

# High repetition rate Tunable Wavelength Femtosecond OPCPA Systems



UltraFlux HR series is a compact high repetition rate tunable wavelength femtosecond laser system which incorporates the advantages of dual output ultrafast fiber laser, solid-state and parametric chirped pulse amplification technologies.

A novel OPCPA front-end technology uses a dual output picosecond fiber laser for seeding both picosecond DPSS pump laser and femtosecond parametric amplifier with a spectrally broadened output.

This approach greatly simplifies the system – excludes femtosecond regenerative amplifier and eliminates the need of pump and seed pulse synchronization while ensuring practically zero jitter between the channels. In addition to that, contrast of the output pulses in picosecond to nanosecond time scale is enhanced.

All UltraFlux series laser systems are assembled on a rigid breadboard or optical table to ensure excellent long-term stability. Modular internal design offers high level of customization and easy scalability. All of these systems can be customized according to customer requirements by adding custom specifications or multiple channels.

Incorporation of parametric chirped pulse amplification technology together with a novel ultrafast fiber laser helped to create and bring to the market a new tool for femtosecond pump-probe, nonlinear spectroscopy, emerging high harmonic generation experiments and other femtosecond and nonlinear spectroscopy applications. With this laser ultrafast science breakthrough is closer to any photonics lab than ever before.

## UltraFlux HR SERIES

### FEATURES

- ▶ Based on the novel OPCPA (Optical Parametric Chirped Pulse Amplification) technology
- ▶ Patented front-end design (patents no. EP2827461 and EP2924500)
- ▶ 750 – 960 nm, 375 – 480 nm, 250 – 320 nm and 210 – 230 nm wavelength tuning ranges
- ▶ Up to 14 mJ pulse energy at 1 kHz repetition rate
  - Excellent pulse energy stability:  $\leq 1\%$  RMS
  - Excellent long-term average power stability:  $\leq 1.5\%$  RMS over 8-hour period
- ▶ Perfectly synchronized fs and ps output option available
- ▶ Hands free wavelength tuning
- ▶ High contrast pulses without any additional improvement equipment

### APPLICATIONS

- ▶ Broadband CARS and SFG
- ▶ Femtosecond pump-probe spectroscopy
- ▶ Nonlinear spectroscopy
- ▶ High harmonic generation

