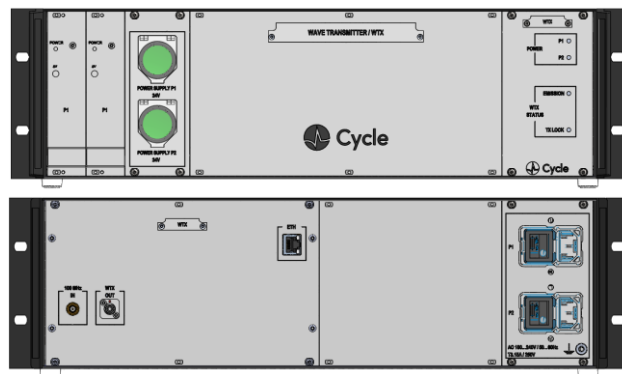




WAVE

Stabilized RF over Fiber Link

Lowest noise RF over Fiber transmission



APPLICATIONS

Lowest noise fiber-optic frequency and time signal transfer for applications such as:

- Atomic clock signal distribution such as active or passive H-masers, Cs or Rb clocks
- RF signal distribution in free-electron lasers and particle accelerators
- UTC time realization and distribution
- Reference signal distribution in space telescopes

BENEFITS

- Wide range RF transfer (5/10/100 MHz and [1 GHz – 4 GHz])
- Stability better than state-of-the-art masers
- Modular & configurable
- Synchronous time signals (1PPS, IRIG & NTP)

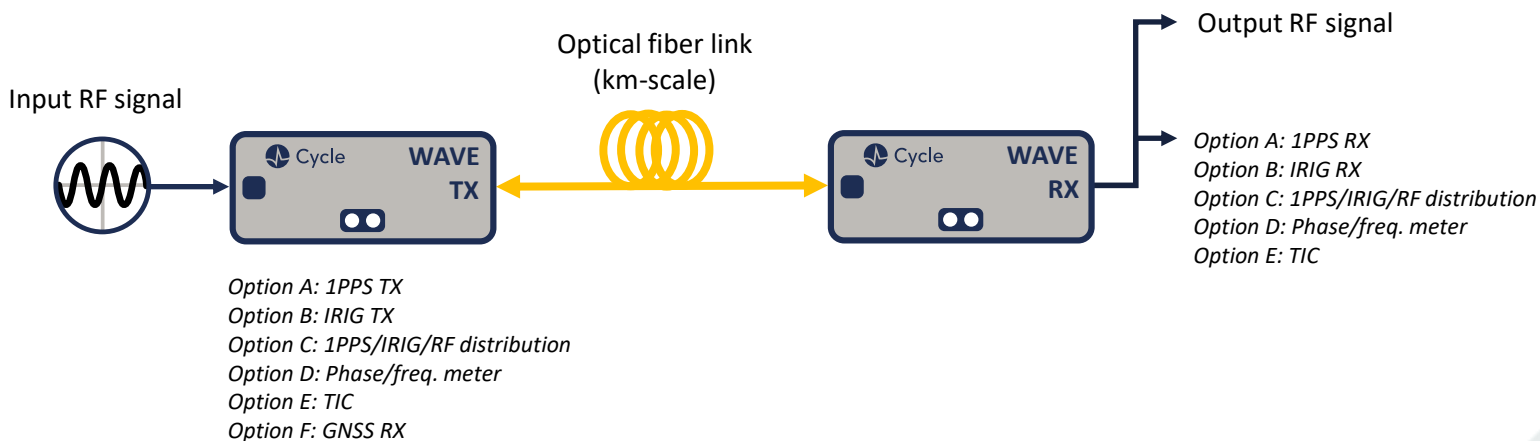
DESCRIPTION

WAVE Link allows precise transmission of frequency and time signals to kilometer distances using optical fibers with stability better than state-of-the-art masers.

It consists of a transmitter (TX) and a receiver (RX) unit, both equipped with advanced Cycle electro-optical modulation and fiber optic delay stabilization technology.

Its modular design enables application-specific configurations, including stable 1PPS, IRIG & NTP transfer, time interval counters, phase/frequency meters, and GNSS tracking and referencing.

