product data

GPS-88 and GPS-89

GPS-controlled Frequency Standards

Traceable accurate Frequency Standards

- Traceable internal calibration system approved by SP
- No calibration cost – ever
- Remote monitoring via Ethernet interface (NEW)
- Cesium stability – at budget price
- No doubt about accuracy, display of frequency offset
- Standard frequencies for telecom, calibration and test systems

Cesium controlled frequency via GPS satellites

The GPS-controlled frequency standards from Pendulum - models GPS-88 and GPS-89 - deliver a precision frequency and time reference, everywhere in the world. They receive their *long-term frequency stability* from built-in Cesium-controlled standards in the GPS-satellites. GPS shows a better short-term stability than other transmission systems, due to the fact that it is satellite based and not ground based. There is much less signal interference problems with the GPS-signals than with other systems (e.g. LW-systems Loran-C and DCF-77). The GPS can be used in all countries.

The GPS-88 and GPS-89 are designed to provide also a very-high *short-term frequency stability* via high-quality local oscillators. They are *cost-efficient, traceable* and *extremely accurate* frequency standards.

The models GPS-88/GPS-89 are very suitable as frequency standards in the telecommunication and electronics industry. They fit in the calibration laboratory, as a frequency reference in test systems and as a local reference in the design department.

Unique traceable frequency standard

Off-air frequency standards have existed for several years with the same internal architecture, see figure 1.

The typical unit is a “black box” for the user, with an antenna input and a frequency output. The control process (disciplining) of the local oscillator is totally hidden for the user. How can the user monitor or even trust the frequency output from the “black box”? The traditional way is to use another frequency reference (e.g. a rubidium standard), a phase comparator and a PC for logging the deviation between the “black box” and the other frequency reference.

We have now made the comparison and control process *visible and documented* (a requirement for traceability is a "comparison process on a continuing basis that produces documented measurement results").

We have used our leadership in high resolution counting technology and built-in an advanced phase measurement kernel. The received GPS-signal is continuously measured against the local oscillator and the phase/ frequency deviation is stored in a non-volatile storage and can at any time be transferred to a PC for printout of a calibration report. The unbroken calibration history chain – day by day – is maintained in the non-volatile memory for several years, see figure 2. Based on calibration data, the current 24h mean frequency offset, is continuously displayed on the front panel. Furthermore, also the short-term stability of the frequency reference is continuously calibrated and can be documented, when the unit is connected to a PC.

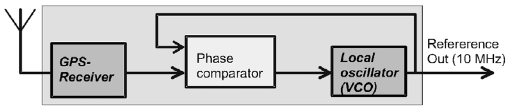

Figure 1. A typical “black box” GPS-receiver (antenna in - reference out). Internal oscillator offset and adjustments are invisible to the user

We have put a lot of efforts to ensure that the user will have an unbroken traceability chain, from the first day of operation and for the years to come. The user should connect the frequency standard to a PC at least once every second year to download the 24h frequency offset data and print out a calibration report via the enclosed PC program GPS-View™. See figure 3. To include also the short-term phase variation (hour by hour), download of instrument data should be made once per month. Days with insufficient GPS-contact, e.g. due to transportation, storage, service or whatever are clearly marked.

The GPS-88 and GPS-89 are the only TRUE traceable and documenting GPS-controlled frequency standards on the market.

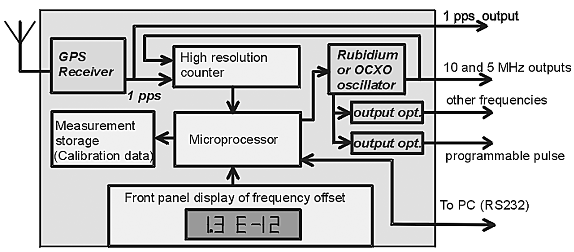

Figure 2. The model GPS-88 and GPS-89 have build-in comparison between the GPS-receiver and the internal oscillator. The frequency offset is displayed and stored and a traceable calibration protocol can be produced at any time

