GPS PicoReference™

Pico Second Resolution Test Set

pendulum

- **Rubidium frequency reference**
- **GPS disciplined**
- **PicoSecond resolution**
- **Clock characterization such as quartz crystal oscillator, Rubidium atomic clocks and cesium clocks**
- **Complete calibration test set**

The Pendulum GPS PicoReference™ is a low-cost, high-performance frequency reference and measurement test set. It integrates a smart GPS and a Rubidium reference, features a flexible 1-30 MHz frequency testing range and a cutting-edge 1ps measurement resolution. It's ideally designed for clock characterization and calibration applications.

PicoReference Product Characteristics

- GPS disciplined Rb clock: Auto-adaptive SmarTiming
- Compact: 1U rack mount chassis
- Testing Frequency Range: 1-30 MHz
- Reference Frequency: Integrated GPS-locked Rubidium clock
- Phase time resolution and noise: <2ps rms
- Output Frequency : 4x 10 MHz/4x 1pps or 8x 10 MHz
- User programmable SYNTH output
- Integrated smart auto calibration

The GPS PicoReference includes two modules: a Frequency Reference module and a Measurement module.

Measurement Module Description

This module is based on a heterodyne architecture with a double frequency conversion to reach a resolution around the pico-second level.

The following figure shows the typical system noise. The module integrates autonomous software, enabling the GPS PicoReference to work with an external 10 MHz reference or through its built-in 10 MHz reference module. The flexible testing frequency range is any frequencies between 1-30 MHz.

Additionally, the following 3 outputs are available to perform extra measurements using an external frequency counter:

- 1kHz output, using a crystal-filter based PLL to restrict the bandwidth to only 1Hz
- 1kHz output, providing about 100 kHz bandwidth
- 1pps output

The module also contains a clock recovery interface circuit. It extracts the clock rate of a E1 (2048 kHz) or T1 (1544 kHz) line in order to be able to measure it with the measurement module.
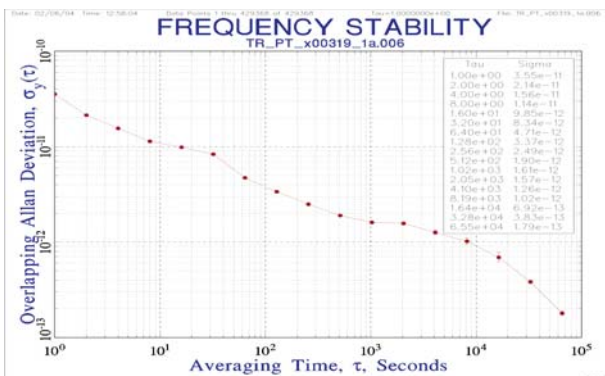

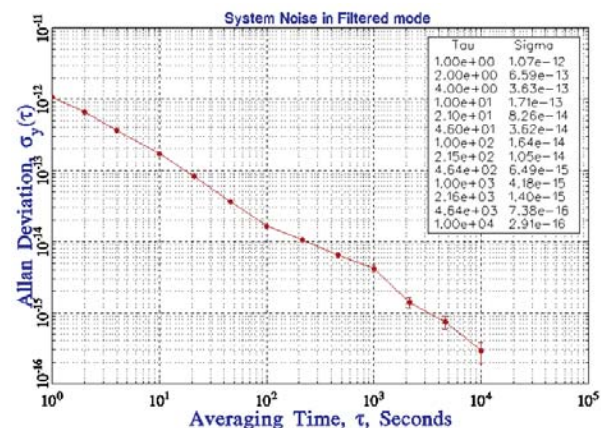**Figure 1:** Frequency Stability Performance

Figure 2: Noise Measurement Performance at 10 MHz

Electrical

Reference module	Standard	Options
RFOUT Frequency Number of Output	10 MHz 4x backplane 1x faceplate	10 MHz 8x backplane 1x faceplate (ordering code: 8RF)
PPSOUT Functionality Number of Output	1pps See SmarTiming section 4x backplane 1x faceplate	1pps 1x faceplate (ordering code: 8RF)
Short Term Stability 1s 10 s 100 s	3×10^{-11} 1×10^{-11} 3×10^{-12}	(ordering code: S) 1×10^{-11} 3×10^{-12} 1×10^{-12}
Phase Noise (dBc/Hz) (RFOUT: 10 MHz) 1Hz 10 Hz 100 Hz 1kHz 10 kHz	-75 -95 -125 -145 -145	(ordering code: S) -80 -100
Aging (Measured after 3 months of continuous operation)	$< 5\times10^{-11}$/month (typical: 3×10^{-11}/month)	
Frequency Retrace Off/On (In stable temperature, gravity, pressure and magnetic field conditions)	$< 5\times10^{-11}$ 24 h/1h	
RFOUT Levels Output Impedance Harmonics Spurious $f_0 \pm 100$ kHz (SYNTH Off)	Sine wave, 0.5 Vrms (±10% /50 W), 1x faceplate **Sine wave, 1.0 Vrms (±10% /50 W), 4x backplane (** ordering code: 8RF 8x) 50 W ±20% <-25 dBc <-80 dBc	
SYNTHESIZER (SYNTH) Output level Frequency range Resolution Spurious	Square wave 3.3V LV CMOS 0 to 20 MHz 3.97 mHz (Fout= N´60'000'000/2^{32}) -35 dBc (1-10 MHz) -30 dBc (10-20 MHz)	
GPS Antenna Connector	SMA	