## SPECIFICATIONS

| Model                                          | UltraFlux FT031k                         | UltraFlux FT31k                          | UltraFlux FT61k                                            | UltraFlux FT141k                                           |
|------------------------------------------------|------------------------------------------|------------------------------------------|------------------------------------------------------------|------------------------------------------------------------|
| <b>MAIN SPECIFICATIONS <sup>1)</sup></b>       |                                          |                                          |                                                            |                                                            |
| Output energy <sup>2)</sup>                    |                                          |                                          |                                                            |                                                            |
| Signal                                         | 300 $\mu$ J                              | 3 mJ                                     | 6 mJ                                                       | 14 mJ                                                      |
| SH output <sup>3)</sup>                        | 60 $\mu$ J                               | 0.6 mJ                                   | 1.5 mJ                                                     | 3.5 mJ <sup>4)</sup>                                       |
| TH output <sup>3)</sup>                        | 15 $\mu$ J                               | 150 $\mu$ J                              | 0.4 mJ                                                     | 1.2 mJ <sup>4)</sup>                                       |
| FH output <sup>3)</sup>                        | 3 $\mu$ J                                | 30 $\mu$ J                               | 100 $\mu$ J                                                | 300 $\mu$ J <sup>4)</sup>                                  |
| Pulse repetition rate                          | 1 kHz                                    | 1 kHz                                    | 1 kHz                                                      | 1 kHz                                                      |
| Wavelength tuning range                        |                                          |                                          |                                                            |                                                            |
| Signal <sup>5)</sup>                           | 750 – 960 nm                             | 750 – 960 nm                             | 750 – 960 nm                                               | 750 – 960 nm                                               |
| SH output <sup>3)</sup>                        | 375 – 480 nm                             | 375 – 480 nm                             | 375 – 480 nm                                               | 375 – 480 nm                                               |
| TH output <sup>3)</sup>                        | 250 – 320 nm                             | 250 – 320 nm                             | 250 – 320 nm                                               | 250 – 320 nm                                               |
| FH output <sup>3)</sup>                        | 210 – 230 nm                             | 210 – 230 nm                             | 210 – 230 nm                                               | 210 – 230 nm                                               |
| Scanning steps                                 |                                          |                                          |                                                            |                                                            |
| Signal                                         | 5 nm                                     | 5 nm                                     | 5 nm                                                       | 5 nm                                                       |
| SH output <sup>3)</sup>                        | 5 nm                                     | 5 nm                                     | 5 nm                                                       | 5 nm                                                       |
| TH output <sup>3)</sup>                        | 3 nm                                     | 3 nm                                     | 3 nm                                                       | 3 nm                                                       |
| FH output <sup>3)</sup>                        | 2 nm                                     | 2 nm                                     | 2 nm                                                       | 2 nm                                                       |
| Pulse duration <sup>5) 7)</sup>                | 40 $\pm$ 20 fs                           | 40 $\pm$ 20 fs                           | 40 $\pm$ 20 fs                                             | 40 $\pm$ 20 fs                                             |
| Pulse energy stability <sup>8)</sup>           | $\leq$ 1.5 %                             | $\leq$ 1 %                               | $\leq$ 1 %                                                 | $\leq$ 1 %                                                 |
| Long-term power drift <sup>9)</sup>            | $\pm$ 1.5 %                              | $\pm$ 1.5 %                              | $\pm$ 1.5 %                                                | $\pm$ 1.5 %                                                |
| Beam spatial profile                           | Gaussian                                 | Super-Gaussian <sup>10)</sup>            | Super-Gaussian <sup>10)</sup>                              | Super-Gaussian <sup>10)</sup>                              |
