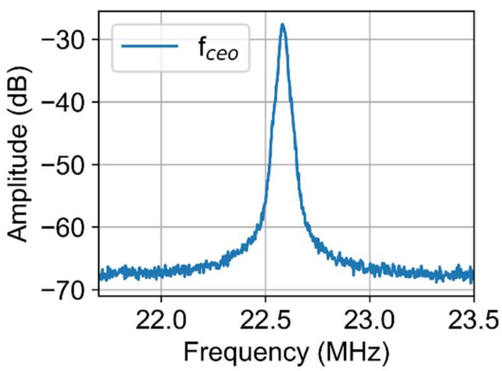
Comb Offset Stabilization Module (COSMO)

Summary: The Octave Photonics Comb Offset Stabilization Module (COSMO) provides a compact and convenient solution for *f-2f* self-referencing a laser frequency comb using nanophotonic waveguide technology. Additionally, the COSMO allows the carrier-envelope-offset frequency (f_{CEO}) to be detected with exceptionally low pulse energies, enabling lower power consumption or higher repetition rates.

Usage: The COSMO connects to the laser with an FC/APC fiber connector and provides an electrical output (SMA) that can be connected to standard stabilization electronics. The pulse must be compressed at the entrance to the COSMO housing, so an appropriate length of fiber and/or dispersion-compensating fiber should be used by the customer. Additionally, control over the input pulse energy allows the signal-to-noise ratio of the f_{CEO} signal to be optimized.



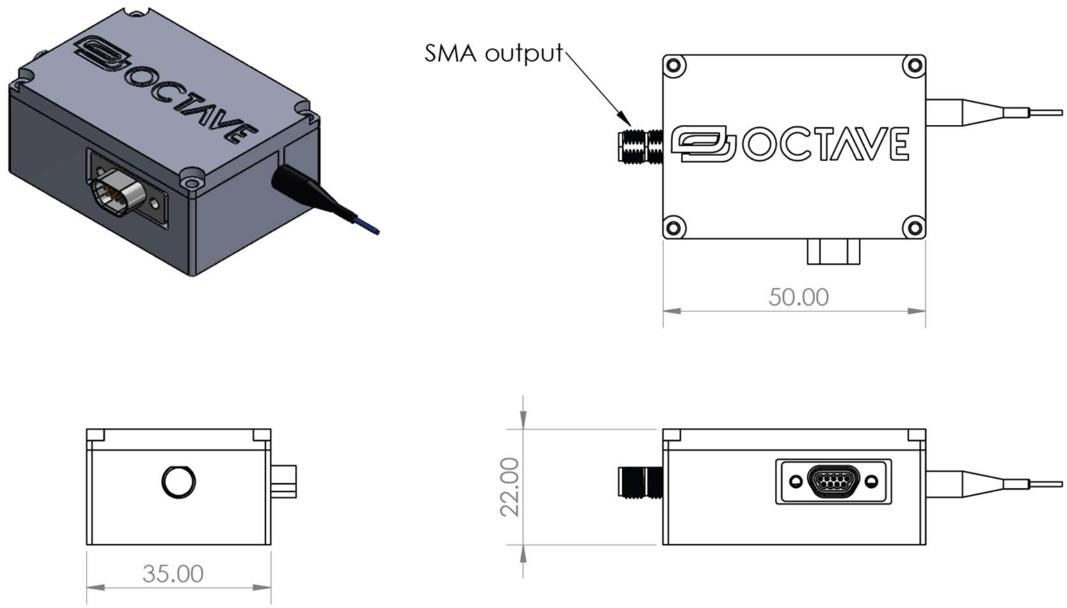
Specification	COSMO
Input pulse wavelength	~1560 nm
Minimum input pulse energy	150 pJ typ. 200 pJ max.
Absolute maximum input pulse energy	1 nJ
Recommended input pulse duration	<250 fs
f_{ceo} frequency range	<100 MHz, <500 MHz, <1 GHz
Input fiber	PM1550
Input optical connector	FC/APC
Output electrical connector	SMA
Dimensions (excluding connectors)	50x35x22 mm*
Typical electrical power draw (without TEC)	0.6 Watts (50 mA @12 V)
Weight	75 grams
Thermoelectric cooler (TEC)	Optional
Input average power [with TEC]	400 mW, [<4 Watts]
Operating temperature [with TEC]	15 to 30 C, [-10 to 60 C]
Signal-to-noise ratio of CEO peak	>35 dB** (300 kHz RBW)

See Ordering Details on Page 3

* Contact Octave Photonics for custom COSMO case styles.

