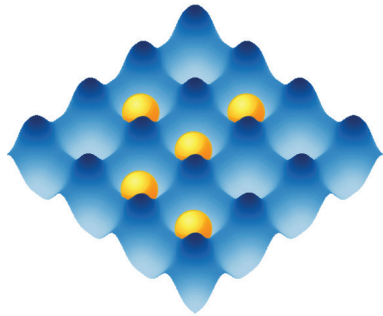


# FC1500-ULN<sup>plus</sup>

## Ultra Low Noise Optical Frequency Comb for Optical Lattice Clocks



The Menlo Systems FC1500-ULN<sup>plus</sup> Ultra Low Noise Optical Frequency Comb is the ideal clockwork for optical lattice clocks. Our all polarization maintaining figure 9<sup>®</sup> mode locking technology together with high bandwidth actuators (>1 MHz) for both the carrier-envelope offset frequency and the repetition rate guarantees ultimate performance.

Ever increasing demands for stability and accuracy of time and frequency signals require improved oscillators and frequency references. Today's best optical clocks rely on narrowband optical transitions and use a frequency comb as a clockwork. The FC1500-ULN<sup>plus</sup> clearly keeps pace with the best optical lattice clocks, which is proven in an out of loop comparison between two independent ULN<sup>plus</sup> Combs. This comparison is an elementary part of every systems' quality check at the Menlo factory. Such Menlo guarantees and proves by measurement that the outstanding spectral purity of the oscillator is transferred perfectly to the desired wavelength for every system delivered to the customer.

**MenloSystems**

**NEW**

### KEY SPECIFICATIONS

- Comb Spacing 250 MHz
- Accuracy  $1 \times 10^{-18}$  ( $\tau > 100$  s)
- Stability:  $5 \times 10^{-18}$  in 1 s,  $5 \times 10^{-19}$  in 1000 s
- Operational Range from 500 nm to 2  $\mu$ m
- Integrated Phase Noise <80 mrad [1 Hz-2 MHz]

### APPLICATIONS

- Optical Lattice Clocks
- Optical Clocks
- Transfer of CW Laser Stability to Full Comb Spectrum from 500 nm to 2  $\mu$ m

### FEATURES

- High Repetition Rate
- High Bandwidth >1 MHz Actuators for CEO and Repetition Rate
- Fully stabilized and qualified HMP-VIS/NIR at custom wavelength (500 nm to 2  $\mu$ m)
- Turnkey Metrology System. Fully automated, including data evaluation software, designed for continuous operation

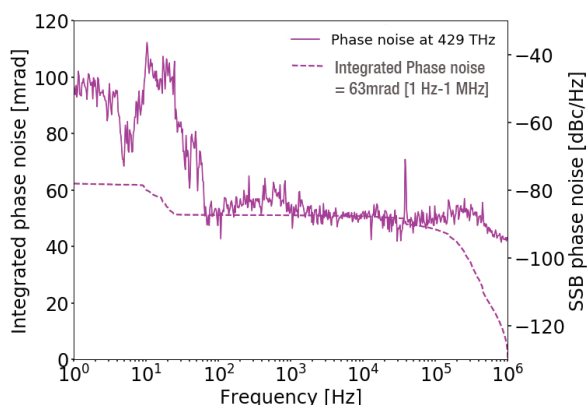
### OPTIONS

#### Complete Solution with Modular Extensions

Menlo Systems Optical Frequency Combs are complete solutions. The modular system architecture allows for easy additions of more functionality to an existing system. Multiple extensions can be combined in a system.

- **M-NIR:** Extension Package
- **M-VIS:** Extension Package
- **HMP:** High Power Measuring Port
- **P250 PM Pulse EDFA:** Erbium-doped Fiber Amplifier
- **M-780:** High Power output around 780 nm
- **BDU:** Beat Detection Unit
- **LLE-SYNCR0:** Laser Locking Electronics
- **Microwave:** Ultrastable RF Output
- **GPS:** -based 10 MHz Frequency Reference
- **WLM-NIR /WLM-VIS:** Integrated Wavelength Meters

#### Phase Noise of Comb-Comb Comparison at 698 nm



Analysis of the out of loop beat signal between two ULN<sup>plus</sup> combs at the Strontium clock transition frequency:

The extremely low phase noise proves that the spectral purity is transferred to the target wavelength, which makes the ULN<sup>plus</sup> a unique clockwork for Strontium and other optical lattice clocks.

# FC1500-ULN<sup>plus</sup>

**MenloSystems**  
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## Ultra Low Noise Optical Frequency Comb for Optical Lattice Clocks

### SPECIFICATIONS

### FC1500-250-ULN<sup>PLUS</sup>

Comb Spacing	250 MHz
Accuracy	$1 \times 10^{-18}$ for $\tau > 100\text{s}^*$
Stability	$5 \times 10^{-18}$ in $1\text{s}^{\Delta}$ , $5 \times 10^{-19}$ in $1000 \text{s}^{\Delta}$
Integrated Phase Noise	$<80 \text{ mrad}$ [1 Hz-2 MHz]
Linewidth	$<1 \text{ Hz}^{**}$
Tuning Range of Spacing Between Individual Comb Lines	$>2 \text{ MHz}$
Tuning Range of CEO Frequency	$>250 \text{ MHz}$
Laser Outputs	five fiber-coupled, linearly polarized, PM output ports
Center Wavelength	1560 nm
Spectral Range	$>25 \text{ nm}$ (500-1050 nm with M-VIS, 1050-2100 nm with M-NIR)
Average Output Power	$>13 \text{ mW}$ from each laser port ( $>60 \text{ mW}$ with M-VIS, $>200 \text{ mW}$ with M-NIR)

\*phase lock to optical reference,  $\Delta$ modified Allan deviation ( $\lambda$ -type counter, timebase 1 ms), \*\*limited by resolution bandwidth of analyzer

### REQUIREMENTS

Input Requirements	cw optical reference, power level approx. 1 mW (see Menlo ORS datasheet) 10 MHz frequency reference, power level +7 dBm
Operating Voltage	100/115/230 VAC
Frequency	50 to 60 Hz
Power Consumption	$<500 \text{ W}$ , $<3\text{kW}$ including chiller
Cooling Requirements	closed cycle chiller included
Operating Temperature	$22 \pm 5 \text{ }^\circ\text{C}$
Optical Unit Dimensions/Weight	706 x 716 mm, approx. 80 kg <sup>***</sup>
Control Electronics Dimensions/Weight	600 x 800 mm, approx. 140 kg <sup>***</sup>

\*\*\*Standard system configuration

### ORDERING INFORMATION

Product Code	FC1500-ULNplus
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Please call for pricing. Specifications are subject to change without notice. Custom modifications are available, please inquire.



Invisible laser radiation  
avoid exposure to beam  
Class 4 laser

**MenloSystems**  
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