| Beam diameter <sup>11)</sup>                   | $\sim$ 2 mm                              | $\sim$ 5 mm                              | $\sim$ 7 mm                                                | $\sim$ 15 mm                                               |
| Beam pointing stability <sup>12)</sup>         | $\leq$ 30 $\mu$ rad                      | $\leq$ 30 $\mu$ rad                      | $\leq$ 30 $\mu$ rad                                        | $\leq$ 30 $\mu$ rad                                        |
| Temporal contrast <sup>13)</sup>               |                                          |                                          |                                                            |                                                            |
| APFC (within $\pm$ 50 ps)                      | 10 <sup>10</sup> : 1                     | 10 <sup>10</sup> : 1                     | 10 <sup>10</sup> : 1                                       | 10 <sup>10</sup> : 1                                       |
| Pre-pulse ( $\leq$ 50 ps)                      | 10 <sup>8</sup> : 1                      | 10 <sup>8</sup> : 1                      | 10 <sup>8</sup> : 1                                        | 10 <sup>8</sup> : 1                                        |
| Post-Pulse ( $>$ 50 ps)                        | 10 <sup>8</sup> : 1                      | 10 <sup>8</sup> : 1                      | 10 <sup>8</sup> : 1                                        | 10 <sup>8</sup> : 1                                        |
| Optical pulse jitter <sup>14)</sup>            |                                          |                                          |                                                            |                                                            |
| Trig out                                       | $\leq$ 100 ps                            | $\leq$ 100 ps                            | $\leq$ 100 ps                                              | $\leq$ 100 ps                                              |
| Pre-Trig out                                   | $\leq$ 50 ps                             | $\leq$ 50 ps                             | $\leq$ 50 ps                                               | $\leq$ 50 ps                                               |
| With –PLL option                               | $\leq$ 2 ps                              | $\leq$ 2 ps                              | $\leq$ 2 ps                                                | $\leq$ 2 ps                                                |
| Polarization                                   | Linear, Horizontal                       | Linear, Horizontal                       | Linear, Horizontal                                         | Linear, Horizontal                                         |
| <b>PHYSICAL CHARACTERISTICS <sup>15)</sup></b> |                                          |                                          |                                                            |                                                            |
| Laser head size (W×L×H mm)                     | 750 × 1200 × 300                         | 900 × 1500 × 300                         | 900 × 1800 × 300                                           | 1200 × 2000 × 300                                          |
| Power supply size (W×L×H mm)                   | 553 × 600 × 850                          | 553 × 600 × 850                          | 553 × 600 × 850                                            | 553 × 600 × 1250                                           |
| Umbilical length <sup>16)</sup>                | 2.5 m                                    | 2.5 m                                    | 2.5 m                                                      | 2.5 m                                                      |
| <b>OPERATING REQUIREMENTS <sup>17)</sup></b>   |                                          |                                          |                                                            |                                                            |
| Electrical power                               | 200 – 240 V AC, single-phase, 47 – 63 Hz | 200 – 240 V AC, single-phase, 47 – 63 Hz | 208, 380 or 400 V AC, three-phase, 50/60 Hz <sup>18)</sup> | 208, 380 or 400 V AC, three-phase, 50/60 Hz <sup>18)</sup> |
| Power consumption <sup>19)</sup>               | $\leq$ 1 kW                              | $\leq$ 2 kW                              | $\leq$ 5 kW                                                | $\leq$ 8 kW                                                |
| Water supply                                   | not required                             | not required                             | not required                                               | $\leq$ 5 l/min, 2 Bar, max 20 °C                           |
| Operating ambient temperature                  | 22 $\pm$ 2 °C                            | 22 $\pm$ 2 °C                            | 22 $\pm$ 2 °C                                              | 22 $\pm$ 2 °C                                              |
| Storage ambient temperature                    | 15 – 35 °C                               | 15 – 35 °C                               | 15 – 35 °C                                                 | 15 – 35 °C                                                 |
| Relative humidity (non-condensing)             | $\leq$ 80 %                              | $\leq$ 80 %                              | $\leq$ 80 %                                                | $\leq$ 80 %                                                |
| Cleanliness of the room                        | ISO Class 7                              | ISO Class 7                              | ISO Class 7                                                | ISO Class 7                                                |