pendulum

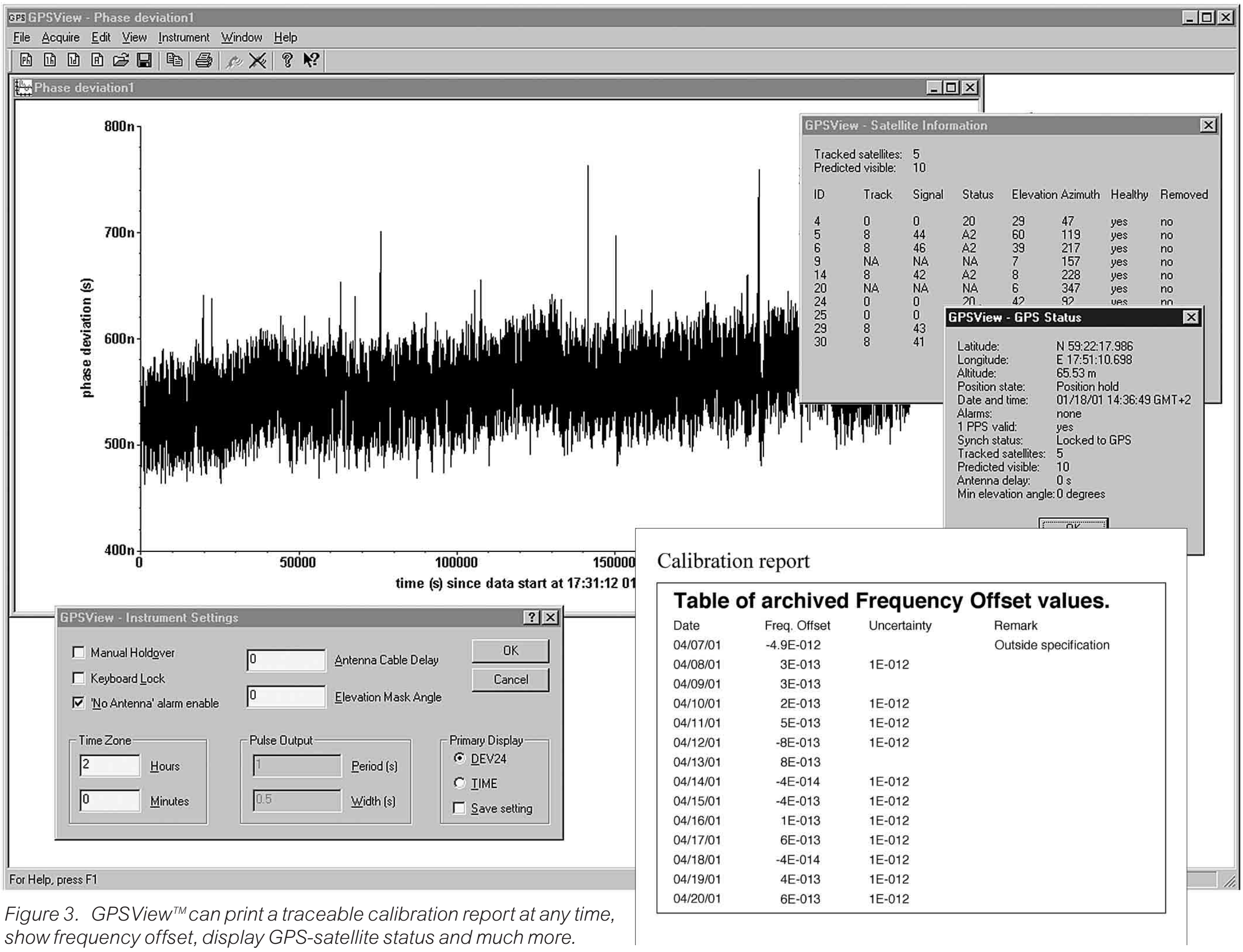

Table of archived Frequency Offset values.

Date	Freq. Offset	Uncertainty	Remark
04/07/01	-4.9E-012		Outside specification
04/08/01	3E-013	1E-012	
04/09/01	3E-013		
04/10/01	2E-013	1E-012	
04/11/01	5E-013	1E-012	
04/12/01	-8E-013	1E-012	
04/13/01	8E-013		
04/14/01	-4E-014	1E-012	
04/15/01	-4E-013	1E-012	
04/16/01	1E-013	1E-012	
04/17/01	6E-013	1E-012	
04/18/01	-4E-014	1E-012	
04/19/01	4E-013	1E-012	
04/20/01	6E-013	1E-012	

Figure 3. GPSView™ can print a traceable calibration report at any time, show frequency offset, display GPS-satellite status and much more.

Two models and optional configurations

Pendulum offers two models to choose from:

- *The very-high stability* GPS-89 with its built-in Rubidium atomic clock as the local oscillator.
- *The budget model* GPS-88 with its high-stability local oven controlled crystal oscillator.

Both models come as standard with one 5 MHz and five 10 MHz sine wave outputs, plus a 1 pps (one pulse-per-second) output.

