GPS-88 and GPS-89

GPS-controlled Frequency Standards

Traceable accurate Frequency Standards

- No calibration cost – ever
- Traceable internal calibration data stored for several years
- Best stability – both short and long term
- Display of frequency offset
- 11 fixed frequency outputs (10, 5, 2.048 MHz) and one programmable

Cesium controlled frequency via GPS satellites

The new 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-standards in the GPS-satellites. The GPS-88 and GPS-89 are designed to provide also a very-high short-term 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 of course in the calibration laboratory, but also as a frequency reference in the production test system and as a local reference in the design department.

Unique traceable frequency standard

Off-air frequency standards have existed for several years. But, until now, they have had 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 he 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").

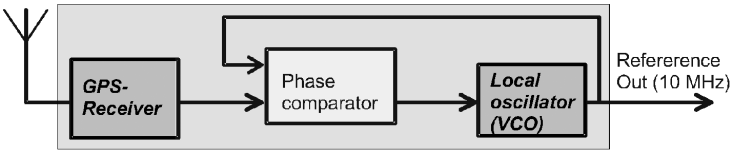

Figure 1. A typical "black box" GPS-receiver (antenna in - reference out). Internal oscillator offset and adjustments are invisible to the user

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 traceability record. The unbroken calibration history chain – day by day – is maintained in the non-volatile memory for several years, see figure 2.

The calibration data, i.e. the current 24h mean frequency offset, is continuously dis-played on the front panel. Furthermore, also the short-term stability of the frequency refer mented, when the unit is connected to a PC.

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 coming years. The user should connect the frequency standard to a PC at least once during a two-year period, to download the calibration data and print out a traceability record via the enclosed PC program GPSViewTM. See figure 3. Days with no 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.

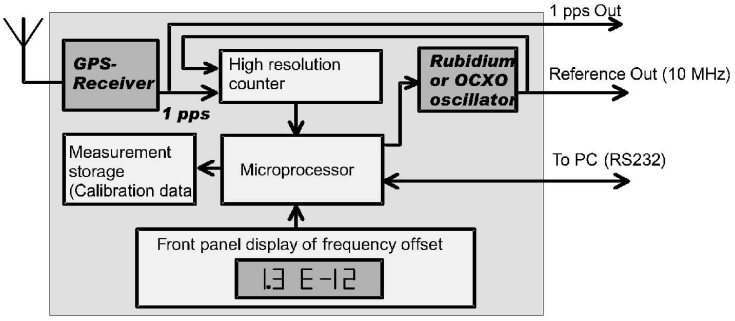

Figure 2. The model GPS-88 and GPS-89 have build-in comparison between the GPS-receiver and the internal oscillator. The frequency offset is displayed and stored and a traceable calibration protocol can be produced at any time

