

High Stability Frequency Standards 908 & 909

Operators Manual

908 OCXO Frequency Standard
909 Rubidium Frequency Standard
Operators Manual
Copyright Pendulum Instruments AB 2000
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1. Safety Instructions

Introduction

Read this page carefully before you install and use the instrument.

This instrument has been designed and tested according to safety Class 1 requirements of EN61010-1 and CSA 22.2 No.1010.1, and has been supplied in a safe condition. The user of this instrument must have the required knowledge of it. This knowledge can be gained by thoroughly studying this manual.

This instrument is designed to be used by trained personnel only. Removal of the cover for repair or rack-mounting of the instrument must be done by qualified personnel who are aware of the hazards involved. There are no user-serviceable parts inside the instrument.

Safety precautions

To ensure the correct and safe operation of this instrument, it is essential that you follow generally accepted safety procedures in addition to the safety precautions specified in this manual.

Caution and warning statements

CAUTION: Shows where incorrect procedures can cause damage to, or destruction of equipment or other property.

WARNING: Shows a potential danger that requires correct procedures or practices to prevent personal injury.

Symbols



Shows where the protective ground terminal is connected inside the instrument. Never remove or loosen this screw.



Indicates that the operator should consult the manual.

If in doubt about safety

Whenever you suspect that it is unsafe to use the instrument, you must make it inoperative by doing the following:

- Disconnect the line cord
- Clearly mark the instrument to prevent its further operation
- Inform Pendulum Instruments AB or your local representative for repair actions.
- For example, the instrument is likely to be unsafe if it is visibly damaged.

Fuse

A 2A/250V slow blow fuse is placed in the internal power supply.

CAUTION: If this fuse is blown, it is likely that the power supply is badly damaged. Do not replace the fuse. Send the instrument to Pendulum Instruments AB or your local representative.

Grounding

Whenever an instrument is connected to the line voltage, a grounding fault will make it potentially dangerous. Before connecting any unit to the power line, you must make sure that the protective ground functions correctly. Only then can a unit be connected to the power line and only by using a three-wire line cord. No other method of grounding is permitted. Extension cords must always have a protective ground conductor.

WARNING: If a unit is moved from a cold to a warm environment, condensation may cause a shock hazard. Ensure, therefore, that the grounding requirements are strictly met.

WARNING: Never interrupt the grounding cord. Any interruption of the protective ground connection inside or outside the instrument or disconnection of the protective ground terminal is likely to make the instrument dangerous.

2. Installation

Unpacking

Check that the shipment is complete and that no damage has occurred during transportation. If the contents are incomplete or damaged, file a claim with the carrier immediately. Also notify Pendulum Instruments AB or its local representative in case repair or replacement may be required.

Check list

The shipment should always contain the following:

- The 908 or 909 Frequency Standard
- Line cord
- This Operators Manual
- Certificate of calibration

If you ordered PM9622/00, a rack mount kit should also be included.

If you ordered PM9627, a transport case should also be included.

Identification

The type number plate on the rear side identifies the version.

The basic model with 5x 10 MHz and 1x 5 MHz outputs has 6 BNC-outputs on the rear panel.

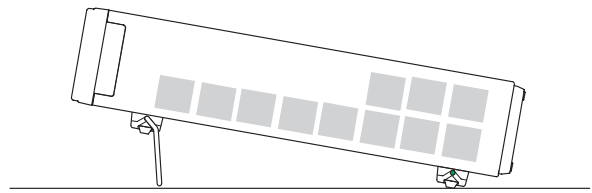
The extended model with 10x 10MHz and 1x 5MHz outputs has 11 BNC-outputs on the rear panel.

Supply voltage

The 908/909 Frequency Standard may be connected to any AC supply with a voltage rating of 100 to 240 Vrms; 47 to 63 Hz. The instrument is automatically adjusted to the input line voltage.

