GHz Electro-Optic Frequency Comb (GECO)

Summary: The GHz Electro-Optic Laser Frequency combs (GECO) provide a reliable method for generating frequency combs at repetition rates between 5 and 30 GHz. These repetition rates are much higher than can be accessed with typical mode-locked-laser frequency combs. Octave Photonics specializes in building EO combs with low phase noise, octave-spanning bandwidth, and femtosecond pulse durations. Applications include spectrograph calibration, dual-comb spectroscopy, high-speed optical communications research, and optical frequency division.

Specification	GECO	GECO+
Repetition rate	5 to 30 GHz	5 to 30 GHz
Repetition rate tuning range	1+ GHz (typical)	5 MHz (typical)
Center wavelength*	1540-1560 nm	1540-1560 nm
Output power	10 mW (typical)	Up to 5 Watts
Pulse duration	0.8 to 1.5 ps	As short as 20 fs
Dimensions**	0.65 x 0.4 x 0.16 m (3U 19-inch-rack mount)	GECO plus additional unit(s)

*Contact Octave Photonics for additional wavelength options.

**Dimensions depend on configuration and do not include power supplies.

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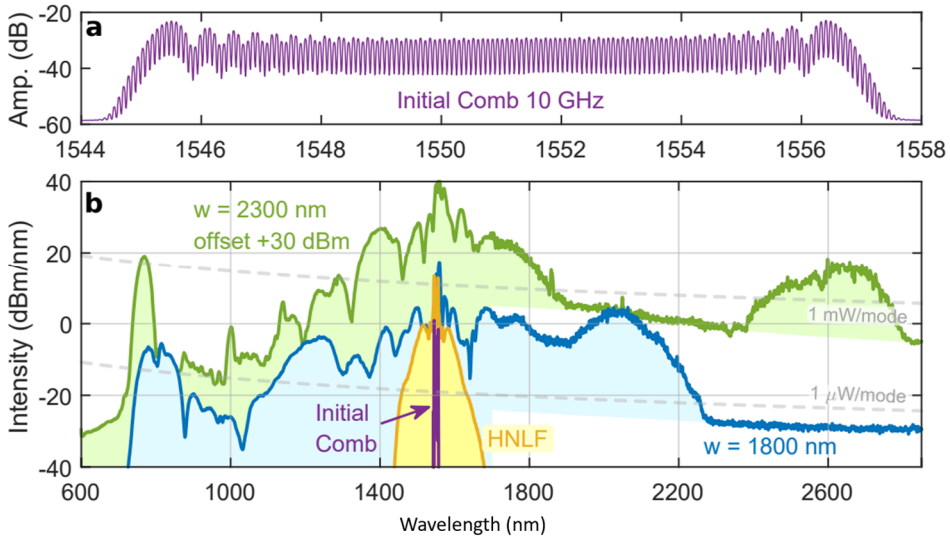
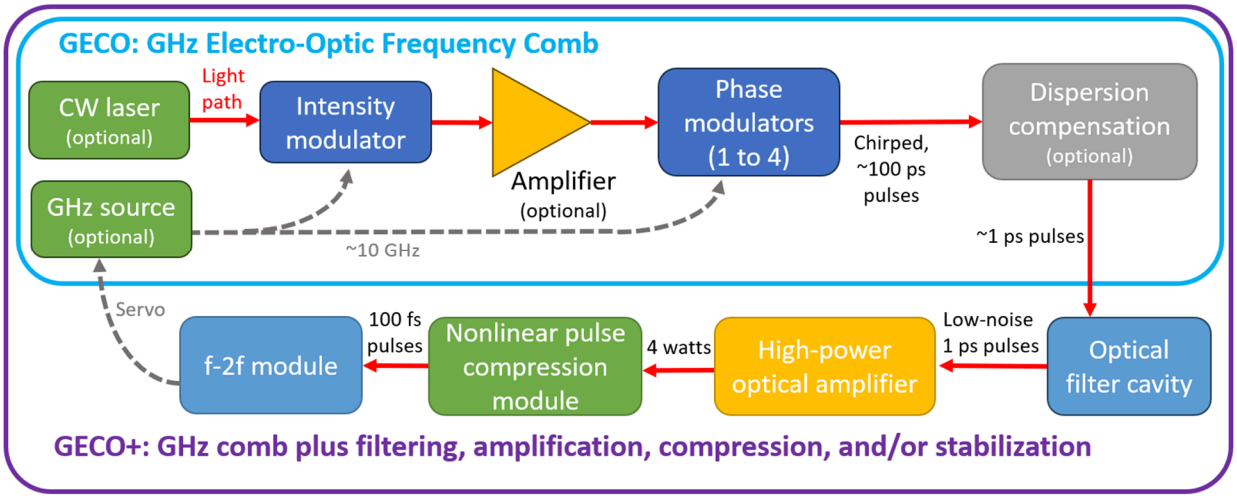


(Top) The spectrum of the base EO comb, with 10 GHz comb teeth visible. (Right) The green and blue lines show the EO comb spectrum after broadening in nanophotonic waveguides.