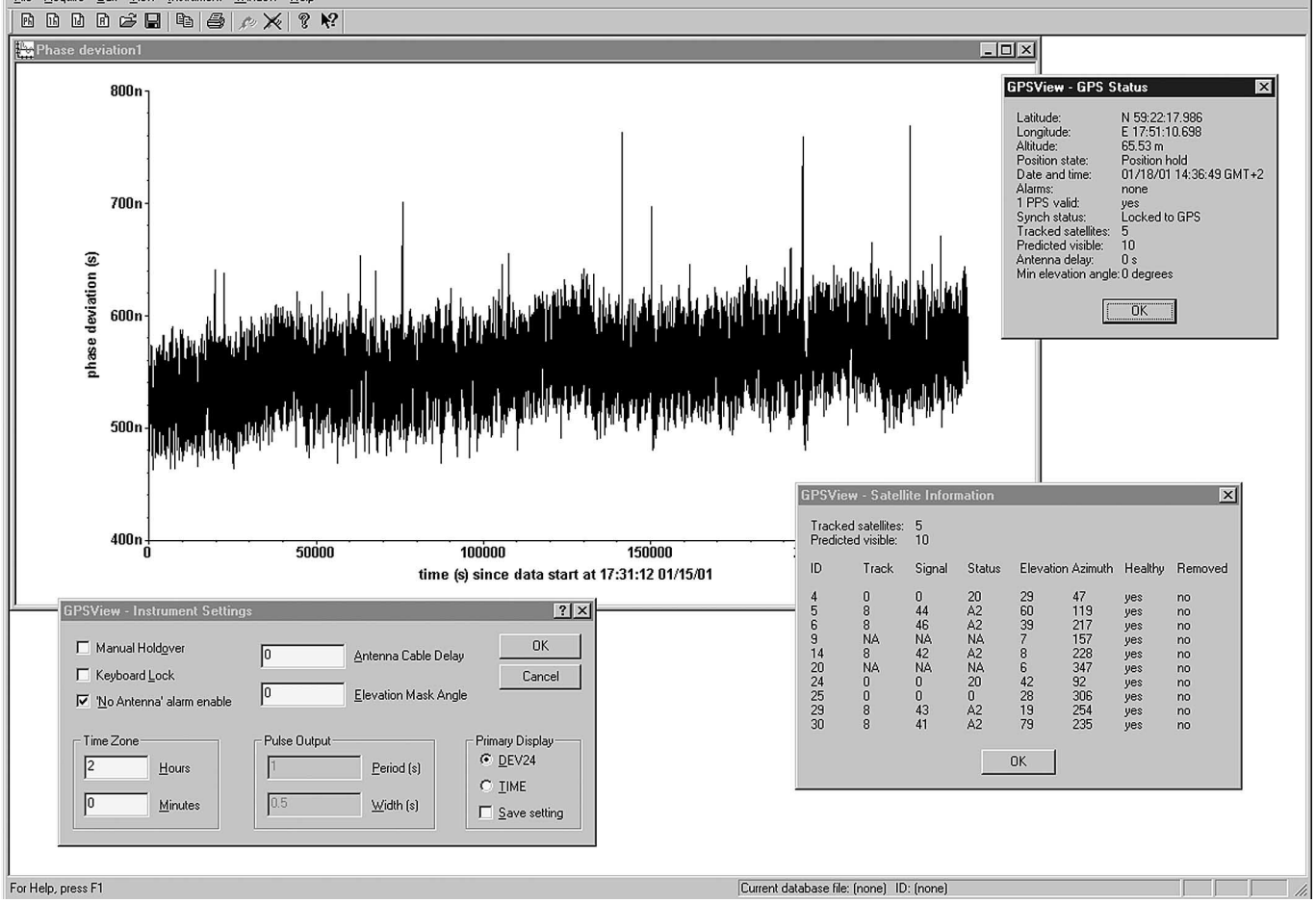

Figure 3. GPSView™ can print a traceable calibration protocol at any time, show frequency offset, display GPS-satellite status and much more.

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 or the budget model 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.

If the actual application requires more, for example in test systems when multiple instruments should be supplied from the same frequency standard, the option 70 allows for five more 10 MHz outputs to be mounted. Option 72 gives you 5 additional 2,048 MHz outputs (E1) for use in telecom applications.

And finally, the option 75, allows the user to define his own pulse frequency output, for example 1 Hz, 50 Hz, 100 kHz and 1 MHz.

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.

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 protocols, view short-term phase variations and long-term frequency variations and to view GPS-satellite status.

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

Reference outputs (BNC)

10 MHz:	Sine wave, 0.6V rms in 50 Ω
5 MHz:	Sine wave, 0.6V rms in 50 Ω
1 pps:	TTL-levels; low < 0.4V, high > 2V in 50 Ω load.
Pulse output (opt. 75):	TTL-levels; low < 0.4V, high > 2V in 50 Ω load

10 MHz and 5 MHz outputs

Freq. Stability:	See frequency stability specs for GPS-88 resp. GPS-89

1-pps output (locked to GPS)

Duty cycle:	Approx. 20%
Jitter:	< 60 ns rms relative to UTC or GPS (position hold, SA on)

2.048 MHz Clock outputs (option 72)

Ref. Frequency:	2.048 MHz square-wave
No. of outputs:	5 buffered outputs
Connector:	BNC
Freq. Stability/24h:	$1x10^{-12}$ (GPS-89) resp. $2x10^{-12}$ (GPS-88)
Jitter:	<0.01 UI
Output level:	Acc. to G703:10; ±1.2V ±10% in 75Ω

Pulse output (option 75)

The frequency is set via the included PC-program GPSView

Selectable frequency:	$1/Nx10^{7}$ Hz; $2 < N < 2^{38}$
Selectable pulse width:	$Nx10^{-7}$ s; $1 < N < 2^{38} - 1$
Factory default setting:	1 Hz, approx. 50% duty cycle
Jitter:	<500 ps rms
Freq. Stability:	See frequency 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

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)
	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)

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

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

Fan

Temperature controlled

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

GPS View SW

GPS View 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 (2 days), also short-term phase variation data can be obtained over the latest 2 day period.

From GPS View, 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.

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

Calibration data can be printed in graph format to produce a traceability record, 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. 72:	5 extra 2.048 MHz outputs
Opt. 75:	1 extra pulse output 0.5 Hz...5 MHz

Included with Instrument

Operators manual
Calibration certificate
GPS View SW

Optional accessories

Option 22:	19" rack mount kit
Option 27:	Carrying Case
Option 27H:	Heavy-DutyTransport Case
Option 01:	GPS antenna
Option 02:	Antenna cable, 20m

Specifications subject to change without notice

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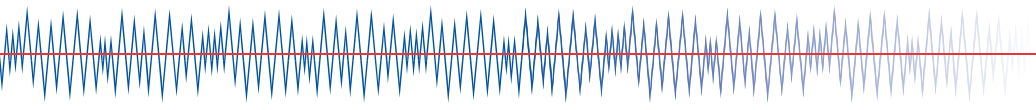
Pendulum Instruments AB
www.pendulum.se

– experts in Time & Frequency Calibration, Measurement and Analysis



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