Orientation and cooling

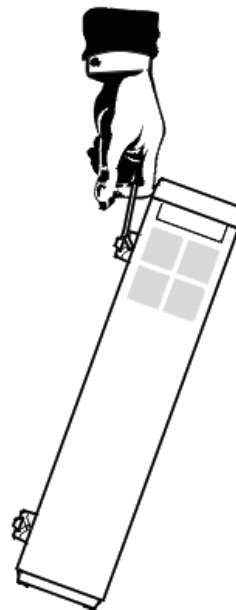
The instrument can be operated in any position desired. Make sure that the air flow through the ventilation slots are not obstructed. Leave approx 1 centimeter (1/2 inch) of space around the instrument.



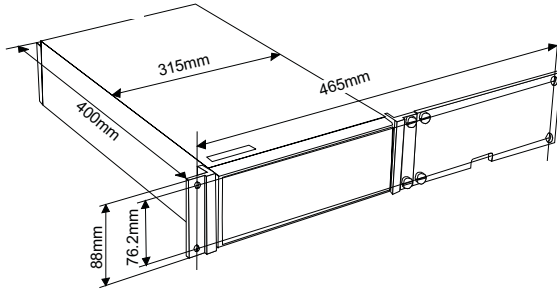
CAUTION: Never cover the ventilation slots at the right or left side. If the slots are covered, the instrument may overheat.

Fold-down Support

For bench top use, a fold-down support is available for use underneath the instrument. This support can also be used as a handle to carry the instrument.



3. Rack mount adapter



If you have ordered a 19 inch rack mount kit for your instrument, it has to be assembled after delivery of the instrument. The rack mount kit consists of the following:

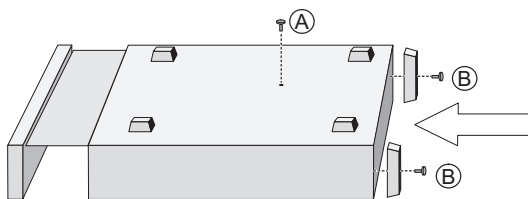
- 2 brackets, (short, left; long, right)
- 4 screws, M5 x 8
- 4 screws, M6 x 8

WARNING: When you remove the cover you will expose live parts and accessible terminals which can cause death.

WARNING: Capacitors inside the instrument can hold their charge even if the instrument has been separated from all voltage sources.

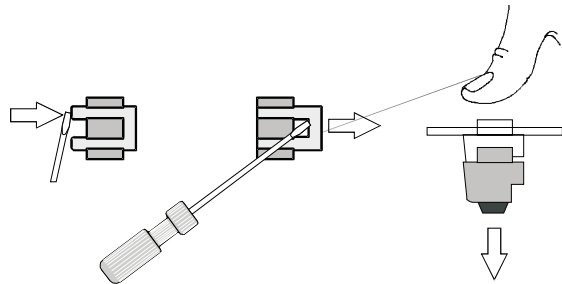
Assembling the rack mount kit

- Make sure the power cord is disconnected from the instrument.
- Turn the instrument upside down.

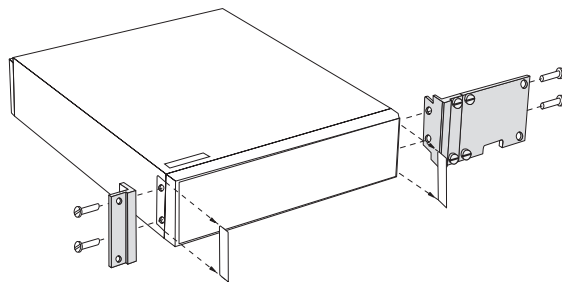


- Loosen the two screws (A) at the rear feet.
- Grip the front panel and gently push at the rear.
- Pull the instrument out of the cover.
- Remove the four feet from the cover.

Use a screwdriver as shown in the following illustration or a pair of pliers to remove the springs holding each foot, then push out the feet.