SETUP EXAMPLE





SPECIFICATIONS

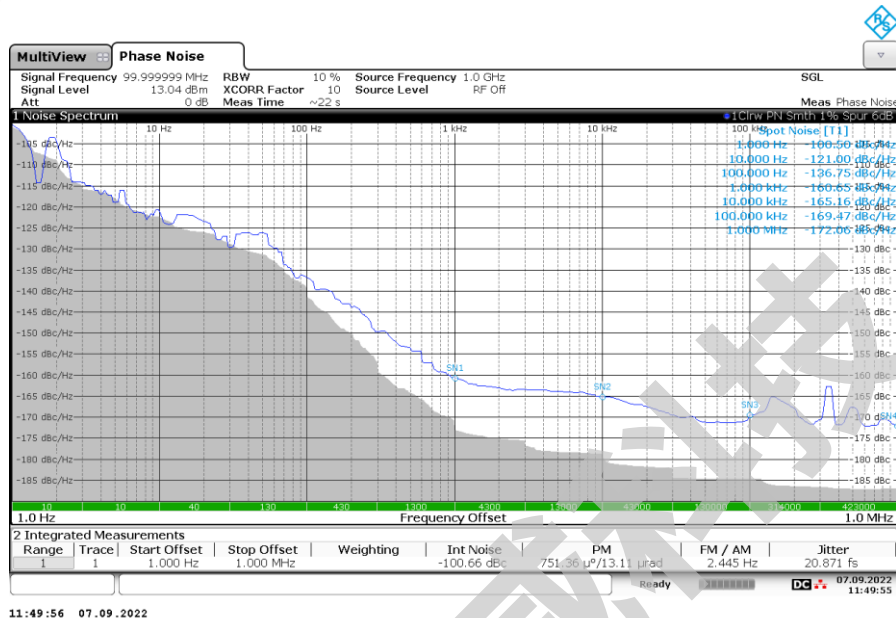
Parameter	Specification	Comment		
Timing jitter	< 200 fs RMS	integrated residual noise [0.1 Hz – 100 kHz] ¹		
Frequency range	5/10/100 MHz and [1 GHz – 4 GHz]	Single frequency at [10 – 13 dBm] input power, not sweeping		
RX outputs	[2 – 4] x SMA type	at [10 – 13 dBm] output power		
Control system interface	TCP/IP	e.g., EPICS or Telnet		
Dimensions, TX + RX	3 U + 3 U	19” rack module, options may increase U		
Residual ADEV	< 1.5E-13 at 1 s < 2E-14 at 10 s < 5E-15 at 100 s < 2E-15 at 1 000 s < 2E-15 at 10 000 s	with active fiber delay stabilization ¹		
Phase noise	Offset frequency	10 MHz carrier	100 MHz carrier	1 GHz carrier
	1 Hz	-105 dBc/Hz	-100 dBc/Hz	-95 dBc/Hz
	10 Hz	-130 dBc/Hz	-115 dBc/Hz	-110 dBc/Hz
	100 Hz	-150 dBc/Hz	-125 dBc/Hz	-120 dBc/Hz
	1 000 Hz	-160 dBc/Hz	-153 dBc/Hz	-140 dBc/Hz
	10 000 Hz	-160 dBc/Hz	-162 dBc/Hz	-150 dBc/Hz
	100 000 Hz	-160 dBc/Hz	-163 dBc/Hz	-155 dBc/Hz
Requirements				
Fiber link length	< 1 km	contact Cycle for longer fiber links.		
Fiber link loss	< 10 dB	if higher fiber loss, see option G: EDFA.		
Fiber link reflectance	< -40 dB	APC type fiber connectors are recommended.		
Option A: 1PPS transfer				
Signal level	2.5 V TTL	50 Ω impedance		
Pulse rise and fall times	≤ 1 ns	from 10% to 90% level		
Pulse duration	20 μs – 500 ms	adjustable		
Return loss	30 dB	at signal outputs		
Delay adjustment	10-ns step size	at 100-MHz input		
Timing jitter	< 5 ps RMS	added noise to the RF input		
Option B: IRIG transfer				
Timecode	IRIG-B	contact Cycle for more details.		
Option C: Distribution amplifier				
Frequency distribution	1 x 12	1 input, 12 outputs per module		
1PPS or IRIG distribution	2 x 10	2 switchable inputs, 10 outputs per module		
Option D: Phase/frequency meter				
Input signal	Sine wave	[5 MHz – 100 MHz] frequency and [7 – 10 dBm] power		
Input channels	4 x SMA type	ch1 is reference. Real-time phase, frequency and ADEV at 1-s rate, all combinations of two channels are reported.		
ADEV measurement floor ³	< 4E-14 at 1 s < 1E-14 at 10 s < 2E-15 at 100 s < 1E-15 at 1 000 s < 1E-15 at 10 000 s			
Option E: Time interval counter				
Input signal	1 PPS	2.5 V TTL at 50 Ω impedance		
Input channels	4 x SMA type	real-time time interval measurements at 1-s rate, all combinations of two channels are reported.		
Resolution	20 ps RMS			
Option F: GNSS tracking & referencing				
GNSS receiver	Furuno GT-100	SMA-type, multi-GNSS receiver optional with a GNSS antenna		
Outputs	1PPS & 10 MHz	SMA-type, synchronized UTC time and frequency output		
Option G: EDFA				
Gain	13 dB	one way, 16 dB total gain in round-trip operation		

