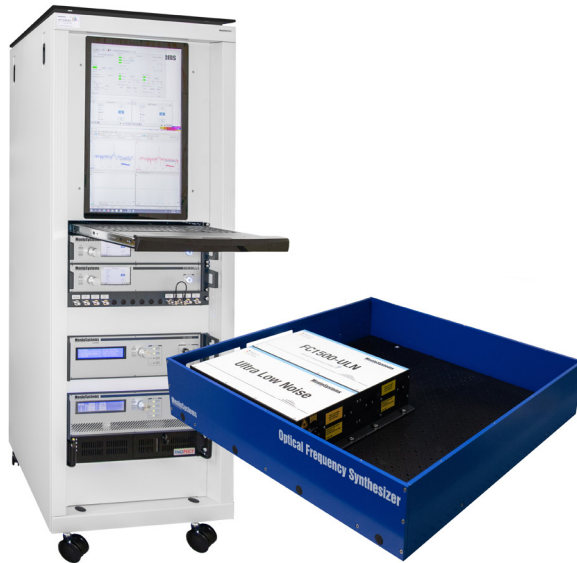


# FC1500-250-ULN

## Ultra Low Noise Optical Frequency Comb



The FC1500-250-ULN Ultra Low Noise Optical Frequency Comb is a compact and versatile fiber-based metrology system. Laser operation relies on the figure 9<sup>®</sup> mode locking technology, which ensures excellent stability and low-noise operation. The femtosecond laser is ready-to-use at the press of a single button, and automatic phase lock loops ensure easy stabilization to either a RF or an optical reference. Thanks to the mature system design, users report long-term uninterrupted operation. With a variety of extension packages and add-ons, systems are exactly tailored to the individual experimental requirements.

Ever increasing demands for stability and accuracy of time and frequency signals require improved frequency references. But even the best optical references have very limited spectral coverage. The FC1500-250-ULN overcomes these limitations by transferring the spectral purity of a stable reference to the entire wavelength range of 500-2000 nm. This unique feature enables the users to compare different (optical) frequency references, stabilize all CW lasers to one absolute frequency reference and use it as a clockwork for optical clocks. The overall stability is evaluated in an out of loop comparison between two independent optical frequency combs, which is integral part of the quality check during factory acceptance of each system. Choose between two variants, depending on the stability and accuracy that you require in your lab.

**MenloSystems**

### KEY SPECIFICATIONS

- Comb Spacing 250 MHz
- Accuracy  $10^{-17}$  ( $\tau > 100$  s)
- Stability:  $1 \times 10^{-16}$  in 1 s,  $1 \times 10^{-18}$  in 1000 s
- Operational Range from 500 nm to 2  $\mu$ m
- Integrated Phase Noise  $< 100$  mrad [100 Hz-2 MHz]

### APPLICATIONS

- FTIR Spectroscopy
- Calibration of Lasers
- High Precision CW Laser Stabilization
- Transfer of CW Laser Stability to Full Comb Spectrum
- Cold Atoms and Ions
- High Resolution Spectroscopy
- Low-noise Microwave Generation

### FEATURES

- High Repetition Rate
- High Bandwidth  $> 1$  MHz Actuators for CEO and Repetition Rate
- Fully Fiber-coupled CEO Frequency Generation
- Turnkey Metrology System. Fully automated, including data evaluation software, designed for continuous operation

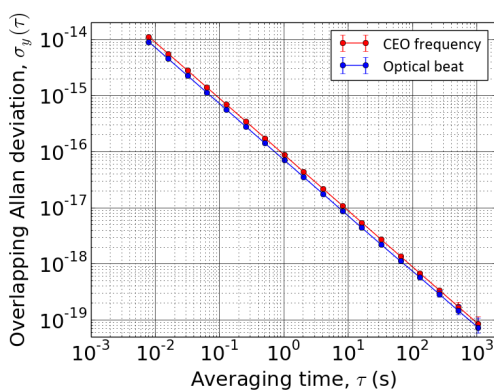
### OPTIONS

#### 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

### STABILITY OF CEO AND OPTICAL REFERENCE BEAT FREQUENCY



Measured with dead-time free  $\pi$ -type counter.

