Balanced Optical Microwave Phase Detector (BOMPD)

APPLICATION

- Tight synchronization between ultrafast lasers to microwave signals
- Tight synchronization between microwave signals to ultrafast lasers
- Tight synchronization of microwave sources to the output of stabilized fiber links
- Generation of ultra-low-noise microwave signals from an ultrafast optical oscillator
- Tight synchronization of ultrafast lasers to electron bunches in an accelerator, when used together with a bunch arrival monitor (BAM)

DESCRIPTION

The fully-automated BOMPD precisely detects the time delay between an optical pulse train, and the zero-crossings of a microwave signal. It generates a baseband signal that is proportional to the timing error between the two inputs, which in turn can be used in a phase locked loop configuration to tightly synchronize a laser to a microwave source or vice versa. Due to its balanced detection scheme, the BOMPD is immune to amplitude fluctuations of both optical and microwave sources and greatly suppresses the AM-PM conversion noise in the photodetection process. Cycle offers two additions to the BOMPD to complement our customers' applications: RF generation option (which includes a low-noise VCO for generating an RF signal based on an optical clock), low-noise option (down to 5 fs synchronization). Standard optical wavelengths are 800 nm, 1030 nm, and 1550 nm. Please contact one of our timing experts for your customization needs.

SPECIFICATIONS

General Parameters			
Parameter	**Value**	**Unit**	**Comment**
Control system interfaces	included		Available in Epics, Tango…
Auto lock	included		
Dimensions			Rack mountable, 19 inch width, 5HU
Weight	10-20	kg	Depending on options

BOMPD @ 1550 nm			
Parameter	**Value**	**Unit**	**Comment**
Timing sensitivity	> 0.05	mV / fs	At the detector output (not amplified)
Timing resolution	< 0.5	fs	Integrated detector noise floor within 10 kHz bandwidth
Requirements			
RF input power	>15	dBm	Up to 10 GHz. BOMPD tailored to frequency of interest
Optical input wavelength	1550 ± 40	nm	Operating at pulsed mode
Optical input power	> 20	mW	Required average power
Optical input type	PM Fiber		FC or SC connector
Pulse repetition rate	< 10	GHz	BOMPD is tailored for the repetition rate of interest

RF Generation Option for BOMPD @ 1550 nm			
Parameter	**Value**	**Unit**	**Comment**
VCO	Included		Customizable upon request
Integrated feedback	Included		Optimized PID parameters
Timing Jitter	< 30[1]	fs RMS	Within 35 µHz - 1 MHz bandwidth; relative to the master oscillator
RF output frequency	< 10	GHz	Can be tailored for the frequency of interest
Locking bandwidth	> 10	kHz	Between the optical master and RF slave oscillator
RF output power	> 10	dBm	50 Ω impedance
RF power stability	< 0.1	%	

RF Generation and 5-fs Option for BOMPD @ 1550 nm			
Parameter	**Value**	**Unit**	**Comment**
VCO	Included		Customizable upon request
Integrated feedback	Included		Optimized PID parameters
Timing Jitter	< 5[1]	fs RMS	Within 35 µHz - 1 MHz bandwidth; relative to the master oscillator
RF output frequency	< 10	GHz	Can be tailored for the frequency of interest
Locking bandwidth	> 10	kHz	Between the optical master and RF slave oscillator
RF output power	> 10	dBm	50 Ω impedance
RF power stability	< 0.1	%	

[1]when operated in an environment with maximum 0.1 K temperature and 2 % relative humidity fluctuations. Higher precision is available upon request.

BOMPD @ 800 nm			
Parameter	**Value**	**Unit**	**Comment**
Timing sensitivity	> 0.05	mV / fs	At the detector output (not amplified)
Timing resolution	< 1	fs	Integrated detector noise floor within 10 kHz bandwidth
Requirements			
RF input power	>15	dBm	Up to 10 GHz. BOMPD tailored to frequency of interest
Optical input wavelength	800 ± 20	nm	Operating at pulsed mode
Optical input power	> 20	mW	Required average power
Optical input type	PM Fiber		FC or SC connector
Pulse repetition rate	< 10	GHz	BOMPD tailored to the repetition rate of interest

