

GPS-88 & GPS-89

GPS-controlled Frequency Standards

Traceable Accurate Frequency Standards

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



Deliver precision frequency and time reference with these GPS-controlled frequency standards. The GPS- 88 and GPS-89 are fully traceable and extremely accurate frequency standards, with applications in telecommunications, calibration laboratories, automated test systems and design departments.

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 atomic clocks in the GPS-satellites.

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.

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 nonvolatile 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.

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

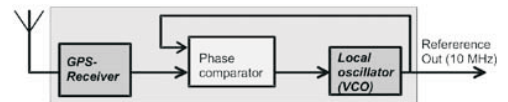


Figure 1. A typical “black box” GPS-receiver (antenna in - reference out). Internal oscillator offset and adjustments are invisible to the user

the frequency standard to the enclosed PC program GPSView™ at least once every second year to download the 24h frequency offset data and print out a calibration report.

To include also the short-term phase variation (hour by hour), download of instrument data should be made, and a run of the control and monitoring program GPSView™, once per month (see figure 3). Days with insufficient GPS-contact, e.g. due to transportation, storage, service or whatever are clearly marked, in the calibration report generated by GPSView™.

The GPS-88 and GPS-89 are really true traceable and documenting GPS-controlled frequency standards!

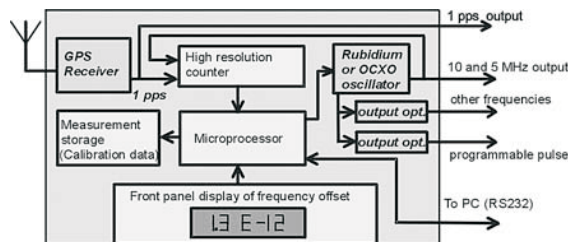


Figure 2. The model GPS-88 and GPS-89 have built-in continuous comparison between the GPS-receiver and the internal oscillator. The frequency offset is displayed and stored and a traceable calibration protocol can be produced at any time

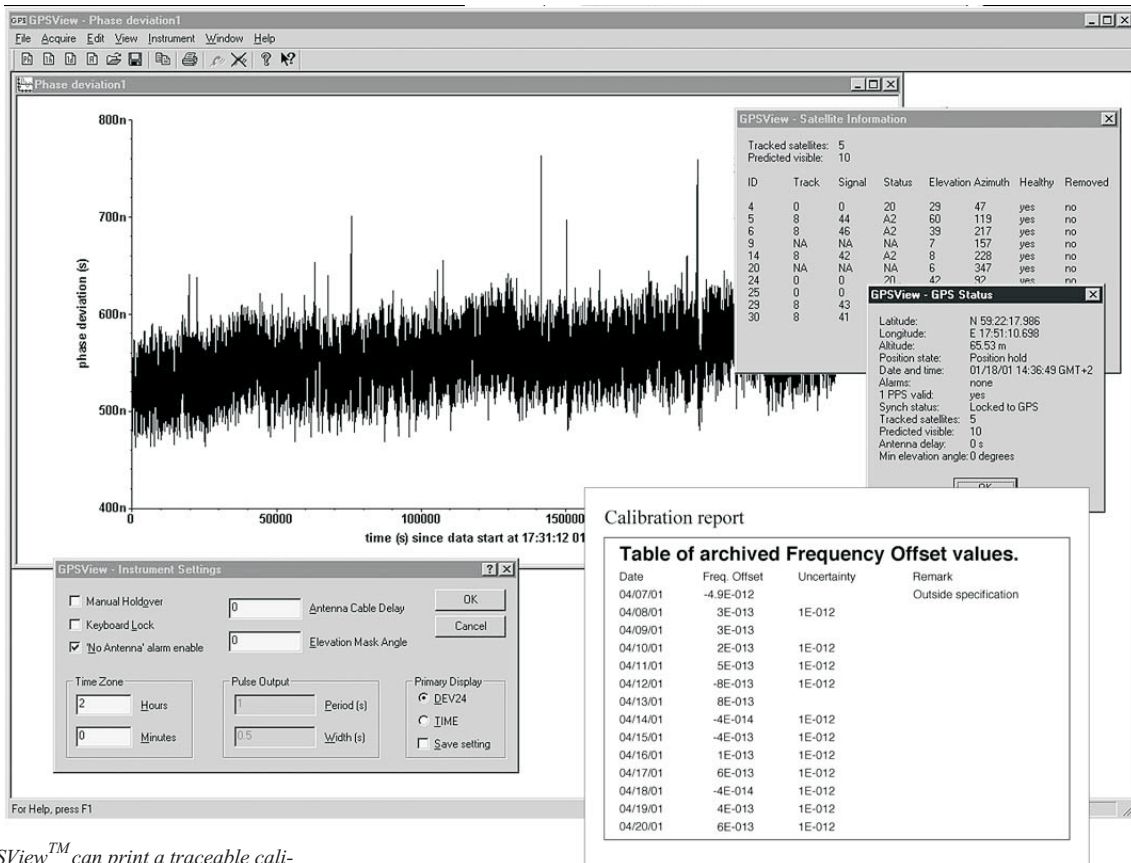


Figure 3. GPSView™ can print a traceable calibration report at any time, show frequency offset, display GPS-satellite status and much more.