Operation: The GECO converts a CW laser into pulses using electro-optic modulators. The output passes through an amplifier and dispersion compensator to provide 1 ps pulses with up to several watts of average power. In the fully stabilized GECO+ configuration, the pulses pass through an optical filter cavity to produce a low-noise pulse train. These pulses then enter the pulse compressor, where their duration is reduced to 100 fs. Finally, supercontinuum generation in a nanophotonic waveguide produces an octave spanning spectrum, which is used for *f-2f* self-referencing and stabilization of the carrier-envelope-offset frequency. Octave Photonics can also assist with the integration of EO combs with applications.



References

Carlson et al., "Ultrafast electro-optic light with subcycle control" *Science* **361**, 1358 (2018). arxiv.org/abs/1711.08429

Metcalf et al., "Stellar spectroscopy in the near-IR with a laser frequency comb" *Optica* **6**, 233 (2019). arxiv.org/abs/1902.00500

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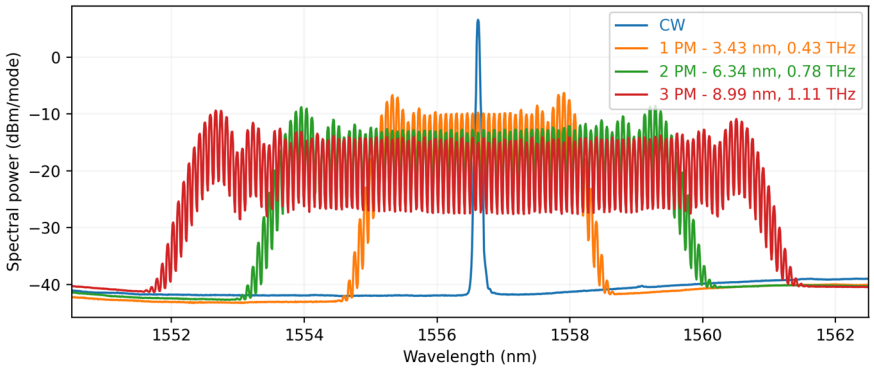
GECO configuration

The GECO is a flexible platform that can be customized for specific applications. The following specifications should be considered when purchasing:

Repetition rate: Since the GECO uses modulators to convert a CW laser into a pulse train, the repetition rate is completely flexible, at least in principle. In practice, mode-locked-laser combs can offer a compelling alternative for repetition rates below 2 GHz, while costs increase substantially for repetition rates above 20 GHz. The achievable repetition rate is ultimately limited to ~40 GHz by the performance of the electro-optic modulators. Most GECO units have a repetition rate of about 10 GHz.

Optical bandwidth: The required optical bandwidth should be carefully considered because it has a substantial impact on the cost of the system. If a narrow bandwidth is required, the GECO is built with one intensity modulator and one phase modulator, resulting in about 40 comb teeth at 10 GHz. Broader bandwidth is achieved by adding additional phase modulators, with three phase modulators providing about 110 comb teeth at 10 GHz. For significantly broader bandwidth, the GECO+ can incorporate a several-watt optical amplifier and nonlinear fiber or a supercontinuum generation module.



The output spectrum of the Base EO Comb with various numbers of phase modulators activated. When all three phase modulators are used, the spectrum reaches ~9.0 nm (~1.1 THz) bandwidth, at the -10 dB level. For the cases of 1, 2, and 3 PM, the intensity modulator is also active.

Stabilization: The carrier-envelope-offset frequency of the GECO can be stabilized via *f-2f* interferometry and locking electronics. This also requires the use of an optical cavity to reduce the high-frequency noise of the comb.

Built-in CW laser: The GECO can have a built-in CW laser or accept an optical input on the front panel. Many commercial CW lasers can be incorporated into the GECO, and the appropriate selection will depend on the desired linewidth and tunability.

Built-in GHz source: The GECO can incorporate a built-in GHz source or accept an external GHz input on the back panel. The RF source can be selected to prioritize low-noise operation or tunability.

Output optical power: The GECO can contain a built-in optical amplifier to compensate for the loss of the electro-optic modulators and to provide output powers of up to 1 watt. External optical power amplifiers can further increase the power to up to 5 watts.