There are four frequency output options to choose from:

- *Option 70*, which allows for five more 10 MHz outputs to be mounted, ideal for e.g. test systems when multiple instruments should be supplied from the same frequency standard.
- *Option 71*, which gives four sine wave outputs of resp. 10 MHz, 5 MHz and 0.1 MHz, plus a 0.1 MHz square wave output.
- *Option 72*, which gives five extra 2,048 MHz outputs (E1) for use in telecom applications.
- *Option 75*, which allows the user to define his/her own pulse frequency output.

Both instruments can communicate with a local PC via the RS232-port (standard) or with a remote PC via the Ethernet-port (optional).

Two operating modes

Most users would prefer an automatic adjustment (known as disciplining) of their frequency standard, to fully eliminate long-term frequency changes (aging). This *disciplined mode* is also the default mode in the models GPS-88 and GPS-89. As long as there is a valid satellite signal, the internal local oscillator is monitored and adjusted for drift. Disciplining the local oscillator makes life easy for the average user, and ensures that the mean 24h frequency offset is always virtually zero.

The *manual Hold-over mode* removes the automatic adjustment, thereby improving the short-term stability for GPS-88 (The GPS-89 is always very stable, independent of mode). This mode is intended for critical applications that demand superior medium-term stability, especially jitter and wander measurements in digital telecommunication networks. The unique manual Hold-over mode makes it possible to temporarily switch over from disciplined to Hold-over mode during the actual measurement, thereby achieving a superior frequency accuracy at the start of the measurement and a superior stability through the measurement.

Also in the manual Hold-over mode, the local oscillator is calibrated with full traceability and the frequency offset is displayed and stored.

In the disciplined mode, the aging of the frequency standards is virtually zero.

The 24h mean frequency offset is in the order of 10^{-12}, day after day after day. In the Hold-over mode, the aging of the model GPS-89 is for most applications totally neglectable; less than $5x10^{-11}$ per month.

Remote monitoring of your frequency standard (NEW)

Now you can remotely read the status of your frequency standard, get phase- or frequency deviation data, print calibration reports and much more. Use the optional Ethernet communication interface to access your frequency standard via Internet or any Ethernet LAN (10Base-T).

Made for portability too

When using manual Hold-over mode, the GPS-88/GPS-89 acts like a perfectly calibrated stand-alone OCXO or Rubidium Frequency Standard. This means that one common draw-back of a typical GPS-receiver – the lack of portability – is eliminated. A typical GPS-receiver needs hours to lock, after a change of location, whereas models GPS-88/GPS-89 are up and running after just 10 minutes.

GPSView ™

The GPS-88 and GPS-89 comes as standard with the PC-SW GPSView™. This SW allows you to print calibration reports, view short-term phase variations and long-term frequency variations and to view GPS-satellite status. See figure 3.

SP-Report

The test report from the Swedish National Testing and Research Institute (SP) verifies the outstanding stability and traceability of the GPS-89. The SP-report can be downloaded from www.pendulum.se.

GPS-88 and GPS-89 Specifications

Operating modes

Disciplined mode

The frequency deviation between the local oscillator and the received GPS-signal is used to continuously adjust the oscillator. The resulting 24h mean freq. offset is displayed continuously on the front panel, and stored together with adjustment data in non-volatile memory every 24h.

Hold-Over mode

The internal timebase oscillator is not adjusted. This mode is normally automatically entered when there is no useable received GPS-signal.
This mode can also be activated via the *Manual Hold-over* key. If there is a valid received GPS signal, the actual frequency offset is calculated and displayed plus stored in non-volatile memory every 24h.

GPS-89 (GPS-Rb)

Frequency stability - locked to GPS

Frequency offset (24h mean):	$<1x10^{-12}$ (at temperature 20 °C - 26 °C)
Short term (Allan dev.):	$<1x10^{-12}$ (t = 1000s)
	$<3x10^{-12}$ (t = 100s)
	$<1x10^{-11}$ (t = 10 s)
	$<3x10^{-11}$ (t = 1 s)
Warm up (+25°C):	20 mins to lock

Frequency stability - Hold-over

Aging/24h:	$<2x10^{-12}$ (typ.)
Aging/month:	$<5x10^{-11}$
Temp. (0°C - 50°C):	$<3x10^{-10}$
Temp. (20 °C - 26°C):	$<2x10^{-11}$ (typ.)
Short term (Allan dev.):	$<3x10^{-12}$ (t = 100s)
	$<1x10^{-11}$ (t = 10 s)
	$<3x10^{-11}$ (t = 1 s)
Warm up (+25°C):	10 minutes to $4x10^{-10}$

Phase noise

Offset	*Phase noise*
1 Hz	-80 dBc/Hz (typ.)
10 Hz	-90 dBc/Hz (typ.)
100 Hz	-130 dBc/Hz (typ.)
1 kHz	-140 dBc/Hz (typ.)
10 kHz	-140 dBc/Hz (typ.)
100 kHz	-145 dBc/Hz (typ.)