- Remove the two plastic lids that cover the screw holes on the right and left side of the front panel.
- Push the instrument back into the cover.
- Turn it upside down
- Install the two rear feet with the screws (A) to the rear panel.
- Fasten the brackets at the left and right side with the screws included as illustrated below.



- Fasten the 908 or 909 in the rack via screws in the four rack mounting holes

Reversing the rack mount kit

The instrument may also be mounted to the right in the rack. To do so, first remove the plate on the long bracket and fasten it on the short one, then perform the preceding steps.

4. Operation

The 908 OCXO Frequency Standard contains a high-stability SC-cut, oven-enclosed, crystal oscillator, whereas the 909 contains a high-stable Rubidium time-base oscillator (an “atomic clock”). Both instruments include also a buffer amplifier for either five or ten 10 MHz sine-wave outputs. In addition, also one 5MHz output is always available. The Frequency Standard is designed for bench or rack operation and for stationary as well as portable use.

As with all high-stability frequency standards, optimum stability requires uninterrupted power supply and continuous operation. Thus there is no power switch on the instrument, to avoid accidental removal of the AC power line voltage.

Portable (or intermittent) operation:

Connect the unit to the AC power line

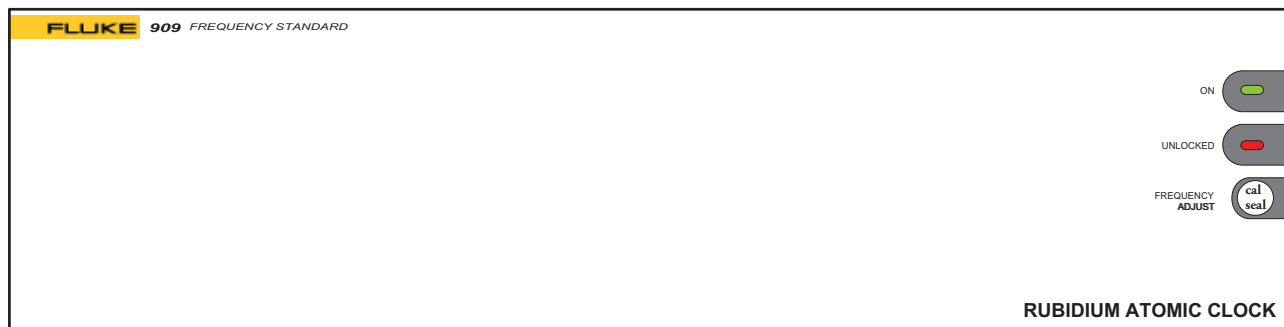
909: Wait approx 5 minutes for the rubidium oscillator to lock (the UNLOCK LED turns off). Now the 909 output frequency deviates approx 10 mHz from 10 MHz. Wait another 30 minutes for improved stability (approx. 1 mHz deviation)

908: Wait approx 10 minutes for the output frequency to deviate approx. 0.05 Hz from final value. The “final value” is 10 MHz $\pm$ ageing since last adjustment (0.03 Hz/month)

Stationary (or continuous) operation:

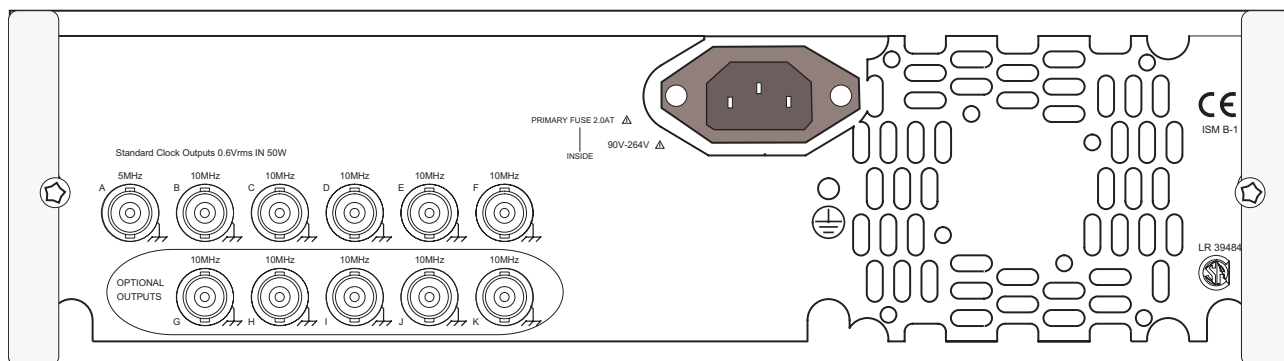
The output frequency stability for continuous uninterrupted operation is 0.03 Hz/month (908) respectively 0.0005 Hz/month (909).

