pendulum

6688 OCXO Frequency Reference
6689 Rubidium Frequency Reference

User's Manual

6688 OCXO Frequency Reference
6689 Rubidium Frequency Reference
Operators manual

4031 666 89001, rev. 5, 2017

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Table of contents

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 IEC publication 1010-1 and CSA 22.2 No.231, 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 6688 or 6689 Frequency Reference
- Line cord
- This Operators Manual
- Certificate of calibration

If you ordered option 22, a rack mount kit should also be included.

If you ordered option 27, 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 is labelled “6688/011" or “6689/011", and has 6 BNC-outputs on the rear panel.

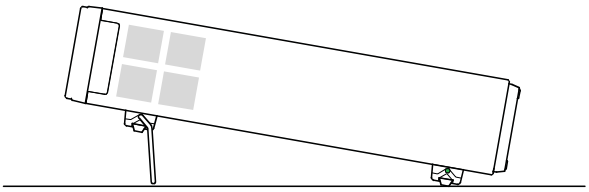
The extended model with 10x 10MHz and 1x 5MHz outputs is labelled “6688/021" or “6689/021", and has 11 BNC-outputs on the rear panel.

Supply voltage

The 6688/6689 Frequency Reference 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

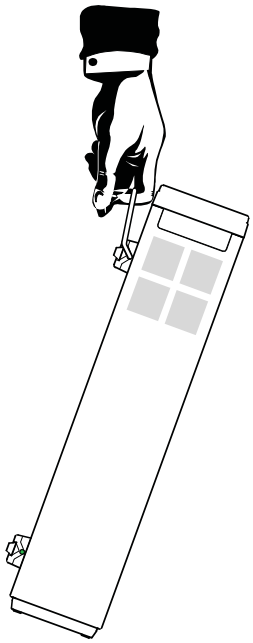
The instrument can be operated in any position desired. Make sure that the air flow through the ventilation slots are not obstructed. Leave approx 1 centimeter (1/2 inch) of space around the instrument.



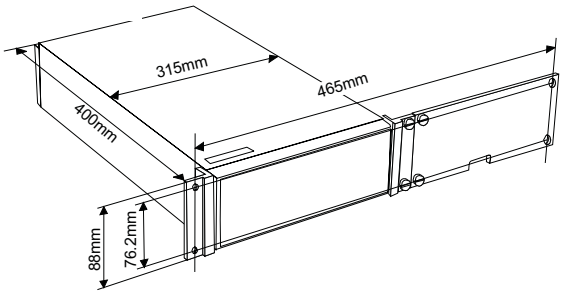
CAUTION: Never cover the ventilation slots at the right or left side. If the slots are covered, the instrument may overheat.

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:

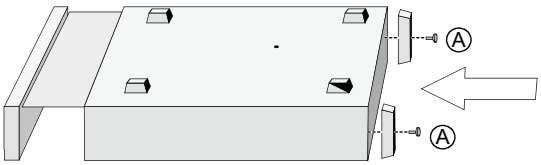
- 2 brackets, (short, left; long, right)
- 4 screws, M5 x 8
- 4 screws, M6 x 8

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.