GPS-88 (GPS-OCXO)

Frequency stability - locked to GPS

Frequency offset (24h mean):	$<2x10^{-12}$ (at temperature 20 °C - 26 °C)
Short term (Allan dev.):	$<5x10^{-11}$ (t = 1000s)
	$<3x10^{-11}$ (t = 100s)
	$<5x10^{-12}$ (t = 10 s)
	$<5x10^{-12}$ (t = 1 s)
Warm up (+25°C):	20 mins to lock

Frequency stability - Hold-over

Aging/24h:	$<3x10^{-10}$
Aging/month:	$<3x10^{-9}$
Temp. (0°C - 50°C):	$<2.5x10^{-9}$
Temp. (20 °C - 26 °C):	$<4x10^{-10}$ (typ.)
Short term (Allan dev.):	$<5x10^{-12}$ (t = 100s)
	$<5x10^{-12}$ (t = 10 s)
	$<5x10^{-12}$ (t = 1 s)
Warm up (+25°C):	10 minutes to $5x10^{-9}$

Phase noise

Offset	*Phase noise*
1 Hz	-100 dBc/Hz (typ.)
10 Hz	-120 dBc/Hz (typ.)
100 Hz	-130 dBc/Hz (typ.)
1 kHz	-135 dBc/Hz (typ.)
10 kHz	-135 dBc/Hz (typ.)
100 kHz	-135 dBc/Hz (typ.)

Common

Standard reference outputs

Connector type BNC

10 MHz:	Sine wave, >0.6V rms in 50 Ω
5 MHz:	Sine wave, >0.6V rms in 50 Ω
Freq. Stability:	See frequency stability specs for GPS-88 resp. GPS-89 for GPS-locked respectively hold-over modes
1 pps:	Approx. 0 V…5 V in open output Approx. 0 V…2.0V in 50 Ω load
Duty cycle (GPS-locked):	Approx. 20%
Jitter (GPS-locked):	60 ns rms relative to UTC or GPS (opposition hold, SA on)
Option 70 outputs:	See specification for 10 MHz above
Option 71 outputs:	
Sine wave outputs:	10, 5, 1 and 0.1 MHz; >1 Vrms in 50 Ω
Pulse output:	0.1 MHz;>3Vp-p in 50 Ω $0V\leq LO<0.8V$ $3V<HI\leq5V$
Freq. stability:	See frequency stability specs for GPS-88 resp. GPS-89 for GPS-locked resp. hold-over modes
Option 72 outputs:	
Frequency:	2.048 MHz square wave
Output level:	-1.2V to + 1.2V ±10% in 75 Ω (G.703:10)
Freq. Stability:	See frequency stability specs for GPS-88 resp. GPS-89 for GPS-locked resp. hold-over modes
Jitter:	<0.01 UI
Option 75 output:	The frequency is adjustable via the included PC-program
Pulse output:	Approx. 0V…5V in open outout Approx. 0V…2.0V in 50 Ω load
Selectable period:	Nx100 ns ($2<N<2^{28}$)
Range:	200 ns to ≈ 27 s (≈ 0.04 Hz to 5MHz)
Selectable pulse width:	Nx100 ns
Range:	($1<N<2^{28}$-1) 100 ns to ≈ 27 s
Factory default setting:	
Frequency:	1 Hz (Period = 1 s)
Duty cycle:	50% (Pulse width = 0.5 s)
Jitter:	<500 ps (rms)
Freq. Stability:	See freq. stability specs for GPS-88 resp. GPS-89

Internal data storage

24h-freq. Offset:	2 years data, Non-volatile memory
Adjustment data:	2 years data, Non-volatile memory
Phase data:	40 days data, Volatile memory

Controls

Manual Hold-over:	Inhibits automatic GPS-adjustment and forces Hold-over operation