More detailed data on frequency stability is found in chapter 8 (Specifications).



Front panel of 909. The ON indicator shows when power is connected. The UNLOCK indicator warns when the output frequency is not yet locked to the rubidium element. The adjustment potentiometer is located under the calibration seal.

The 908 front panel has the same layout, however without the UNLOCK indicator.



The frequency standard signals are available at the BNC-connectors on the rear panel. The rear panels of 908 and 909 are identical. This picture shows the 909 version incl. Option 70 (11 BNC-outputs).

5. Preventive maintenance

Calibration

To maintain the performance of the 908/909, we recommend that you calibrate the timebase of your frequency standard every year, or when required, to a traceable standard. The 909 should be calibrated to a Cesium standard or a GPS-receiver, and the 908 to a calibrated Rubidium standard (or to a Cesium standard or a GPS-receiver).

The frequency of the standard oscillator is influenced by external conditions, such as ambient temperature and supply voltage, as well as aging. When calibrating and adjusting, you compensate the standard oscillator only for deviation due to aging.

The time between calibrations is determined by the degree of frequency uncertainty you are willing to accept.

Frequency uncertainty calculation

Aging and temperature characteristics of the frequency standards are given in chapter 8 (Specifications).

The uncertainty (2σ-level) is given from the formula:

$$2 \cdot \sqrt{\frac{e_i^2 + e_a^2 + e_t^2}{3}}, \text{ where}$$

e_i = initial uncertainty (calibration uncertainty)

e_a = uncertainty due to ageing

e_t = uncertainty due to temperature

Uncertainty	908	909
Initial (e_i)	5×10^{-9}	5×10^{-11}
Ageing/ month (e_a)	3×10^{-9}	5×10^{-11}
Ageing/ year (e_a)	2×10^{-8}	2×10^{-10} <i>typical</i>
Ageing/ 10 years (e_a)	n.s.	1×10^{-9}
Temperature 0...50°C (e_t)	2.5×10^{-9}	3×10^{-10}
Temperature 20...26°C (e_t)	4×10^{-10} <i>typical</i>	5×10^{-11} <i>typical</i>

Example 1: The relative uncertainty 1 year after calibration and adjustment, for a 908, operating in the full temperature range is:

$$2 \cdot \sqrt{\frac{e_i^2 + e_a^2 + e_t^2}{3}}$$

$$2 \cdot \sqrt{\frac{(5 \cdot 10^{-9})^2 + (2 \cdot 10^{-8})^2 + (2.5 \cdot 10^{-9})^2}{3}} \approx 2.4 \cdot 10^{-8}$$

or approx. 0.2 Hz on the 10 MHz output.

Example 2: The relative uncertainty 2 years after calibration and adjustment, for a 909, operating in temperature controlled lab environment is:

$$2 \cdot \sqrt{\frac{e_i^2 + e_a^2 + e_t^2}{3}}$$

$$2 \cdot \sqrt{\frac{(5 \cdot 10^{-11})^2 + (2 \cdot 2 \cdot 10^{-10})^2 + (5 \cdot 10^{-11})^2}{3}} \approx 4.7 \cdot 10^{-10}$$

or approx. 0.005 Hz on the 10 MHz output.

