

Vescent FFC Frequency Combs

The FFC-100 is a fully stabilizable, octave-spanning frequency comb with precise control over f_{rep} , f_{opt} , and f_{CEO} . The Er-doped fiber MOPA architecture is simple and robust, and yet high-performance. A highly non-linear fiber broadens the spectrum and our unique f_{CEO} lock detection reduces the size, weight, and power of the system. The FFC frequency combs are designed and built to ensure stable, low-phase noise operation with Allan Deviations supporting the next generation of optical atomic clocks, gravimeters, quantum computers, optical sensors, and more.

The FFC-100 was designed for low SWaP and turn-key, stable operation: A single 2U 19" rack mount chassis contains the oscillator, amplifier, pump lasers, supercontinuum generation module, and f_{CEO} detection and

lock as well as the control electronics. The simple oscillator mode locks at start up every time and the innovative passive SESAM mode-locker is specially designed for a robust, long life. Our unique oscillator design also makes it easy to precisely factory match the repetition rate of two (or more) FFC-100 combs for multi-comb spectroscopy experiments.



FFC-100 turnkey frequency combs

Features:

- Turn-key operation
- 1560 nm center wavelength
- Low phase & amplitude noise
- 2U 19" rack-mounted enclosure or modular
- f_{rep} monitoring, control, and matching
- Input port for f_{opt}
- Repetition rates from 80 to 250 MHz
- Optional visible extensions
- Optional super continuum flattening
- Made in America

Applications:

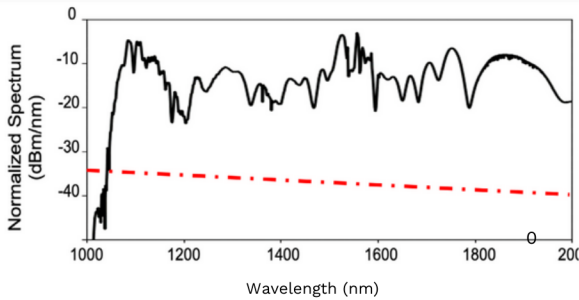
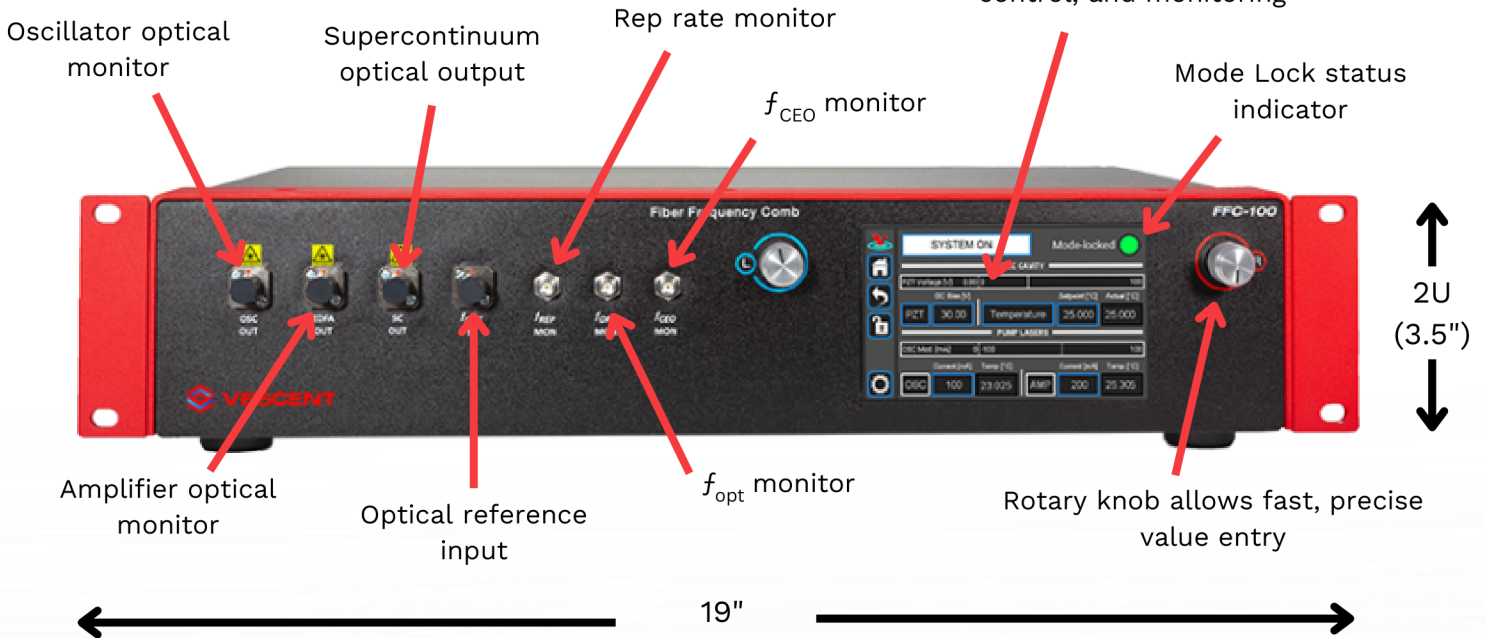
- Time & frequency readout & transfer
- Frequency ruler
- Dual- and multi-comb spectroscopy
- Quantum sensing, computing, & cryptography
- Low-phase noise rf generation