<sup>1)</sup> Due to continuous improvement, all specifications are subject to change without notice. The parameters marked 'typical' are indications of typical performance and will vary with each unit we manufacture. Presented parameters can be customized to meet customer's requirements.

<sup>2)</sup> Maximum pulse energy specified at 840 nm, SH output at 420 nm, TH output at 280 nm and FH output at 210 nm.

<sup>3)</sup> Harmonic outputs are optional. Specifications valid with respective harmonic module purchased. Outputs are not simultaneous. Maximum harmonic energy depends on OPCPA signal beam profile and pulse duration.



- 4) Maximum pump energy for harmonics limited to 10 mJ @ 840 nm.
- 5) Optional extended tuning range of 700 – 1010 nm available upon request.
- 6) Standard pulse duration changes though the wavelength range – shortest pulse duration is achieved ~840 nm spectral range.
- 7) Separate 'F10' option can be ordered to reduce pulse duration to  $\leq 10$  fs. Wavelength tunability not available with 'F10' option.
- 8) Under stable environmental conditions, normalized to average pulse energy (RMS, averaged from 60 s).
- 9) Measured over 8 hours period after 30 min warm-up when ambient temperature variation is less than  $\pm 2$  °C.
- 10) Super-Gaussian spatial mode of 6-11<sup>th</sup> order in near field.
- 11) Beam diameter is measured at signal output at  $1/e^2$  level for Gaussian beams and FWHM level for Super-Gaussian beams.
- 12) Beam pointing stability is evaluated as movement of the beam centroid in the focal plane of a focusing element (RMS, averaged from 30 s).
- 13) Pulse contrast is only limited by amplified parametric fluorescence (APFC) in the temporal range of ~90 ps which covers OPCPA pump pulse duration and is better than  $10^7:1$ . APFC contrast depends on OPCPA saturation level. Our OPCPA systems are ASE-free and pulse contrast value in nanosecond range is limited only by measurement device capabilities (third-order autocorrelator). There are no pre-pulses generated in the system and post-pulses are eliminated by using wedged transmission optics.
- 14) Optical pulse jitter with respect to electrical outputs:  
 – Trig out > 3.5 V @ 50  $\Omega$   
 – Pre-Trig out > 1 V @ 50  $\Omega$   
 – PLL option > 1 V @ 50  $\Omega$
- 15) System sizes are preliminary and depend on customer lab layout and additional options purchased.
- 16) Longer umbilical with up to 10 m for flash lamp pumped and up to 5 m for diode pumped systems available upon request.
- 17) The laser and auxiliary units must be settled in such a place void of dust and aerosols. It is advisable to operate the laser in air conditioned room, provided that the laser is placed at a distance from air conditioning outlets. The laser should be positioned on a solid worktable. Access from one side should be ensured.
- 18) Voltage fluctuations allowed are +10 % / -15 % from nominal value.
- 19) Required current rating can be calculated by dividing power rating by mains voltage. Power rating is given in apparent power (kVA) for systems with flash lamp power supplies and in real power (kW) for systems without flash lamp power supplies where reactive power is neglectable.

## OPTIONS

| Option    | Description                                                               | Comment                                                                                                                       |
|-----------|---------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| -F10      | Short Pulse option reduces output pulse duration to $\leq 10$ fs          | Wavelength tunability not available with 'F10' option                                                                         |
| -CEP      | CEP stabilization to $\leq 400$ mrad                                      | Passive and active CEP stabilization                                                                                          |
| -DM       | 'Deformable Mirror' option for Strehl ration improvement to > 0.9         |                                                                                                                               |
| -SH/TH/FH | Second, third and fourth harmonic outputs                                 | Conversion efficiency from signal respectively ~20 %, ~5 % and ~1 %. Harmonic outputs are not simultaneous with signal output |
| -ps out   | Additional ps output that is optically synchronized to main system output | Can be simultaneous and non-simultaneous to the main system output                                                            |
| -AW       | Air-Water cooling                                                         | No external water required. Heat dissipation equals total power consumption                                                   |