Fan Replacement

If your frequency standard is operating 24h/day, you need to replace the fan every 5:th year to maintain high reliability. For part-time applications and low ambient temperatures, an extended service interval is acceptable.

Fan replacement requires no special tools (screwdrivers only). The order number for the replacement fan is 4031 105 02830.

6. Acceptance Test

908

To check the performance of the 908, a high stability frequency standard source is needed. For example a calibrated 909 (Rubidium Frequency Standard) or similar

Required Test Equipment

Type	Uncertainty	Model
10 MHz standard	$<1 \times 10^{-9}$	Calibrated Rubidium standard
Timer/Counter		PM6681 (incl. TimeView SW) + PC (incl. GPIB-card)

Test procedure

- Let the 908 be disconnected from power during 24h
- Connect PM6681 to a PC (via GPIB) and start the TimeView program. In this way you can monitor the frequency stabilization process.
- Let the PM6681 Timer/Counter warm up for 30 minutes. Select default settings and change the measuring time to 5 s. Connect the external 10 MHz frequency standard (from e.g. the 909) to the Ext. Ref. Input of PM6681 (at rear panel).
- Connect one of the 10 MHz outputs of 908 to input A of the PM6681.
- Connect the 908 to the power line.
- Check that the ON LED turns on immediately.
- Now check that the frequency reading, 10 minutes after power-on is $10 \text{ MHz} \pm \Delta \text{ Hz}$
- $\Delta = 0.15 + 0.03 \cdot n \text{ (Hz)}$, where n is the number of months since last calibration and adjustment of the 908.

909

To fully check the performance of the 909, a very-high stability standard signal is needed. Examples of such standards are Cesium Atomic standards, or transmitted signals from nationally or internationally traceable sources, like GPS.

The procedure described here gives less accuracy as it compares one Rubidium frequency standard with another. However, the procedure gives an indication of proper functioning of the Frequency Standard in typical portable applications.

Required Test Equipment

Type	Uncertainty	Model
10 MHz standard	$<1 \times 10^{-10}$	Calibrated Rubidium standard
Timer/Counter		PM6681 (incl. TimeView SW) + PC (incl. GPIB-card)

Test procedure

- Disconnect the 909 from power during 24h prior to testing.
- Connect PM6681 to a PC (via GPIB) and start the TimeView program. In this way you can monitor the frequency stabilization process.
- Let the PM6681 Timer/Counter warm up for 30 minutes. Select default settings and change the measuring time to 5 s. Connect the external 10 MHz frequency standard to the Ext. Ref. Input of PM6681 (at rear panel).
- Connect one of the 10 MHz outputs of 909 to input A of the PM6681.
- Connect the 909 to the power line.
- Check that the UNLOCK indicator on 909 turns on immediately, and then turns off again within approx. 6 minutes after connecting line power. Now check that the frequency reading is $10 \text{ MHz} \pm 0.02 \text{ Hz}$
- Wait for approx. 30 minutes. Check that the frequency reading is $10 \text{ MHz} \pm 0.01 \text{ Hz}$. Look at the TimeView screen for visual feed-back of frequency stability.

7. Calibration and Adjustments

NOTE: Before adjusting, the 908 or 909 Frequency Standard must have been continuously connected to the power line for at least 24 hours.

Required Test Equipment - 908

Type	Uncertainty	Model
10 MHz standard	$<1 \times 10^{-9}$	Calibrated Rubidium standard
Timer/Counter		PM6681 (incl. TimeView SW) + PC (incl. GPIB-card)

Required Test Equipment - 909

Type	Uncertainty	Model
10 MHz standard	$<2 \times 10^{-11}$	Cesium frequency standard 910R GPS-receiver (Rubidium)
Timer/Counter		PM6681 (incl. TimeView SW) + PC (incl. GPIB-card)

Calibration setup of PM6681

- Connect one of the 10 MHz outputs on the 908 or 909 to input A of the PM 6681 timer/counter.
- Connect the external 10 MHz standard to the External Frequency Standard input of the PM6681 timer/counter (rear panel).