LED indicators

Locked to GPS:	ON	Disciplined mode
	OFF	Hold-over mode
Alarm:	ON	Alarm condition. Explaining text in 7-segment display area
	OFF	Normal operation
Manual Hold-over:	ON	Manual Hold-over mode
	OFF	Automatic choice of disciplined or Hold-over mode depending on “Locked to GPS” status

Display indicators

7-segment area:	24h mean freq. offset	(if valid data exist for the past 24 h)
	Time of day	(if GPS-contact gives valid time)
	“GPS-88” / “GPS-89”	(otherwise)
	Alarm text	(plus Alarm LED)
REMOTE segment:	Local Lock-out	(from PC)
Analog bar graph:	Satellite signal strength	

GPS-receiver

Antenna connector:	Type N
Channels:	8, parallel tracking
Carrier, code:	L1, C/A

Antenna (option 01)

Type:	active L1
Operating temp.:	-40°C to +70°C
Height:	81 mm (3.2")
Weight:	230 g (8 oz.)
Gain:	>30 dB
Connector:	TNC

Antenna cable (option 02/20, option 02/50)

Type:	RG213.
Length:	20 m (02/20), 50m (02/50)
Connectors:	N-type and TNC (male)
Cable delay:	101 ns (02/20), 251 ns (02/50)
Attenuation:	Approx. 8dB at 1.6 GHz (02/20) Approx. 20 dB at 1.6 GHz (02/50)

PC-connection

Interface:	RS232, DTE
Connector:	9-pin male DB9, Rx on pin2, Tx on pin 3, GND on pin 5
Baud rate:	9600 bps
Data structure:	8 data bits 1 stop bit, no parity

Option 76 Ethernet

Communication port:	
Connector:	RJ45
Protocol:	10Base-T
Buffer RAM:	1 kbit
Configuration port:	
Connector:	Dsub9, RS232

Fan

Temperature controlled

GPS-88 and GPS-89

Environmental

Temperature:	0°C to +50°C (operating) -40°C to +70°C (storage)
Safety:	Compliant to CE: EN 61010-1 + A1 (1992) + A2 (1995), Cat II, Pollution degree 2
EMI:	Compliant to CE: EN61326-1 (1997)

Power consumption

Line voltage:	100 to 240 V (±10%)
Line frequency:	47 to 63 Hz
Power GPS-89:	<75 W at warm-up <35 W continuous operation
Power GPS-88:	<25 W at warm-up <12 W continuous operation

Mechanical Data

WxHxD:	315x86x395 mm
Weight:	
GPS-89:	Net 4.4 kg Shipping 7.4 kg
GPS-88:	Net 3.9 kg Shipping 6.9 kg

GPSView SW

GPSView is a Windows 95/NT-program that communicates with GPS-88/GPS-89.

It provides a traceable calibration document based on the 24h frequency offset values, internally stored in the non-volatile memory of the Frequency Standards. It is only needed to connect a PC to the GPS-88/GPS-89 once every second year, to obtain an unbroken traceability chain since first use. For performance analysis over a shorter period (40 days), also short-term phase variation data can be obtained over the latest 40 day period.

From GPSView, the user can select time-of-day or frequency-offset display, control the operating mode (disciplined or Hold-over), and lock the front panel to prevent unintended change via the "manual Hold-over" key. The user can also set the optional pulse output frequency and duty cycle.

GPSView can also retrieve and display GPS-receiver status info.

Calibration data can be printed in graph format to produce a calibration report, and can also be stored in a file format suitable for direct import in MS-Excel for further analysis.

Ordering information

GPS-88:	GPS-controlled OCXO Frequency Standard. 5x 10 MHz and 1x 5 MHz outputs
GPS-89:	GPS-controlled Rubidium Frequency Standard. 5x 10 MHz and 1 x 5 MHz outputs
Opt. 70:	5 extra 10 MHz outputs
Opt. 71:	Multiple reference outputs 0.1/1/5/10 MHz
Opt. 72:	5 extra 2.048 MHz outputs
Opt. 75:	1 extra pulse output 0.5 Hz...5 MHz
Opt. 76:	Ethernet connection

Included with Instrument

	Operators manual
	Calibration certificate
	GPSView SW

Optional accessories

Option 22:	19" rack mount kit
Option 27:	Carrying Case
Option 27H:	Heavy-Duty Transport Case
Option 01:	GPS antenna
Option 01/50:	GPS Antenna Mounting Kit
Option 02:	Antenna cable, 20m
Option 02/50:	Antenna cable, 50 m

Specifications subject to change without notice

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Pendulum Instruments AB
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– experts in Time & Frequency Calibration, Measurement and Analysis

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