Waveguide BOC

Waveguide Balanced Optical Cross Correlator

Timing detector on chip with zeptosecond resolution

In partnership with AdvR

DESCRIPTION

Waveguide BOC (WBOC) enables ultra-precise measurement of timing jitter between two independent optical pulse trains with up to 100 times more sensitivity than the bulk BOC. It requires much less input pulse energy and is very suitable for high-repetition rate on-chip laser sources and micro-combs.

It provides exceptionally high timing sensitivity, zepto-second timing resolution, amplitude invariance and robustness against environmental fluctuations.

The output of the WBOC is a baseband voltage signal that is proportional to the relative time delay between the two sources. It can be combined with a Cycle ESYNC to synchronize two on-chip laser sources.

BENEFITS

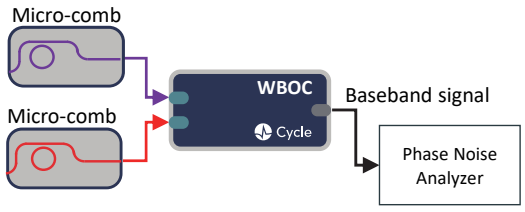
- Performant at low pulse energy and high repetition rate
- Up to 100 times more sensitive than bulk BOC
- More than 20 mV/fs sensitivity
- Zeptosecond-level timing jitter resolution

APPLICATIONS

- Noise investigations of micro-combs
- Repetition rate locking of micro-combs and on-chip mode-locked lasers
- Timing jitter and drift characterization of femtosecond lasers with low peak power and high repetition rate
- Measurement and stabilization of optical path lengths (e.g., fiber link stabilization)

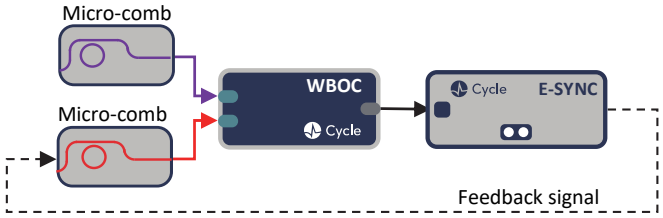
SETUP EXAMPLES

Micro-comb timing jitter characterization



WBOC inputs/outputs	
Input 1	micro-comb (PM fiber)
Input 2	micro-comb (PM fiber)
Output	Baseband signal proportional to relative timing jitter

Micro-comb synchronization



ESYNC inputs/outputs	
Input	Baseband signal proportional to relative timing jitter
Output	Feedback signal for microcomb TEC controller

SPECIFICATIONS

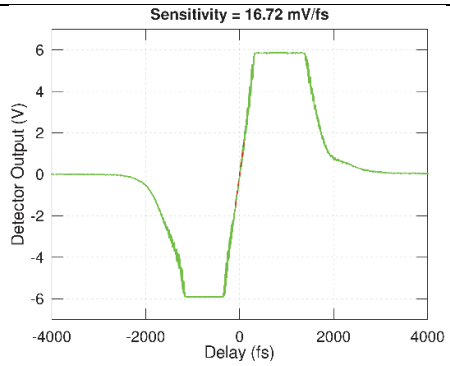
Parameter	Specification	Comment
Detector specifications		
Timing sensitivity	> 20 mV/fs	main balanced output with 1 MΩ load impedance
Timing noise floor	< 0.1 fs RMS	integrated noise floor [1 Hz - 100 kHz]
Timing resolution	< 0.001 fs RMS	integrated noise floor within 1 Hz bandwidth above 100 Hz
Detector bandwidth	> 100 kHz	3-dB signal bandwidth
Dimensions (H x W x L)	225×150×100 mm^3	dimensions of the optical detector head
Option ESYNC: Electronic Synchronization Unit		
Timing jitter	< 15 fs RMS	integrated residual noise [35 µHz – 100 kHz], i.e., for 8 hours[1]
Control unit type	Cycle ESYNC	Provides auto search, lock and feedback control functions
Control unit dimensions	3 U	19” rack module
Control system interface	TCP/IP	e.g., EPICS or Telnet
Input specifications		
Optical input wavelength	1555 ± 5 nm	within the FWHM of the peak spectra
Optical input type	PM fiber	
Optical input power	< 10 mW	average optical power coupled in PM fiber
Pulse peak power	> 0.5 kW	per pulse with uniform temporal shape
Pulse repetition rate	> 1 MHz	

[1] with appropriate laser inputs, in a thermally controlled environment (temperature +18 to +24°C, with slope < 0.4°C/h and variation < 1°C pk-pk; humidity < 60 %RH with variation < 10 %RH pk-pk).

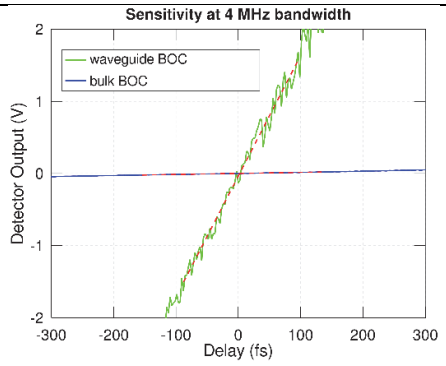
MEASUREMENT DATA

WBOC performance with 5 mW optical power for each input at 4 MHz detector bandwidth:

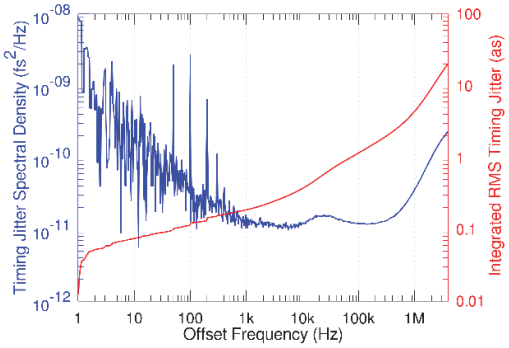
Timing sensitivity



Timing sensitivity compared with bulk BOC



Timing noise floor



Offset Frequency (Hz)	Jitter Spectral Density (fs^2/Hz)	Integrated jitter from 1 Hz (as)
1	8.78×10^{-9}	-
10	1.92×10^{-10}	0.07
100	2.74×10^{-9}	0.12
1,000	1.22×10^{-11}	0.19
10,000	1.24×10^{-11}	0.37
100,000	1.20×10^{-11}	1.16
1,000,000	3.58×10^{-11}	4.40
4,000,000	2.34×10^{-10}	20.82