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 five 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 73*, which gives five extra 13 or 26 MHz outputs intended for GSM base station 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.

Remote Monitoring of Your Frequency Standard

You can remotely read the status of your frequency standard, get phase- or frequency de-

viation 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

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. Other GPS-receivers may need 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 at www.pendulum-instruments.com

GPS-88 and GPS-89 Technical 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):

$<1 \times 10^{-12}$ (at temperature 20 °C - 26 °C)

Short term (Allan dev.):

$<1 \times 10^{-12}$ (t = 1000s)
 $<3 \times 10^{-12}$ (t = 100s)
 $<1 \times 10^{-11}$ (t = 10 s)
 $<3 \times 10^{-11}$ (t = 1 s)

Warm up (+25°C):

20 mins to lock

Frequency stability - Hold-over

Aging/24h: $<2 \times 10^{-12}$ (typ.)

Aging/month: $<5 \times 10^{-11}$

Temp. (0°C - 50°C): $<3 \times 10^{-10}$

Temp. (20 °C - 26°C): $<2 \times 10^{-11}$ (typ.)

Short term (Allan dev.):

$<3 \times 10^{-12}$ (t = 1000s)
 $<1 \times 10^{-11}$ (t = 10 s)
 $<3 \times 10^{-11}$ (t = 1 s)

Warm up (+25°C):

10 minutes to 4×10^{-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):

$<2 \times 10^{-12}$ (at temperature 20 °C - 26 °C)

Short term (Allan dev.):

$<5 \times 10^{-11}$ (t = 1000s)
 $<3 \times 10^{-11}$ (t = 100s)
 $<5 \times 10^{-12}$ (t = 10 s)
 $<5 \times 10^{-12}$ (t = 1 s)

Warm up (+25°C):

20 mins to lock

Frequency stability - Hold-over

Aging/24h: $<3 \times 10^{-10}$

Aging/month: $<3 \times 10^{-9}$

Temp. (0°C - 50°C): $<2.5 \times 10^{-9}$

Temp. (20 °C - 26°C): $<4 \times 10^{-10}$ (typ.)

Short term (Allan dev.):

$<5 \times 10^{-12}$ (t = 100s)
 $<5 \times 10^{-12}$ (t = 10 s)
 $<5 \times 10^{-12}$ (t = 1 s)

Warm up (+25°C):

10 minutes to 5×10^{-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 \wedge

5 MHz: Sine wave, >0.6V rms in 50 \wedge

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 \wedge 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 \wedge

Pulse output: 0.1 MHz; >3Vp-p in 50 \wedge

0V. LO<0.8V 3V<HI.5V

Freq. stability: See frequency stability specs for GPS-88 resp. GPS-89 for GPS-locked resp. hold-over modes

Option 72, 73/13 or 73/26 outputs:

Frequency: 2.048 MHz square wave (opt. 72)
 13 MHz (option 73/13)
 26 MHz (option 73/26)

Output level: -1.2V to +1.2V $\pm 10\%$ in 75 \wedge
 (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:

Pulse output: Approx. 0V...5V in open output
 Approx. 0V...2.0V in 50 \wedge load

Selectable period: Nx100 ns (2<N<228)

Range: 200 ns to . 27 s (. 004 Hz to 5MHz)

Selectable pulse width: Nx100 ns

Range: (1<N<228-1) 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

Controls

Manual Hold-over: Inhibits automatic GPS-adjustment and forces. Hold-over operation. Also toggles between freq. offset and time-of-day display

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: 12, 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, and option 02/130)

Type: RG213

Length: 20 m (02/20), 50m (02/50), 130m (02/130)

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

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

Attenuation: Approx. 8dB at 1.6 GHz (02/20)
Approx. 20 dB at 1.6 GHz (02/50)

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 2000/XP/Vista-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, and run GPSView™, 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

Basic Model

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

Option 70: 5 extra 10 MHz outputs
Option 71: Multiple reference outputs 0.1/1/5/10 MHz
Option 72: 5 extra 2.048 MHz outputs
Option 73/13: 5 extra 13 MHz outputs
Option 73/26: 5 extra 26 MHz outputs
Option 75: 1 extra pulse output 0.5 Hz...5 MHz
Option 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, 50m
Option 02/130: Antenna cable, 130m

Specifications subject to change without prior notice

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- Experts in time & frequency calibration,
measurement and analysis

Pendulum Instruments is a company of the Orolia Group