## PERFORMANCE

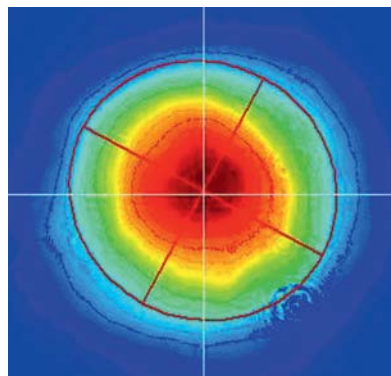


Fig 1. Typical UltraFlux FT031k near field beam profile

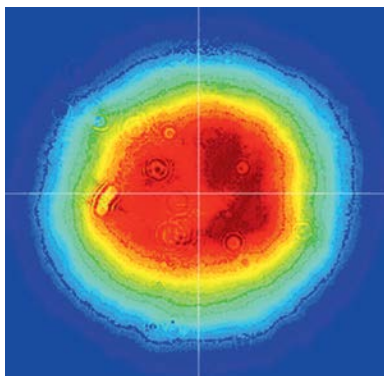


Fig 2. Typical UltraFlux FT31k near field beam profile

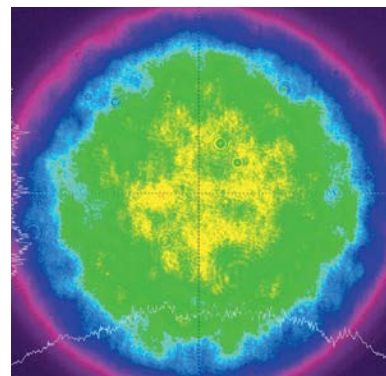


Fig 3. Typical UltraFlux FT61k and FT141k near field beam profile

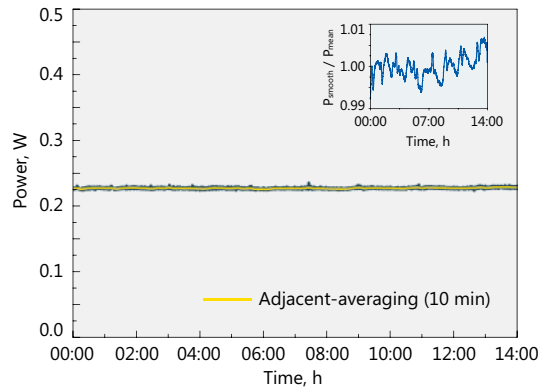


Fig 4. Long-term power stability measurement at 800 nm wavelength

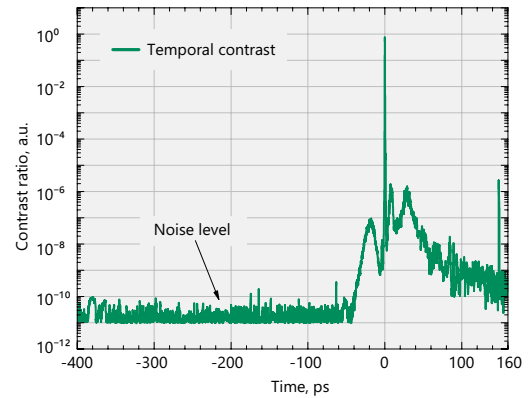


Fig 5. Typical temporal contrast of UltraFlux systems

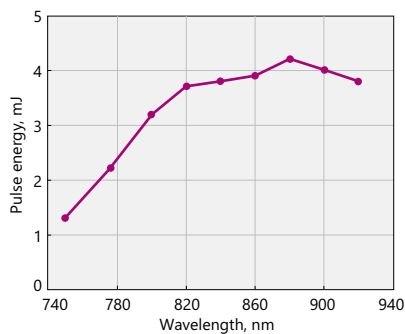


Fig 6. Typical energy tuning curve of UltraFlux FT31k laser system

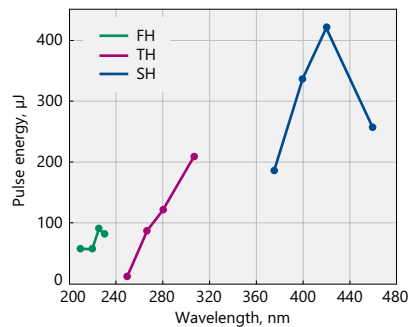


Fig 7. Typical energy tuning curves of UltraFlux FT31k second, third and fourth harmonic outputs

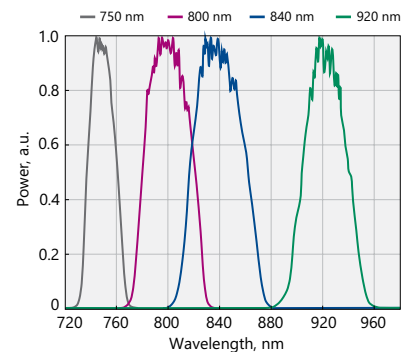


Fig 8. Typical output spectra of UltraFlux FT31k system at multiple wavelengths



Fig 9. Typical external view of UltraFlux FT031k system (actual design might vary)