Calibration measurement

- Set the PM6681 measuring time to 10 s.
- Select MATH (K*X+L) and set a negative offset of 10 MHz (L = -10E6)
- Select STAT (statistics), N=100 and “mean”
- Press RESTART. After approx. 17 minutes the mean value over 100 readings is displayed

Adjustment criteria - 908

If the display reading does not exceed 50 mHz (50×10^{-3} Hz), no adjustment is required.

Adjustment criteria - 909

If the display reading does not exceed 0.5 mHz (0.5×10^{-3} Hz), no adjustment is required.

NOTE. If a GPS-receiver other than 910R is used as standard, change number of samples N in the STAT menu in PM6681 to 8640 (instead of 100) to enable a frequency mean value over 24h (instead of 17 minutes). GPS-receivers have an excellent long-term stability (24h) but can be quite unstable over shorter time periods.

Adjustment procedure

- Switch off statistics (STAT=OFF) in PM6681
- Remove the seal from the front panel of 908/909
- Adjust the potentiometer behind the seal until the display shows 50×10^{-3} Hz or less for 908 respectively 0.5×10^{-3} Hz or less for 909.
- Repeat the calibration measurement (switch on STAT, N=100 and mean) to verify the adjustment.
- Check that the value is stable over time, (more than 30 minutes). TimeView is an excellent tool for viewing frequency stability over time.
- Attach a calibration seal sticker so that it covers the Calibration Adjustment hole in the front panel beside the “FREQUENCY ADJUST” text.

8. Specifications

Standard outputs

10 MHz: 5 outputs (668X/011 version)
10 outputs (668X/021 version)

5 MHz: 1 output

Output signal: Sine wave, 0.5V rms in 50 Ω

Frequency uncertainty - 908

Calibration uncertainty (+23 $\pm$ 3 $^{\circ}$ C):

5×10^{-9}

Aging/month: 3×10^{-9}

Aging/year: 2×10^{-8}

Temperature: 2.5×10^{-9} (0 $^{\circ}$ C...+50 $^{\circ}$ C)

Short term (Root Allan variance):

5×10^{-12} (τ = 10 s)

5×10^{-12} (τ = 1 s)

Warm up: 10 minutes to 5×10^{-9} from final value (at +25 $^{\circ}$ C)

Frequency uncertainty - 909

Calibration uncertainty (+23 $\pm$ 3 $^{\circ}$ C):

5×10^{-11}

Aging/month: 5×10^{-11}

Aging/10 years: 1×10^{-9}

Temperature: 3×10^{-10} (0 $^{\circ}$ C...+50 $^{\circ}$ C)

Short term (Root Allan variance):

1×10^{-11} (τ = 10 s)

3×10^{-11} (τ = 1 s)

Warm up: 5.4 minutes to lock (at +25 $^{\circ}$ C)
10.6 minutes to 4×10^{-10}

Environmental

Temperature: 0 $^{\circ}$ C...+50 $^{\circ}$ C (operating)

-40 $^{\circ}$ C...+70 $^{\circ}$ C (storage)

Safety: Compliant to EN 61010-1, cat. II, CE

EMI: Compliant to EN 55011, group 1,
class B and EN 50082-2, CE

Power requirements

Line voltage: 100...240 V $\pm$ 10%

Line frequency: 47...63 Hz

908 rating: <20 W at warm-up,
< 7 W continuous operation

909 rating: <70 W at warm-up,
<30 W continuous operation

Dimensions and weight

WxHxD: 315 x 86 x 395 mm

Weight: 4.8 kg (net), 7.8 kg (shipping)

Warranty

Warranty period: 12 months

5 year warranty on the rubidium lamp (909 only)

