

# RUBRIComb™ Frequency Comb

**/ˈrū-bri-kōm/, proper noun**

**A reference, a frequency ruler for precision measurements, a standard for turnkey and reliable optical frequency combs.**



You want an optical frequency comb that keeps your experiment or in-the-field solution running smoothly and efficiently. Frequency combs have a reputation for being complicated instruments that cause downtime at the worst times—that era has now ended with the RUBRIComb™. Redefine reliability with a laser that never lets you down.

The RUBRIComb™ from Vescent is a fully stabilized optical frequency comb with precise control over the repetition rate ( $f_{\text{rep}}$ ), the carrier-envelope offset frequency ( $f_{\text{CEO}}$ ), and the optical reference beat ( $f_{\text{opt}}$ ). At its core is a passively mode-locked erbium-doped fiber oscillator. Our unique approach reduces the system size, weight, and power (SWaP). The complete RUBRIComb™ frequency comb is designed and built to ensure stable, low-phase-noise operation, with Allan Deviations supporting the next generation of optical atomic clocks.

The entire laser, including self and external referencing modules, is contained in a single 2U 19" rack mount chassis. The laser mode-locks at startup every time and is specially designed for a robust, long life. Our unique oscillator design also makes it easy to precisely factory-match the repetition rate of several RUBRIComb™ combs for multi-comb spectroscopy experiments.

## Leading Application Solutions

- Atomic Clocks and Time Transfer
- Quantum Computing
- Dual Comb Spectroscopy

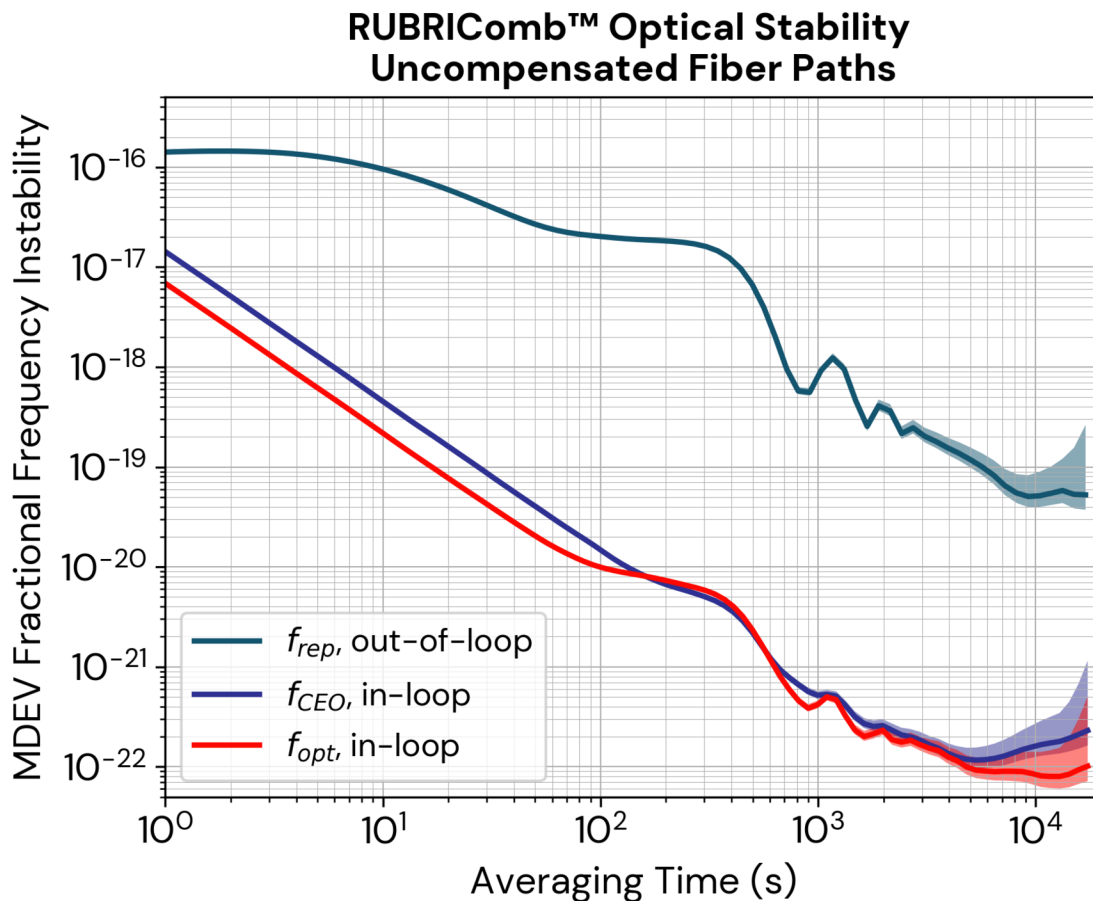


FREQUENCY COMBS | LASERS | CONTROLLERS

# RUBRIComb™ Frequency Comb

## Features

- Turnkey Operation: up and running in 30 minutes
- Low Noise: supports the best optical clocks and more
- Robust: passes demanding shake, vibe, and thermal tests
- Stable: remains locked for months
- Color Support: lock many lasers with additional options
- Deliver: low noise to every laser in your system



### **RUBRIComb™: Exceptional Stability**

This plot highlights the stability of the RUBRIComb optical frequency comb, as measured by the Modified Allan Deviation (MDEV). The log-log axes show the stability between 1 and 10,000 seconds, demonstrating fractional frequency stability that averages below the  $10^{-18}$  level. The out-of-loop trace was measured from the beat note between two RUBRICombs phase-locked to the same optical reference (Stabilaser 1542e) and demonstrates the low-noise of independent comb systems. The in-loop traces of  $f_{CEO}$  (blue) and  $f_{rep}$  (green) showcase the comb's intrinsic noise floor, enabling it to support cutting-edge applications like optical clocks and low-phase-noise microwave generation.