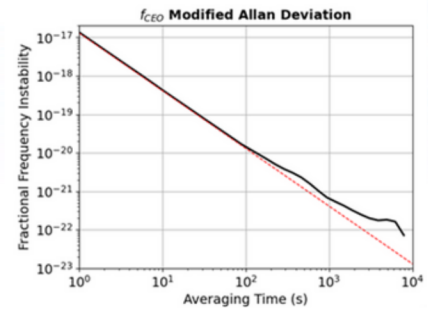
Also available in compact modular form for OEM integration.

Meet the FFC-100

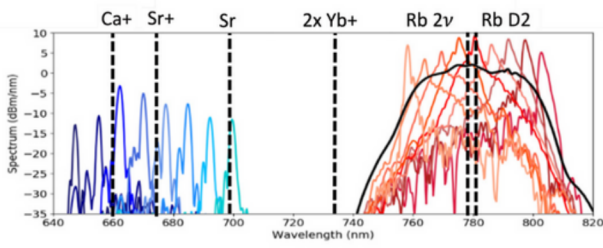
Touch screen for easy set up, control, and monitoring



Full octave-spanning spectrum with optional flattened super-continuum. Dashed line indicates f_{opt} minimum lockable power.



Rock-solid performance of the FFC offers favorable stability with respect to the next generation of atomic clock requirements.



Non-linear extension of comb teeth allows for referencing of f_{opt} in the visible. 700-740 nm also available, but not shown for clarity.



FFC-100 Specifications

Parameter	Min.	Typ.	Max.	Units	Comments
Center Wavelength	1555	1565	1575	nm	
Repetition Rate	100		200	MHz	Standard: 100,125,200 MHz
Optical Powers					All connectors PM FC/APC
Oscillator Average Output Power	0.01			mW	>15 nm optical bandwidth
Amplifier Average Output Power	5			mW	>30 nm optical bandwidth
Supercontinuum Output Power	20			mW	1000-2000 nm spectrum
RF Outputs					All connectors SMA
f_{CEO} Signal-to-Noise Ratio	35			dB	100 kHz RBW
f_{CEO} Integrated Phase Noise			1	rad	10 Hz-1 MHz
f_{CEO} Frequency Stability ²			$5.0 \times 10^{-17} / \tau$	Unitless	In-loop Allan Deviation
f_{opt} Optical Input Power			1	mW	
f_{opt} Signal-to-Noise Ratio ³		40		dB	100 kHz RBW
f_{opt} Integrated Phase Noise ³		300		mrad	10 Hz-1 MHz
f_{opt} Frequency Stability ^{2,3}		$2.5 \times 10^{-17} / \tau$		Unitless	In-loop Allan Deviation
f_{rep} Output Power Level		0		dBm	
Frequency Transducers					
f_{CEO} Tuning Range	100			MHz	Pump current tuning
f_{CEO} Input Voltage Tuning Range	-10		+10	V	SMA input
f_{rep} PZT Tuning Range	30			Hz	Depends on repetition rate. See Temperature tuning spec allows for larger changes in f_{rep} .
f_{rep} Input Voltage Tuning Range	0		+6	V	SMA input
f_{rep} Temperature Tuning Range	25			kHz	Touchscreen control ⁴
f_{rep} Temperature Tuning Sensitivity	0.5			kHz/°C	Depends on Repetition Rate
Size, Weight, and Power					
Line Voltage	90		250	VAC	50/60 Hz
Power Consumption			50	W	
Weight		5.5		kg	
Size		12.3		L	2U rack mount, 43.5 cm Width x 10.5 cm Height x 27 cm Depth

¹ Does not include the SLICE-FPGA controller, which is sold separately.

² Allan Deviation from zero-dead-time L counter with 1s gate time.

³ Depends on user-supplied optical reference. Data given for 1 kHz 1560 nm reference laser with > 0.1 mW input power when phase locked with a SLICE-FPGA.

⁴ Allows access to a slow servo correction mode that automatically changes oscillator cavity temperature so that the PZT is centered in its operating range.