WAVE-100

Stabilized RF over Fiber Link

Stability beyond active H-masers for frequency and time distribution

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.

BENEFITS

- Optimized for precision reference frequency transfer (10 / 100 MHz)
- Electronic delay stabilization: simple, robust, cost-efficient
- Stability exceeding active H-masers
- Synchronous time signals (1PPS, IRIG & NTP)

APPLICATIONS

- Atomic clock signal distribution (H-masers, optical clocks, Cs, Rb etc.)
- Atomic clock comparison between remote sites
- Reference signal distribution in space telescopes
- UTC time realization and distribution

SPECIFICATIONS

Parameter	Specification	Comment
TX input frequency	100 MHz	+/- 50 kHz range, [10 – 13 dBm] input power
RX outputs	2 x SMA type	at [10 – 15 dBm] level
Control system interface	TCP/IP	Telnet and HTTP
Dimensions, TX + RX	3 U + 3 U	19” rack module, options may increase U
Residual ADEV[1]	1 s 10 s 100 s 1 000 s 10 000 s	< 8.0E-14 < 1.5E-14 < 5.0E-15 < 2.0E-15 < 8.0E-16
Phase noise	**Offset frequency** 1 Hz 10 Hz 100 Hz	**100 MHz carrier** -105 dBc/Hz -118 dBc/Hz -127 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 H: EDFA.
Fiber link reflectance	< -40 dB	APC type fiber connectors are recommended.
Option: 10 MHz input & output		
TX input frequency	10 MHz	a 10× multiplier added (i.e., 10 x 10 MHz = 100 MHz)
RX outputs	4 x SMA type	[10 – 15 dBm] level, a 10÷ divider added (i.e.,100 MHz ÷ 10 = 10 MHz)
Phase noise	**Offset frequency** 1 Hz 10 Hz 100 Hz	**10 MHz carrier** -120 dBc/Hz -135 dBc/Hz -145 dBc/Hz

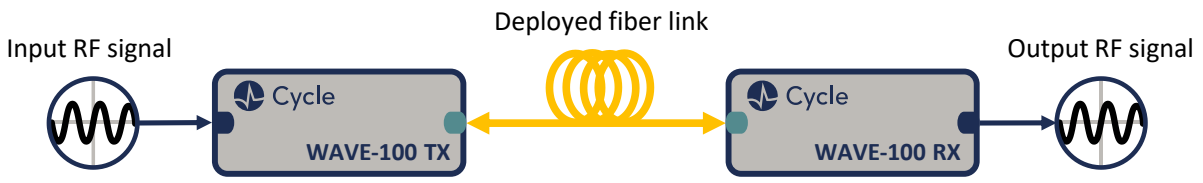
Option: Clean-up oscillator			
Phase noise	**Offset frequency**	**100 MHz carrier**	**10 MHz carrier[2]**
	1 Hz	-105 dBc/Hz	-120 dBc/Hz
	10 Hz	-118 dBc/Hz	-135 dBc/Hz
	100 Hz	-127 dBc/Hz	-145 dBc/Hz
	1 000 Hz	-153 dBc/Hz	-150 dBc/Hz
	10 000 Hz	-165 dBc/Hz	-155 dBc/Hz
	100 000 Hz	-165 dBc/Hz	-155 dBc/Hz
Option: 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: IRIG transfer			
Timecode	IRIG-B	contact Cycle for more details.	
Option: Distribution amplifier			
Frequency distribution	2 x 12	2 switchable inputs, 12 outputs per module [5, 10 & 100MHz]	
1PPS or IRIG distribution	2 x 10	2 switchable inputs, 10 outputs per module	
Option: Phase/frequency meter			
Input signal	Sine wave	[5 MHz – 100 MHz] frequency and [7 – 10 dBm] power	
Input channels	4 x SMA type	real-time, 1-s rate, all input combinations reported, ch1=REF.	
ADEV measurement floor[1]	1 s	< 4.0E-14	
	10 s	< 1.0E-14	
	100 s	< 2.0E-15	
	1 000 s	< 1.0E-15	
	10 000 s	< 1.0E-15	
Option: Time interval counter			
Input signal	1 PPS	2.5 V TTL at 50 Ω impedance	
Input channels	4 x SMA type	real-time, 1-s rate, all input combinations reported.	
Resolution	20 ps RMS		
Option: GNSS tracking & referencing			
GNSS receiver	Furuno GT-100	1x SMA-type, multi-GNSS RX, optional with a GNSS antenna	
Outputs	1PPS & 10 MHz	1x SMA-type each, synchronized UTC time and freq. output	
Option: EDFA			
Gain	13 dB	one way, 16 dB total gain in round-trip operation	