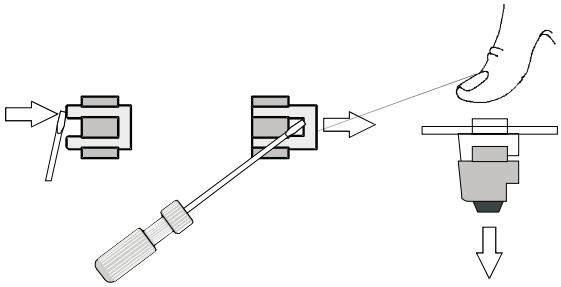
Assembling the rack mount kit

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

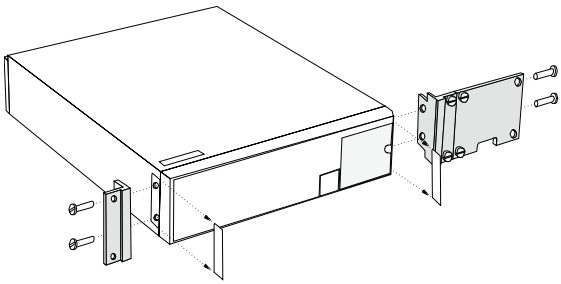


- Loosen the two screws (A) at the rear feet.
- Grip the front panel and gently push at the rear.
- Pull the instrument out of the cover.
- Remove the four feet from the cover.

  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 6688 or 6689 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 6688 OCXO Frequency Reference contains a high-stability SC-cut, oven-enclosed, crystal oscillator, whereas the 6689 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 5 MHz output is always available. The Frequency Reference is designed for bench or rack operation and for stationary as well as portable use.

As with all high-stability frequency references, 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

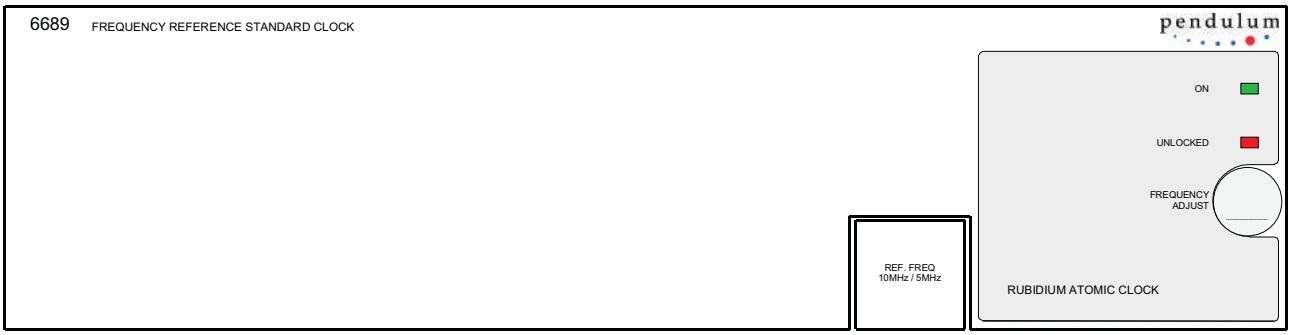
6689: Wait approx 5 minutes for the rubidium oscillator to lock (the UNLOCK LED turns off). Now the 6689 output frequency deviates approx 10 mHz from 10 MHz. Wait another 30 minutes for improved stability (approx. 1 mHz deviation)

6688: Wait approx 10 minutes for the output frequency to deviate approx. 0.05 Hz from final value. The “final value” is 10 MHz ± ageing since last adjustment (0.03 Hz/month)

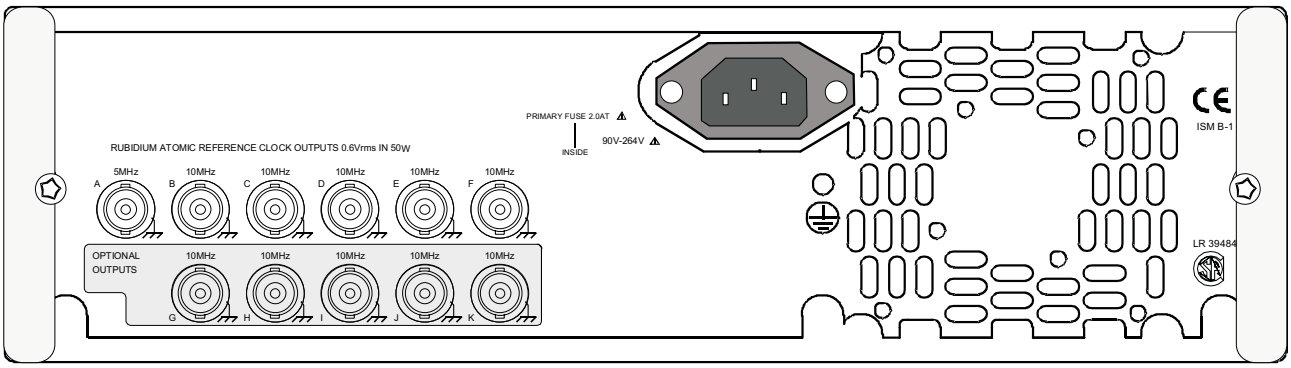
Stationary (or continuous) operation:

