High Energy Femtosecond OPCPA Systems

UltraFlux HE
SERIES

UltraFlux FF. Custom high pulse energy femtosecond fixed wavelength laser systems delivering up to 1 J pulse energy with pulse duration down to 10 fs.

High Energy UltraFlux laser series delivers up to **30 TW** peak power operating up to 10 Hz.

Originally built for ELI-ALPS (Extreme Light Infrastructure – Attosecond Light Pulse Source) in Hungary, this series is now available for a wide variety of applications.

The master oscillator is a patented (no. EP2827461 and EP2924500) all-in-fiber Yb doped picosecond laser seed source with two fiber outputs. One seeds the OPCPA Front-End and another seeds the Picosecond Pump Laser. Both outputs originate from the same fiber so they are optically synchronized.

This approach eliminates the need for a complex temporal synchronization system typically present in other OPCPA systems.

The Nd:YAG Picosecond Pump Laser system (PPL) is comprised of several sub-systems: diode pumped Regenerative Amplifier, diode pumped Preamplifier, flash lamp pumped Amplifiers, and Second Harmonic Generators which convert fundamental 1064 nm wavelength to 532 nm. PPL outputs multiple beams at 532 nm. One beam is directed to NOPCPA Front-End subsystem and others are directed to NOCPA amplification stages.

The Front-End NOPCPA (Non-collinear Optical Parametric Chirped Pulse Amplifier) consists of several sub-systems: Picosecond Optical Parametric Amplifier (ps-OPA) amplifying oscillator output pulses, Grating Compressor compressing ps-OPA output pulses, White Light Generator (WLG) broadening the spectrum of ps-OPA output pulses and Femtosecond Non-collinear Optical Parametric Amplifier (fs-NOPA) amplifying WLG output pulses.

The Stretcher sub-system is a Grism (diffraction gratings combined together with prisms) or Offner type pulse stretcher, which stretches output pulse from NOPCPA Front-End and Dazzler (optional Acousto-Optic Programmable Dispersive Filter) for high order phase compensation.

FEATURES

- *Based on the novel **OPCPA** (Optical Parametric Chirped Pulse Amplification) technology*
- *Patented front-end design (patents no. EP2827461 and EP2924500)*
- *Up to **1 J** pulse energy at **5 Hz** repetition rate*
- *From **Single Shot** to **100 Hz** pulse repetition rate*
- *Down to **10 fs** pulse duration*
- *Up to **50 mJ** pulse energy at **100 Hz** repetition rate*
  - *Excellent pulse energy stability: ≤ **1 %** RMS*
  - *Excellent long-term average power stability: ≤ **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*
- *Wake field particle acceleration*
- *X-ray generation*

UltraFlux HE

Multiple stages of NOPCPA (Non-collinear Optical Parametric Chirped Pulse Amplifiers) are used to amplify the stretched pulse from the Stretcher up to 1 J.

Finally, amplified pulses are compressed back down to fs duration in the Pulse Compressor. Bulk glass compressor (combined together with chirped mirror) or traditional diffraction grating compressor can be used depending on pulse duration required and output energy level.

The built-in Output Diagnostics stage ensures reliable, turn-key operation by monitoring critical parameters such as energy, duration, and beam profile.