[1] TX, RX temperature from +10 to +30°C, with slope < 0.4°C/h & variation < 1°C pk-pk; humidity < 60 %RH with variation < 10 %RH pk-pk.

[2] Requires additional option: 10 MHz input & output.

SETUP EXAMPLE

Stabilized RF over fiber transmission using Cycle WAVE-100 TX and RX units:



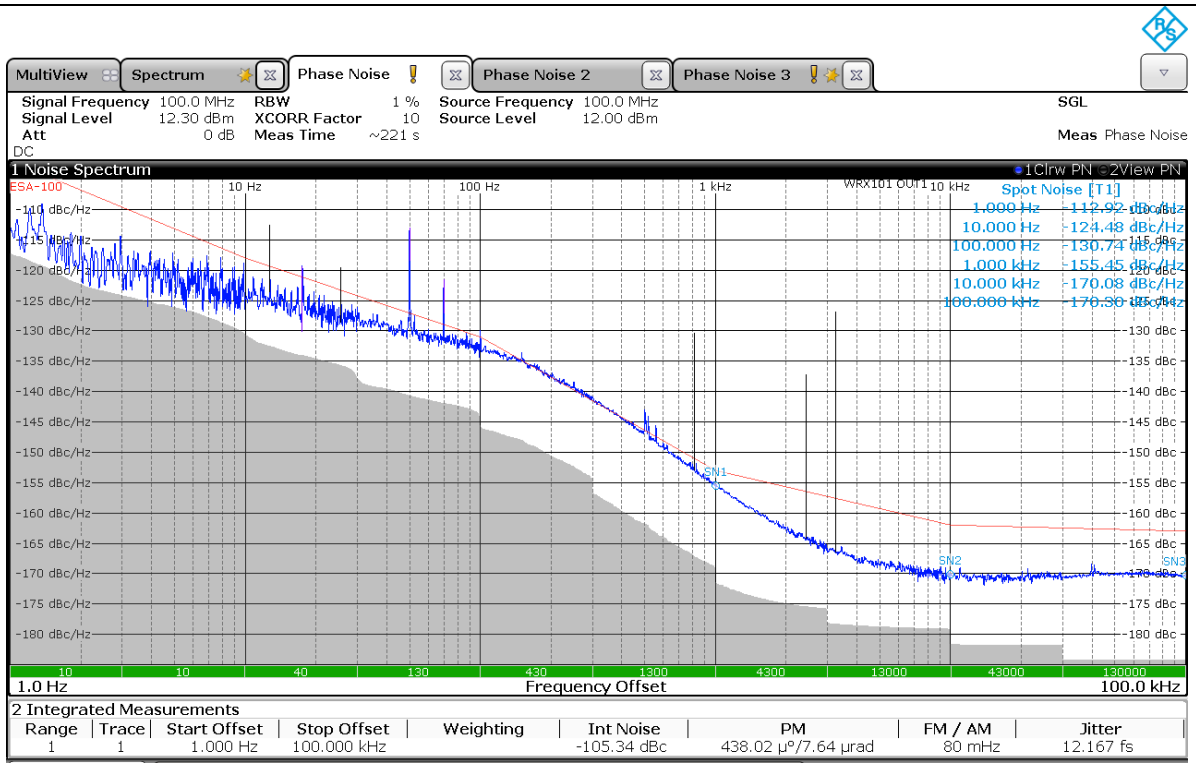
Option: 10 MHz input (multiplier)
Option: 1PPS transfer (TX)
Option: IRIG transfer (TX)
Option: Distribution amp. (RF/1PPS/IRIG)
Option: Phase/frequency meter
Option: Time interval counter
Option: GNSS tracking & ref. (GNSS RX)
Option: EDFA