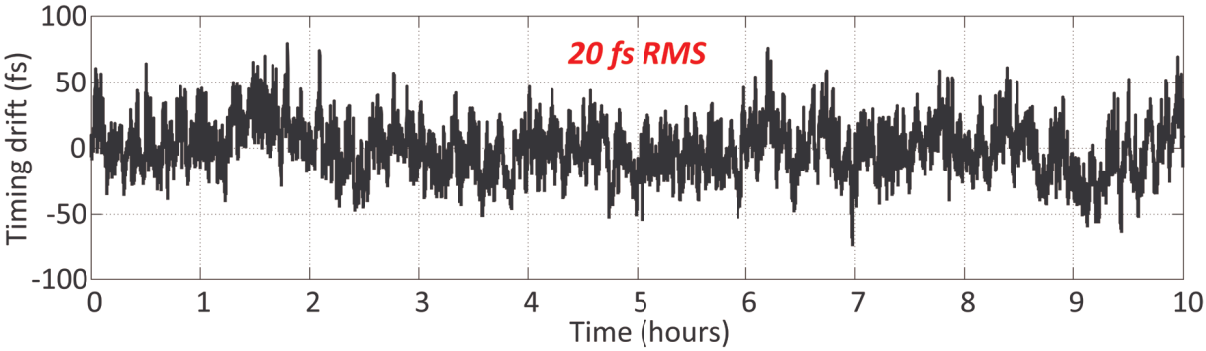
RF Generation Option for BOMPD @ 800 nm			
Parameter	**Value**	**Unit**	**Comment**
VCO	Included		Customizable upon request
Integrated feedback	Included		Optimized PID parameters
Timing Jitter	< 30[1]	fs RMS	Within 35 µHz - 1 MHz bandwidth; relative to the master oscillator
RF output frequency	< 10	GHz	Can be tailored for the frequency of interest
Locking bandwidth	> 10	kHz	Between the optical master and RF slave oscillator
RF output power	> 10	dBm	50 Ω impedance
RF power stability	< 0.1	%	

RF Generation and 10-fs Option for BOMPD @ 800 nm			
Parameter	**Value**	**Unit**	**Comment**
VCO	Included		Customizable upon request
Integrated feedback	Included		Optimized PID parameters
Timing Jitter	< 10[1]	fs RMS	Within 35 µHz - 1 MHz bandwidth; relative to the master oscillator
RF output frequency	< 10	GHz	Can be tailored for the frequency of interest
Locking bandwidth	> 10	kHz	Between the optical master and RF slave oscillator
RF output power	> 10	dBm	50 Ω impedance
RF power stability	< 0.1	%	

[1]when operated in an environment with maximum 0.1 K temperature and 2 % relative humidity fluctuations. Higher precision is available upon request.

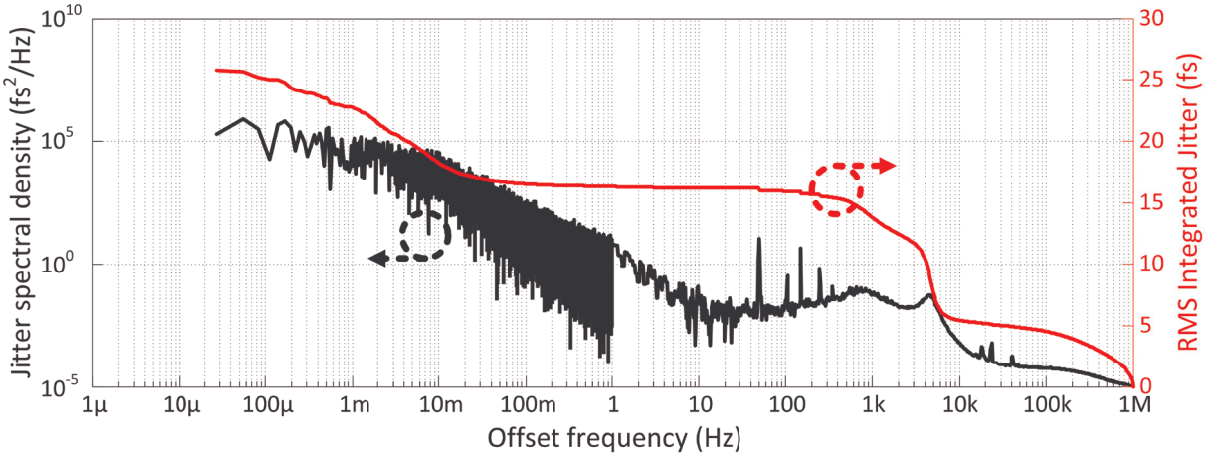
MEASUREMENT DATA

Out-of-loop timing drift below 1 Hz between a remotely synchronized ultrafast laser and a microwave signal[2] using a standard 1550nm BOMPD, with RF generation option:



[2]when operated in an environment with maximum 0.1 K temperature and 2 % relative humidity fluctuations.

Out-of-loop timing jitter spectral density between the generated RF and the optical reference, from 1 MHz down to 4.63 µHz[3]:



[3]The spectrum below 1 Hz is the Fourier transformation of the timing drift data, whereas the spectrum above 1 Hz is measured with a baseband analyzer.