Measurement module	Standard version
Reference Frequency	10 MHz
DUT Center Frequency Range	1MHz – 30 MHz
Clock Recovery circuit	E1 & T1
Measurement Noise at 10 MHz (Maximum Relative Frequency Deviation During Measurements $<1\times10^{-9}$)	<2ps
Measurement Noise at 10 MHz (Maximum Relative Frequency Deviation During Measurements $<1\times10^{-7}$)	<10 ps
Input Signal Level	+3dBm to +17 dBm
Input Impedance	50 Ω ±20%
Connectors Type	BNC
PC Port	Standard 9600 b/s – Serial (COM1 or COM2 or COM3 or COM4)

SmarTiming+® Functionality

Specification	Standard
PPSOUT Output level Pulse width (PW) or duty cycle	1pps CMOS 0-5V (±20 mA sink/source) User settable, 0 to 1s in 133 ns/step
PPSOUT to PPSREF Sync Error In Sync mode	<50 ns No GPS PPSRef noise, ±1°C temp fluctuations
PPSOUT to PPSREF (DE) Programmable delay (In Track mode)	0 to 1s in 133 ns steps
PPSOUT Holdover Time Stability	Within ±2°C 1 ìs/24 hr
Smart Loop Time Constant Phase/Frequency User settable	Auto-adaptive 1000 to 100,000 sec User settable Sync/Track mode ** Selected by RS232 interface ** Sync: phase/time alignment Track: frequency alignment

Back Panel

N°	Type	Definition	I/O
J1	SMA	GPS antenna connection	I
J2	SUB-D9-F	Reference module Serial communication RS232	I/O
J3-J6	BNC	4x 10 MHz sine reference outputs	O
J7-J10	BNC	4x 1pps outputs (4x 10 MHz sine reference outputs with option code 8RF)	O
J11	SUB-D9-F	Measurement module Serial communication RS232	I/O
J12	IEC PLUG	Power connection	I
S1	SWITCH	On/Off switch	–

Front Panel

N°	Type	Definition	I/O
J13	BNC	Measurement module 10 MHz reference	I
J14	BNC	Measurement module 1pps reference for external counter	O
J15	BNC	1kHz filtered for external counter	O
J16	BNC	1kHz non filtered for external counter	O
J17	BNC	Device under test input signal	I
J18	BNC	10 MHz sine reference output	O
J19	BNC	1pps output	O
J20	BNC	SYNTH output	O
J21	BNC insulated	E1 clock recovery input	I
J22	BNC	E1 clock recovery output	O
J23	BNC insulated	T1 clock recovery input	I
J24	BNC	T1 clock recovery output	O
I1	Green LED	Measurement module locked indicator	–
I2	Red LED	Measurement module unlocked indicator	–
I3	Green LED	Power indicator	–
I4	Green LED	Sync or Track mode enabled	–
I5	Red LED	Rubidium clock locked alarm	–
I6	Green LED	1pps GPS applied	–
S2	SWITCH	Free run, Sync or track selection switch	–

GPS Antenna

Standard GPS Antenna
Antenna type: Patch antenna kit
Cable length: 6m/19.7'
This antenna can be installed close to a window. If installed in a region susceptible to lightning, a surge arrestor must be installed. For the installation, please refer to our GPSource user manual, section "Safe GPS Antenna installation".

Optional Rooftop GPS Antenna Kit (Ordering code: RA)
Antenna type: Rooftop antenna kit
Cable length: 5+15 m/16.4'+49'
Lightening Surge Protector: Included

Custom GPS Antenna
The customer can install another antenna. In such case, the antenna connector of the device supplies 5V/30 mA for the amplifier. Please note that the device is CE tested only for an antenna cable less than 30 m (98'). For the installation, please refer to our AppNote "Custom GPS Antenna Installation".

General Specifications

Environment
Operating temperature:
0°C to 40°C, (Relative humidity: 10-85%)
Storage: -25°C to 55°C
Transportation: -25°C to 70°C

Physical
Size: 445x300x44 mm (1U) (17.5x11.8x1.7 in)
Weight: 2.2 kg (4.9 lb)
Mounting, standard: Tabletop feet
Mounting, option:
19" rack mountable ears (ordering code: E)

Power
Power supply: AC input 85-264 VAC
Power input fluctuation:
±10% of nominal supply voltage (230 V~)
Input Frequency: 47–63 Hz
Power Consumption @25°C:
<25 W after warm-up
Connector Type: IEC plug

Ordering Information

Basic Model
PicoReference: Picosecond resolution test set
Included with shipment: GPS patch antenna, EUR power cable, US power cable, Users manual on CD, RS232 communication cable to PC, PicoReference installation SW on CD

Options and accessories
Option ST32: Stable32 postprocessing and analysis SW
Option 8RF: 8x 10 MHz outputs instead of 4x 10 MHz plus 4x 1-pps
Option E: Rackmount ears
Option S: Improved short term stability (Rubidium oscillator)
Option RA: Rooftop GPS Antenna incl 20 m download and lightning arrestor
Option ExtW-3: Extended Warranty to 3 years
Option ExtW-5: Extended warranty to 5 years