¹TX and RX rack units shall be 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

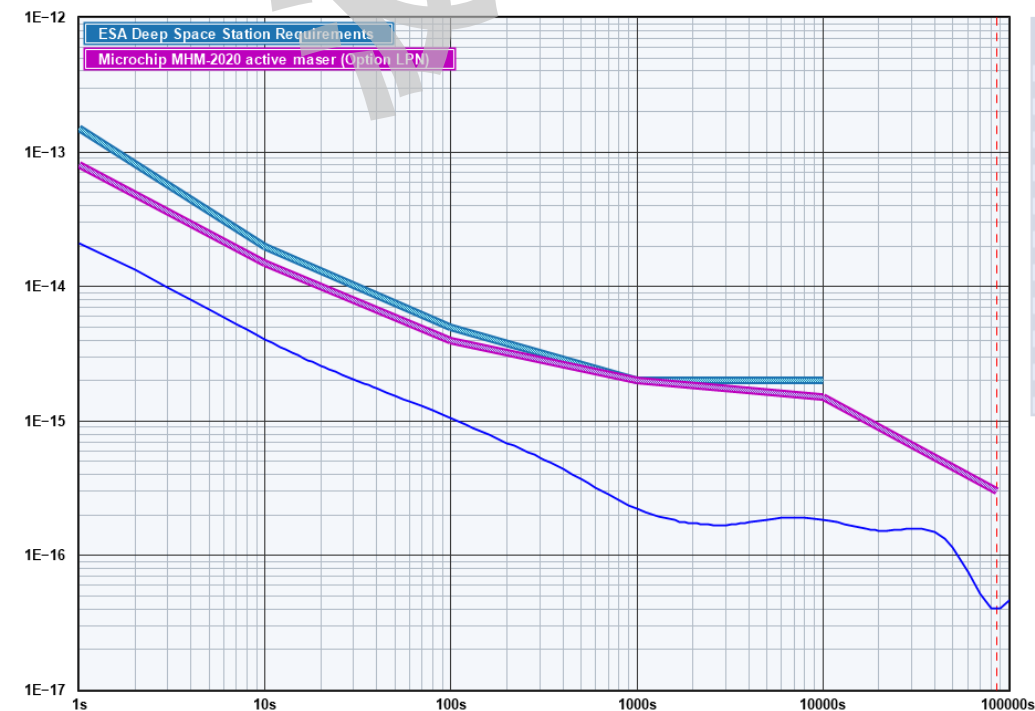
Absolute phase noise measurement at 100 MHz:



Freq. Offset (Hz)	Phase Noise (dBc/Hz)
1	-100.50
10	-121.00
100	-136.75
1 000	-160.65
10 000	-165.16
100 000	-169.47
1 000 000	-172.06

Residual ADEV measurement at 100 MHz:

Allan Deviation $\sigma_y(\tau)$



Trace	Notes	Input Freq	Sample Interval	ADEV at 86400s	Duration	Elapsed	Acquired	Instrument
Cycle WAVE Link	100 MHz	100 MHz	1 s	4.09E-17	5d 13h 20m 0s	5d 13h 20m 0s	480000 pts	Digital Phase Detector