Option: 10 MHz output (divider)
Option: Clean-up oscillator
Option: 1PPS transfer (RX)
Option: IRIG transfer (RX)
Option: Distribution amp. (RF/1PPS/IRIG)
Option: Phase/frequency meter
Option: Time interval counter

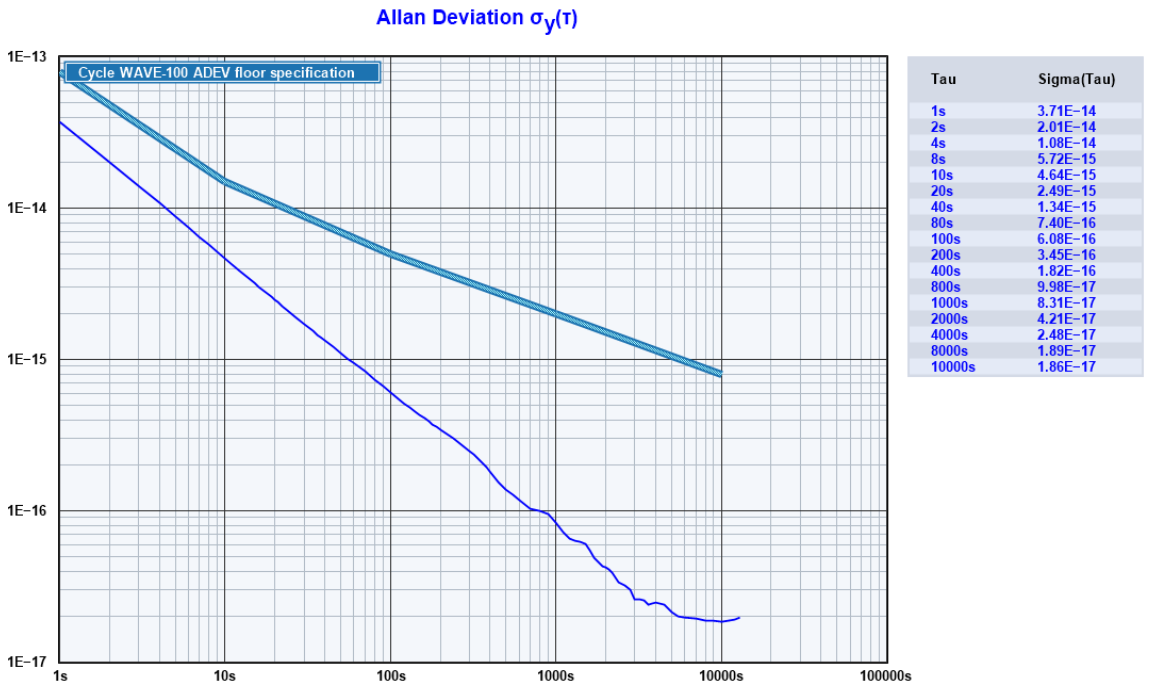
MEASUREMENT DATA

WAVE-100 Link transmission performance over a 1 km fiber link:

Additive phase noise at 100 MHz (Option: Clean-Up Oscillator)



Residual ADEV at 100 MHz



Tau	Sigma(Tau)
1s	3.71E-14
2s	2.01E-14
4s	1.08E-14
8s	5.72E-15
10s	4.64E-15
20s	2.49E-15
40s	1.34E-15
80s	7.40E-16
100s	6.08E-16
200s	3.45E-16
400s	1.82E-16
800s	9.98E-17
1000s	8.31E-17
2000s	4.21E-17
4000s	2.48E-17
8000s	1.89E-17
10000s	1.86E-17

Trace	Input Freq	Duration	Elapsed	Acquired	Instrument
Cycle WAVE Link	100.0 MHz	14h 37m 7s	14h 37m 7s	52627 pts	Microchip 53100A