary feedback electronics, the repetition rate is synchronized to an external RF source using the two piezo stages installed inside the cavity.

The repetition rate locking system can assure an integrated timing jitter of less than 200 fs for RF reference frequencies larger than 500 MHz. Continuous phase shifting is available on request.

DRAWINGS

PHAROS-PH2 drawing

PHAROS-PH2-4mJ drawing