# FC1500-250-ULN

**MenloSystems**

## Ultra Low Noise Optical Frequency Comb

SPECIFICATIONS	FC1500-250-ULN VARIANT 1	FC1500-250-ULN VARIANT 2
Comb Spacing	250 MHz	
Accuracy	$1 \times 10^{-16}$ ( $\tau > 100$ s)*, $1 \times 10^{-14}$ ( $\tau > 1000$ s) $^\Delta$	$1 \times 10^{-17}$ ( $\tau > 100$ s)*, $1 \times 10^{-14}$ ( $\tau > 1000$ s) $^\Delta$
Stability	$\leq 5 \times 10^{-16}$ in 1 s*, $\leq 5 \times 10^{-17}$ in 1000s*, $\leq 5 \times 10^{-13}$ in 1 s $^\Delta$	$\leq 1 \times 10^{-16}$ in 1 s*, $\leq 1 \times 10^{-18}$ in 1000s*, $\leq 5 \times 10^{-13}$ in 1 s $^\Delta$
Integrated Phase Noise	<100 mrad [100 Hz-2 MHz]	
Linewidth	<1 Hz* $^\diamond$	
Tuning Range	>4 MHz (spacing between individual comb lines)	
Tuning Range of CEO Frequency	>250 MHz	
Laser Outputs	five fiber-coupled, linearly polarized, PM output ports, 1560 nm	
Spectral Range	>25 nm (500-1050 nm with M-VIS, 1050-2100 nm with M-NIR)	
Average Output Power	>10 mW from each laser port (>100 mW with M-VIS, >200 mW with M-NIR)	

\*phase lock to optical reference,  $^\Delta$ phase lock to RF reference,  $^\diamond$ limited by resolution bandwidth of analyzer

### SPECIFICATIONS USING THE FC1500-ULN (VAR.1,2 AND PLUS) IN THE TRANSFER OSCILLATOR SCHEME\*\*:

Accuracy	$1 \times 10^{-18}$ ( $\tau > 100$ s)
Stability	$8 \times 10^{-18}$ in 1 s, $5 \times 10^{-20}$ in 1000 s

\*\*see Ref. 1 and Ref. 2 for further details

**Ref. 1:** Benkler, E., Lipphardt, B., Puppe, T., Wilk, R., Rohde, F., Sterr, U., End-to-end topology for fiber comb based optical frequency transfer at the  $10^{-21}$  level. *Optics Express* 2019, Vol. 27, Issue: 25.

**Ref. 2:** <https://www.menlosystems.com/products/optical-frequency-combs/menlo-systems-frequency-comb-technology>

### REQUIREMENTS

Input Requirements	10 MHz frequency reference, power level +7 dBm	cw optical reference, power level approx. 1 mW (see Menlo ORS and ORS-Cubic datasheet)
		10 MHz frequency reference, power level +7 dBm
Operating Voltage	100/115/230 VAC	
Frequency	50 to 60 Hz	
Power Consumption	<500 W	<500 W, <3kW including chiller
Cooling Requirements	no water cooling required	closed cycle chiller included
Operating Temperature	$22 \pm 5$ °C	
Optical Unit Dimensions/Weight	706 x 716 mm, approx. 80 kg (Standard system configuration)	
Control Electronics Dimensions/Weight	600 x 800 mm, approx. 140 kg (Standard system configuration)	

### ORDERING INFORMATION

Product Code	FC1500-250-ULN Variant 1	FC1500-250-ULN Variant 2
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Please call for pricing. Specifications are subject to change without notice. Custom modifications are available, please inquire.

**MenloSystems**



Invisible laser radiation  
avoid exposure to beam  
Class 4 laser

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