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# RUBRIComb™ Specifications

| Parameter   | Min      | Typical                                  | Max                 | Comments                                       |
|---|----------|--|---------------------|--|
| Center Wavelength                                     |          | 1560 nm                                  |                     |  |
| Repetition Rate                                       |          | 100 MHz (for -100)<br>200 MHz (for -200) |                     |  |
| <b>Optical Outputs</b> - All connectors are PM FC/APC |          |  |                     |  |
| Oscillator Average Output Power                       | 0.01 mW  |  |                     |  |
| Oscillator Optical Bandwidth                          | 18 nm    | 35 nm (for -100)<br>25 nm (for -200)     |                     | FWHM   |
| Amplifier Average Output Power                        | 4 mW     |  |                     |  |
| Amplifier Optical Bandwidth                           | 40 nm    | 70 nm                                    |                     | -10 dB full width                              |
| <b>RF Outputs</b> - All connectors are SMA            |          |  |                     |  |
| $f_{\text{CEO}}$ Signal-to-Noise Ratio                | 35 dB    |  |                     | 100 kHz RBW                                    |
| $f_{\text{CEO}}$ Integrated Phase Noise               |          | 400 mrad                                 | 1000 mrad           | 10 Hz-1 MHz                                    |
| $f_{\text{CEO}}$ Frequency Stability <sup>1</sup>     |          |  | $5 \times 10^{-17}$ | At 1 s, In-loop<br>Modified Allan<br>Deviation |
| $f_{\text{opt}}$ Optical Input Power                  | 0.1 mW   |  | 0.6 mW              |  |
| $f_{\text{opt}}$ Signal-to-Noise Ratio <sup>2</sup>   |          | 40 dB                                    |                     | 100 kHz RBW                                    |
| $f_{\text{opt}}$ Integrated Phase Noise <sup>2</sup>  | 200 mrad |  |                     | 10 Hz-1 MHz                                    |
| $f_{\text{opt}}$ Frequency Stability <sup>1,2</sup>   |          |  | $5 \times 10^{-17}$ | At 1 s, In-loop<br>Modified Allan<br>Deviation |
| $f_{\text{rep}}$ Output Power Level                   | -10 dBm  | 0 dBm                                    | 5 dBm               |  |

<sup>1</sup> Allan Deviation from zero-dead-time lambda counter with 1 s gate time.

<sup>2</sup> Depends on user-supplied optical reference. Data given for 1kHz 1560 nm reference laser with >0.1 mW input power when phase locked with a SLICE-FPGA.



# RUBRIComb™ Specifications Continued...

| Parameter                                       | Min                                      | Typical                                    | Max     | Comments  |
|---|--|--|---------|---|
| <b>Frequency Transducers</b>                    |  |  |         |   |
| $f_{\text{CEO}}$ Tuning Range                   | 100 MHz (for -100)<br>200 MHz (for -200) |  |         | Pump Current Tuning   |
| $f_{\text{CEO}}$ Input Voltage Tuning Range     | -5 V                                     |  | 5 V     | SMA Input   |
| $f_{\text{rep}}$ PZT Tuning Range               | 30 Hz                                    | 60 Hz (for -100)<br>240 Hz (for -200)      |         | Depends on Repetition Rate. Temperature tuning spec allows for larger changes in $f_{\text{rep}}$ . |
| $f_{\text{rep}}$ Input Voltage Tuning Range     | 0 V                                      |  | 6 V     | SMA Input   |
| $f_{\text{rep}}$ Temperature Tuning Range       |  | 25 kHz (for -100)<br>50 kHz (for -200)     |         | Cavity temperature between 20 and 45 °C   |
| $f_{\text{rep}}$ Temperature Tuning Sensitivity |  | 1 kHz/°C (for -100)<br>2 kHz/°C (for -200) |         | Depends on Repetition Rate  |
| <b>Size, Weight, and Power</b>                  |  |  |         |   |
| Line Voltage                                    | 100 VAC                                  |  | 230 VAC | 50/60 Hz  |
| Power Consumption                               |  |  | 40 W    |   |
| Weight  |  | 7.3 kg                                     |         |   |
| Chassis Volume                                  |  | 17 L                                       |         |   |
| Dimensions (in)                                 |  | 19 x 19 x 3.875<br>W x D x H               |         | 2U 19" rack mount   |
| Dimensions (cm)                                 |  | 48.3 x 48.3 x 9.8<br>W x D x H             |         | 2U 19" rack mount   |
| <b>Environmental</b>                            |  |  |         |   |
| Operating Temperature                           | 15 °C                                    |  | 35 °C   | Minimum temp must be above dew point  |
| Storage Temperature                             | -10 °C                                   |  | 70 °C   |   |

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