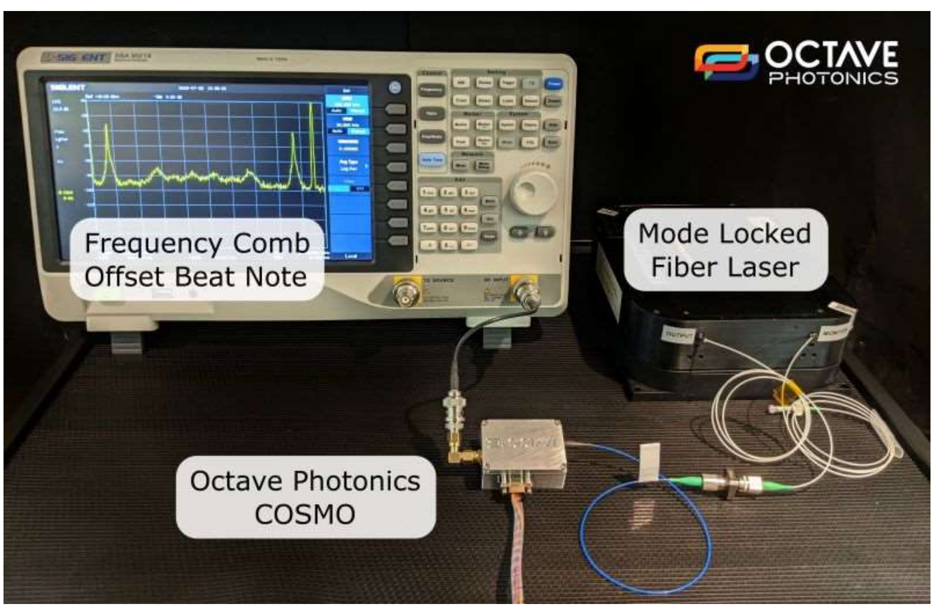
** Observed signal-to-noise ratio depends on laser stability. >35 dB assumes a low-noise laser system.

Schematic and dimensions:



Dimensions are in millimeters. The SMA connector provides RF output from detector. The Micro-D connector provides connections for detector power (5-15 VDC, ~0.6 W), thermistor, and built-in thermo-electric cooler.

Example offset detection: In this simple configuration, the COSMO is connected to the output of an Er:fiber laser. The RF spectrum analyzer shows three peaks: f_{CEO}, $f_{CEO} - f_{rep}$, and f_{rep}, where f_{rep} is the laser repetition rate.



Ordering Information:

Part Number: COSMO-F-P-L/T

F: f_{ceo} frequency range
100M: <100 MHz
500M: <500 MHz
1G: <1 GHz
This is the 3 dB bandwidth of the internal photodetector. We typically recommend dividing your laser repetition rate by two and choosing the closest available value.

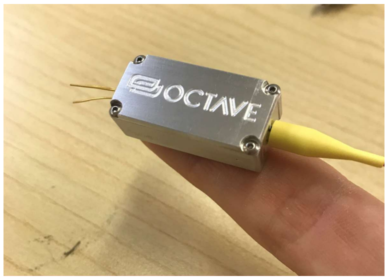
P: Full-width at half-max pulse duration
100: <120 fs
150: 120-180 fs
200: 180-250 fs
If you know the compressed pulse duration of your laser, selecting this value accordingly can help minimize the threshold power for measuring a high SNR f_{ceo} beat signal.

L/T: Input fiber length and tolerance
X: Unspecified or non-critical. Defaults to 35±5 cm.
L: PM1550 fiber length in cm
T: Length tolerance in cm
Optimizing the pulse compression is key to making COSMO work well. If you know how much PM1550 fiber it takes to compress your laser pulses, specify it here.

Examples:
COSMO-100M-120-X: COSMO with a 100 MHz photodetector for use with 120 fs input pulses. Default input fiber length.

COSMO-1G-180-30/2: COSMO with a 1 GHz photodetector for use with 180 fs input pulses. Input fiber length is 30±2 cm.

Customization: The COSMO can be customized to meet specific requirements. In the photo to the right, a miniaturized version of the COSMO (the COSMO-mini) has been constructed to keep the size and weight to a minimum. The COSMO-mini does not contain the electronic amplifier, and instead provides direct electronic access to the photodiode. The COSMO can be provided in other form factors as applications require.



Important: Protecting against optical damage

Nanophotonic waveguides combine extremely tight optical mode confinement with high material nonlinearity. This combination allows low-energy input pulses to reach peak intensities nearing 10^{12} W/cm^2! However, since these intensities approach the optical damage threshold of the waveguide material, **special care must be taken to ensure the seed laser system does not output large transient pulses**. **Uncontrolled pulse amplification will permanently damage the waveguide module.**

The most common scenario for optical damage in a research-lab setting is when an optical amplifier is energized before a stably mode-locked seed laser is connected. This can happen, for example, if the seed laser loses its mode-locked state while the amplifier is running. To prevent damage, the amplifier must be turned off before re-modelocking the seed laser if the waveguide module is connected to the amplifier output.

To protect sensitive waveguide modules from this kind of damage, Octave Photonics offers a companion product called the Fast Laser Amplifier Interlock Module (FLAIM) to quickly turn off an optical amplifier system in the event of momentary or extended disruptions of the seed light. The FLAIM is a compact benchtop module that provides an adjustable input threshold for tripping the protection circuitry, shutting off the connected amplifier with a response time <1 ms. When used properly, the FLAIM can protect valuable nanophotonic components from accidental damage in laboratory environments.