The output frequency stability for continuous uninterrupted operation is 0.03 Hz/month (6688) respectively 0.0005 Hz/month (6689).

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



Front panel of 6689. 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 6688 front panel has the same layout, however without the UNLOCK indicator



The frequency reference signals are available at the BNC-connectors on the rear panel. The rear panels of 6688 and 6689 are identical. This picture shows the 6689/021 version (11 BNC-outputs)

5. Preventive maintenance

Calibration

To maintain the performance of the 6688/6689, we recommend that you calibrate the timebase of your frequency reference every year, or when required, to a traceable reference. The 6689 should be calibrated to a Cesium reference or a GPS-receiver, and the 6688 to a calibrated Rubidium reference (or to a Cesium reference or a GPS-receiver).

The frequency of the reference oscillator is influenced by external conditions, such as ambient temperature and supply voltage, as well as aging. When calibrating and adjusting, you compensate the reference 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 references are given in chapter 8 (Specifications).

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

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

e_i = initial uncertainty (calibration uncertainty)
e_a = uncertainty due to ageing
e_t = uncertainty due to temperature

Uncertainty	*6688*	*6689*
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} *typical*
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} *typical*	5×10^{-11} *typical*

Example 1: The relative uncertainty 1 year after calibration and adjustment, for a 6688, operating in the full temperature range is:

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

$$2 \cdot \sqrt{\frac{(5\cdot10^{-9})^2 + (2\cdot10^{-8})^2 + (2.5\cdot10^{-9})^2}{3}} \approx 2.4\cdot10^{-8}$$

or approx. 0.2 Hz on the 10 MHz output.

Example 2: The relative uncertainty 2 years after calibration and adjustment, for a 6689, operating in temperature controlled lab environment is:

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

$$2 \cdot \sqrt{\frac{(5\cdot10^{-11})^2 + (2\cdot2\cdot10^{-10})^2 + (5\cdot10^{-11})^2}{3}} \approx 4.7\cdot10^{-10}$$

or approx. 0.005 Hz on the 10 MHz output.

Fan Replacement

If your frequency reference 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

6688

To check the performance of the 6688, a high stability frequency reference source is needed. For example a calibrated 6689 (Rubidium Frequency Reference) or similar

Required Test Equipment

Type	Uncertainty	Model
10 MHz reference	$<1\times10^{-9}$	Calibrated Rubidium reference
Timer/ Counter		PM6681 (incl. TimeView SW) + PC (incl. GPIB-card)

Test procedure

- Let the 6688 be disconnected from power during 24h
- Connect PM 6681 to a PC (via GPIB) and start the TimeView program. In this way you can monitor the frequency stabilization process.
- Let the PM 6681 Timer/Counter warm up for 30 minutes. Select default settings and change the measuring time to 5 s. Connect the external 10 MHz frequency reference (from e.g. The 6689) to the Ext. Ref. Input of PM 6681 (at rear panel).
- Connect one of the 10 MHz outputs of 6688 to input A of the PM 6681
- Connect the 6688 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 MHz ± Δ Hz
- $\Delta = 0.15 + 0.03 \cdot n$ (Hz), where n is the number of months since last calibration and adjustment of the 6688.

6689

To fully check the performance of the 6689, a very-high stability reference signal is needed. Examples of such references are Cesium Atomic references, or transmitted signals from nationally or internationally traceable sources, like GPS.