SPECIFICATIONS

Model	FT310	FT10010	FF50100-F10	FF8005
MAIN SPECIFICATIONS [1]				
Output energy [2]				
Signal	3 mJ	100 mJ	50 mJ	800 mJ
SH output [3]	0.6 mJ	3.5 mJ [4]	3.5 mJ [4]	3.5 mJ [4]
TH output [3]	150 µJ	1.2 mJ [4]	1.2 mJ [4]	1.2 mJ [4]
FH output [3]	30 µJ	300 µJ [4]	300 µJ [4]	300 µJ [4]
Pulse repetition rate	10 Hz	10 Hz	100 Hz	5 Hz
Wavelength tuning range				
Signal	750 – 960 nm	750 – 960 nm	840 nm	840 nm
SH output [3]	375 – 480 nm	375 – 480 nm	420 nm	420 nm
TH output [3]	250 – 320 nm	250 – 320 nm	280 nm	280 nm
FH output [3]	210 – 230 nm	210 – 230 nm	210 nm	210 nm
Scanning steps				
Signal	5 nm	5 nm	–	–
SH output [3]	5 nm	5 nm	–	–
TH output [3]	3 nm	3 nm	–	–
FH output [3]	1 nm	1 nm	–	–
Pulse duration [5] [6]	40 ± 20 fs	40 ± 20 fs	≤ 10 fs	40 ± 20 fs
Pulse energy stability [7]	≤ 1.5 %	≤ 1.5 %	≤ 1 %	≤ 1.5 %
Long-term power drift [8]	± 1.5 %	± 1.5 %	± 1.5 %	± 1.5 %
Beam spatial profile	Super-Gaussian [9]	Super-Gaussian [9]	Super-Gaussian [9]	Super-Gaussian [9]
Beam diameter [10]	~ 5 mm	~ 30 mm	~ 80 mm	~ 70 mm
Beam pointing stability [11]	≤ 20 µrad	≤ 20 µrad	≤ 20 µrad	≤ 20 µrad
Temporal contrast [12]				
APFC (within ± 50 ps)	> 10^{10} : 1	> 10^{10} : 1	> 10^{10} : 1	> 10^{10} : 1
Pre-pulse (50 – 10 ps)	> 10^{8} : 1	> 10^{8} : 1	> 10^{8} : 1	> 10^{8} : 1
Pre-pulse (10 – 1 ps)	> 10^{6} : 1	> 10^{6} : 1	> 10^{6} : 1	> 10^{6} : 1
Post-pulse (beyond 20 ps)	> 10^{6} : 1	> 10^{6} : 1	> 10^{6} : 1	> 10^{6} : 1
Optical pulse jitter [13]				
Trig out	≤ 100 ps	≤ 100 ps	≤ 100 ps	≤ 100 ps
Pre-Trig out	≤ 50 ps	≤ 50 ps	≤ 50 ps	≤ 50 ps
With –PLL option	≤ 2 ps	≤ 2 ps	≤ 2 ps	≤ 2 ps
Polarization	Linear	Linear	Linear	Linear
PHYSICAL CHARACTERISTICS [14]				
Laser head size (W×L×H mm)	900 × 1500 × 300	1200 × 2000 × 300	1200 × 3600 × 500	1500 × 2000 × 500, 2 pc. 1200 × 2500 × 500
Power supply size (W×L×H mm)	553 × 600 × 850	553 × 600 × 1200	553 × 600 × 1020 553 × 600 × 500	553 × 600 × 1800, 2 pc. 553 × 600 × 500
Umbilical length [15]	5 m	5 m	2.5 m	5 m

Femtosecond Lasers
Picosecond Lasers
Nanosecond Lasers

Model	FT310	FT10010	FF50100-F10	FF8005
OPERATING REQUIREMENTS [16]				
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 [17]	208, 380 or 400 V AC, three-phase, 50/60 Hz [17]
Power consumption [18]	≤ 1 kVA	≤ 3.5 kVA	≤ 6 kVA	≤ 11 kVA
Water supply	≤ 3 l/min, 2 Bar, max 20 °C	≤ 6 l/min, 2 Bar, max 20 °C	≤ 10 l/min, 2 Bar, max 20 °C	≤ 14 l/min, 2 Bar, max 15 °C
Operating ambient temperature	22 ± 2 °C	22 ± 2 °C	22 ± 2 °C	22 ± 2 °C
Storage ambient temperature	15 – 35 °C	15 – 35 °C	15 – 35 °C	15 – 35 °C
Relative humidity (non-condensing)	≤ 80 %	≤ 80 %	≤ 80 %	≤ 80 %
Cleanness of the room	ISO Class 7	ISO Class 7	ISO Class 7	ISO Class 7

1) 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.

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

3) 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 is limited to 10 mJ @ 840 nm.

5) Standard pulse duration changes though the wavelength range – shortest pulse duration is achieved ~840 nm spectral range.

6) Separate 'F10' option can be ordered to reduce pulse duration to ≤ 10 fs. Wavelength tunability not available with 'F10' option.

7) Under stable environmental conditions, normalized to average pulse energy (RMS, averaged from 60 s).

8) Measured over 8 hours period after 30 min warm-up when ambient temperature variation is less than ±2 °C.

9) Super-Gaussian spatial mode of 6-11th order in near field.

10) Beam diameter is measured at signal output at $1/e^2$ level for Gaussian beams and FWHM level for Super-Gaussian beams.

11) Beam pointing stability is evaluated as movement of the beam centroid in the focal plane of a focusing element (RMS, averaged from 60 s).