Ordering information

Model 908: Frequency Standard, oven time-base;
5 x 10 MHz and 1 x 5 MHz outputs

Model 908 incl. option 70:

Frequency Standard, oven time-base;
10 x 10 MHz and 1 x 5 MHz outputs

Model 909: Frequency Standard, rubidium time-base;
5 x 10 MHz and 1 x 5 MHz outputs

Model 909 incl option 70:

Frequency Standard, rubidium time-base;
10 x 10 MHz and 1 x 5 MHz outputs

Included accessories

User's handbook

Calibration certificate

Optional accessories

PM9622/00: 19" rack-mount kit

PM9627: Carrying case

Specifications subject to change without notice

9. Guarantee Statement

This Fluke guarantee is in addition to all rights which the buyer may have against his supplier under the sales agreement between the buyer and the supplier and according to local legislation.

Fluke guarantees this product to be free from defects in material and workmanship under normal use and service for a period of one (1) year from the date of shipment. This guarantee does not cover possible required re-calibration and/or standard maintenance actions. This guarantee extends only to the original end purchaser and does not apply to fuses, batteries, power adapters, or to any product or part thereof that has been misused, altered, or has been subjected to abnormal conditions of operation and handling.

Fluke-supplied software is guaranteed to be properly recorded on non-defective media. We will replace improperly recorded media without charge for 90 days after shipment upon receipt of the software. Our software is not guaranteed to be error free.

Fluke' obligation under this guarantee is limited to have repaired or replace a product that is returned to an authorized Fluke Service Center within the guarantee period, provided that Fluke determines that the product is defective and that the failure has not been caused by misuse, alteration or abnormal operation.

Guarantee service for products installed by Fluke will be performed at the Buyer's facility at no charge within Fluke' service travel area; outside this area guarantee service will be performed at the Buyer's facility only upon Fluke prior agreement and the Buyer shall pay Fluke round trip travel expenses.

If a failure occurs, send the product, freight prepaid, to the Service Center designated by Fluke with a description of the difficulty. At Fluke' option, repairs will be made or the product replaced. Fluke shall return the product, F.O.B. Repair Center, transportation prepaid, unless the product is to be returned to another country, in which case the Buyer shall pay all shipping charges, duties, and taxes. Fluke assume NO risk for damage in transit.

Disclaimer

The foregoing guarantee is exclusive and is in lieu of all other guarantees, expressed or implied, including but not limited to any implied guarantee of merchantability, fitness, or adequacy for any particular purpose or use. We shall not be liable for any direct, indirect, special incidental, or consequential damages, whether based on contract, tort, or otherwise.

10. Service Centers

For service information, contact your Fluke service center. To locate an authorized service center, visit us on the World Wide Web: <http://www.fluke.com> , or call Fluke using any of the phone numbers listed below:

+1-888-993-5853 in U.S.A and Canada

+31-402-687-200 in Europe

+1-425-356-5500 from other countries

DECLARATION OF CONFORMITY

for

Fluke

OXCO Frequency Standard 908

Rubidium Frequency Standard 909

Fluke Precision Measurement Ltd.
Norwich Airport Industrial Estate
Norwich
Norfolk NR6 6JB
UK

Statement of Conformity

Based on test results using appropriate standards, the product is in conformity with
Electromagnetic Compatibility Directive 89/336/EEC
Low Voltage Directive 73/23/EEC

Sample tests

Standards used:

EN 61010-1 (1993) CAT II
Safety Requirements for Electronic Measuring Apparatus

EN 55011 (1991) Group 1, Class B
Limits and methods of measurement of radio disturbance characteristics of industrial, scientific and medical
radio-frequency equipment

EN 50082-2/1993
Electromagnetic Compatibility Generic Immunity Standard

The tests have been performed in a typical configuration.

This Conformity is indicated by the symbol **CE**, i.e. “Conformité européenne”.