## OUTLINE DRAWINGS

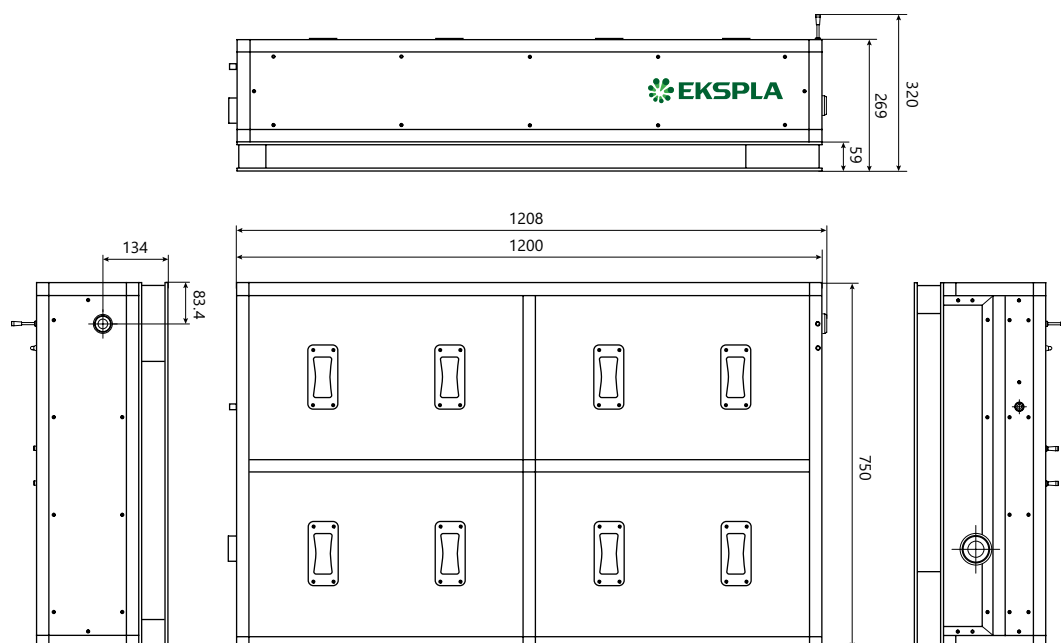


Fig 10. Typical UltraFlux FT031k laser system external dimensions

## POWER SUPPLY

| Cabinet | Usable height | Height H, mm               | Width W, mm | Depth D, mm |
|---------|---------------|----------------------------|-------------|-------------|
| MR-9    | 9 U           | 455.5 (519 <sup>1)</sup> ) | 553         | 600         |
| MR-12   | 12 U          | 589 (653 <sup>1)</sup> )   | 553         | 600         |
| MR-16   | 16 U          | 768 (832 <sup>1)</sup> )   | 553         | 600         |
| MR-20   | 20 U          | 889 (952 <sup>1)</sup> )   | 553         | 600         |
| MR-25   | 25 U          | 1167 (1231 <sup>1)</sup> ) | 553         | 600         |

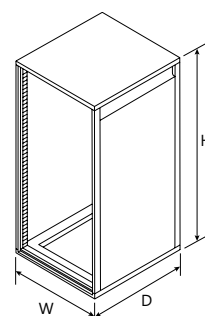
<sup>1)</sup> Full height with wheels.

Fig 11. Typical UltraFlux laser system power supply dimensions (MR rack used depends on the laser model)

## ORDERING INFORMATION

**Note:** Laser must be connected to the mains electricity all the time. If there will be no mains electricity for longer than 1 hour then laser (system) needs warm up for a few hours before switching on.

## UltraFlux (1) (2)(3)-(4)

Model

Fixed or tunable wavelength:  
 FF → fixed wavelength  
 FT → tunable wavelength

Any additional options:  
 See 'Options' table

Pulse repetition rate:  
 1k → 1 kHz

Energy level:  
 03 → 300 μJ  
 3 → 3 mJ  
 6 → 6 mJ  
 14 → 14 mJ