12) Pulse contrast is only limited by amplified parametric fluorescence (APFC) in the temporal range of ~90 ps which covers OPCPA pump pulse duration. 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.

13) Optical pulse jitter with respect to electrical outputs:
– Trig out > 3.5 V @ 50 Ω
– Pre-Trig out > 1 V @ 50 Ω
– PLL option > 1 V @ 50 Ω

14) System sizes are preliminary and depend on customer lab layout and additional options purchased.

15) Longer umbilical with up to 10 m for flash lamp pumped and up to 5 m for diode pumped systems available upon request.

16) 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.

17) Voltage fluctuations allowed are +10 % / -15 % from nominal value.

18) 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 ≤ 10 fs	Wavelength tunability not available with 'F10' option
-CEP	CEP stabilization to ≤ 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	Typical conversion efficiency from signal is ~35 %, ~12 % and ~3 % respectively and depends on beam profile and pulse duration of the system. Harmonic outputs are not simultaneous with signal output
-ps out	Additional narrow spectra ps output that is optically synchronized to main system output	Can be simultaneous and non-simultaneous to the main system output. Offers full optical synchronization to fs pulses
-AW	Air-Water cooling	No external water required. Heat dissipation equals total power consumption

PERFORMANCE

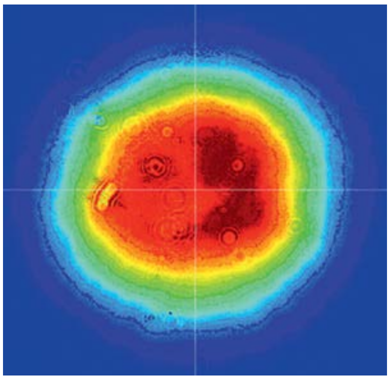

Fig 1. Typical UltraFlux FT310 near field beam profile

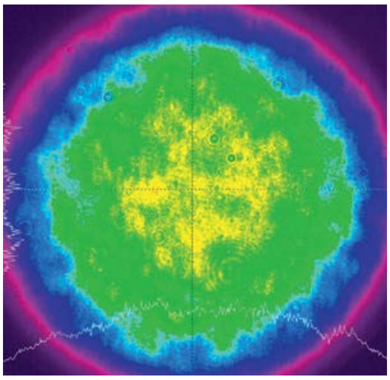

Fig 2. Typical UltraFlux FT10010 and FF50100-F10 near field beam profile

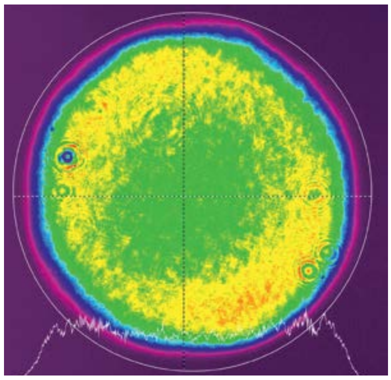

Fig 3. Typical UltraFlux FF8005 near field beam profile

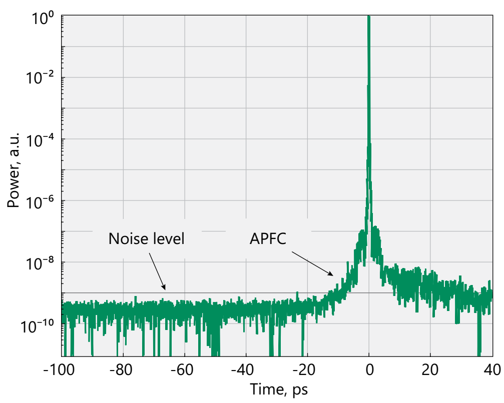

Fig 4. Typical temporal contrast of UltraFlux FF10010 system

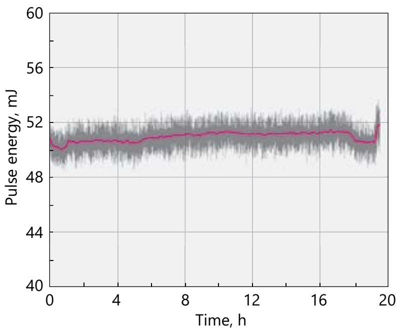

Fig 5. Typical long-term power stability of UltraFlux FF5010-F10 system at 840 nm

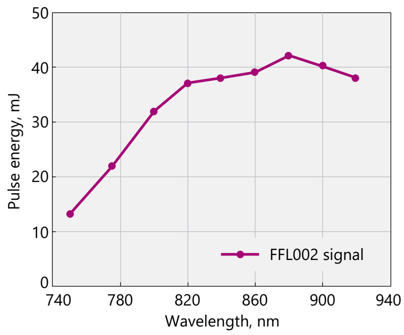

Fig 6. Typical tuning curve of UltraFlux FT4010 laser system

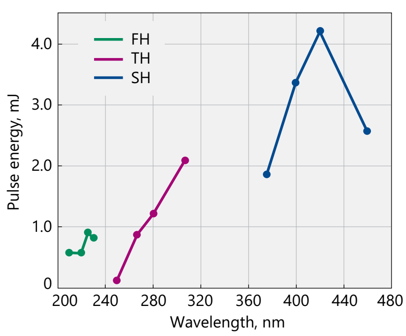

Fig 7. Typical energies of UltraFlux FT4010 second, third and fourth harmonic outputs

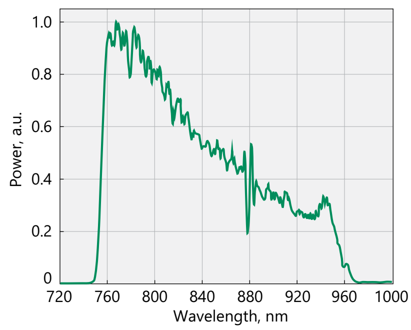

Fig 8. Typical output spectra of UltraFlux FF5010-F10 system

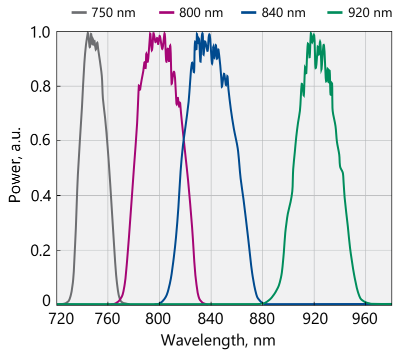

Fig 9. Typical output spectra of UltraFlux FF5010 system at different wavelengths

OUTLINE DRAWINGS

Fig 10. Typical external view of UltraFlux FF5010-F10 system (actual design might vary)

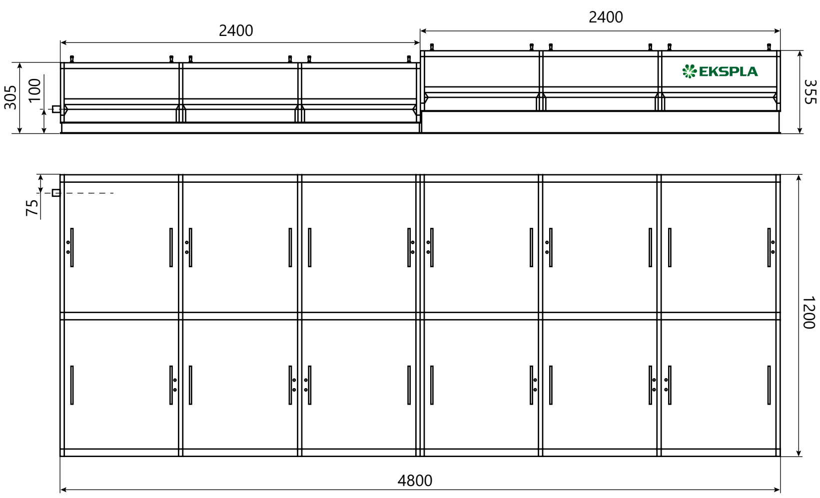

Fig 11. Typical UltraFlux FF5010-F10 laser system external dimensions

POWER SUPPLY

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

[1] Full height with wheels.

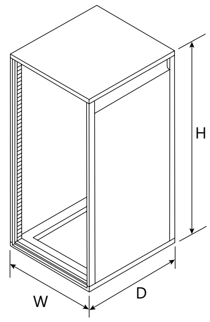

Fig 12. Typical UltraFlux laser system power supply dimensions (MR rack used depends on the laser model)

ORDERING INFORMATION

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

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

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

Energy level:
3 → 3 mJ
50 → 50 mJ
100 → 100 mJ
800 → 800 mJ

Pulse repetition rate:
5 → 5 kHz
10 → 10 Hz
100 → 100 Hz

Any additional options:
See 'Options' table