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

Required Test Equipment

Type	Uncertainty	Model
10 MHz reference	$<1\times10^{-10}$	Calibrated Rubidium reference
Timer/ Counter		PM6681 (incl. TimeView SW) + PC (incl. GPIB-card)

Test procedure

- Let 6689 be disconnected from power during 24h
- Connect PM 6681 to a PC (via GPIB) and start the TimeView program. In this way you can monitor the frequency stabilization process.
- Let the PM 6681 Timer/Counter warm up for 30 minutes. Select default settings and change the measuring time to 5 s. Connect the external 10 MHz frequency reference to the Ext. Ref. Input of PM 6681 (at rear panel).
- Connect one of the 10 MHz outputs of 6689 to input A of the PM 6681
- Connect the 6689 to the power line
- Check that the UNLOCK indicator on 6689 turns on immediately, and then turns off again within approx. 6 minutes after connecting line power. Now check that the frequency reading is 10 MHz ± 0.02 Hz
- Wait for approx. 30 minutes. Check that the frequency reading is 10 MHz ± 0.01 Hz. Look at the TimeView screen for visual feed-back of frequency stability.

7. Calibration and Adjustments

NOTE: Before adjusting, the 6688 or 6689 Frequency Reference must have been continuously connected to the power line for at least 24 hours.

Required Test Equipment - 6688

Type	Uncertainty	Model
10 MHz reference	$<1\times10^{-9}$	Calibrated Rubidium reference
Timer/ Counter		PM6681 (incl. TimeView SW) + PC (incl. GPIB-card)

Required Test Equipment - 6689

Type	Uncertainty	Model
10 MHz reference	$<2\times10^{-11}$	Cesium frequency reference GPS-receiver
Timer/ Counter		PM6681 (incl. TimeView SW) + PC (incl. GPIB-card)

Calibration setup of PM 6681

- Connect one of the 10 MHz outputs on the 6688 or 6689 to input A of the PM 6681 timer/counter.
- Connect the external 10 MHz reference to the External Frequency Reference input of the PM 6681 timer/counter (rear panel).

Calibration measurement

- Set the PM 6681 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 - 6688

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

Adjustment criteria - 6689

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

NOTE. If a GPS-receiver is used as reference, change number of samples N in the STAT menu in PM 6681 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 PM 6681
- Remove the seal from the front panel of 6688/6689
- Adjust the potentiometer behind the seal until the display shows $50x10^{-3}$ Hz or less for 6688 respectively $0.5x10^{-3}$ Hz or less for 6689.
- 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

Reference 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 - 6688

Calibration uncertainty (+23 ± 3 °C):
5×10^{-9}
Aging/month: 3×10^{-9}
Aging/year: 2×10^{-8}
Temperature: 2.5×10^{-9} (0°C...+50°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 °C)

Frequency uncertainty - 6689

Calibration uncertainty (+23 ± 3 °C):
5×10^{-11}
Aging/month: 5×10^{-11}
Aging/10 years: 1×10^{-9}
Temperature: 3×10^{-10} (0°C...+50°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 °C)
10.6 minutes to 4×10^{-10}

Environmental

Temperature: 0°C...+50°C (operating)
-40°C...+70°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 ±10%
Line frequency: 47…63 Hz
6688 rating: <20 W at warm-up,
< 7 W continuous operation
6689 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: 18 months
5 year warranty on the rubidium lamp (6689 only)

Ordering information

6688/011: Frequency reference, oven time-base; 5 x 10 MHz and 1 x 5 MHz outputs
6688/021: Frequency reference, oven time-base; 10 x 10 MHz and 1 x 5 MHz outputs

6689/011: Frequency reference, rubidium time-base; 5 x 10 MHz and 1 x 5 MHz outputs
6689/021: Frequency reference, rubidium time-base; 10 x 10 MHz and 1 x 5 MHz outputs

Included accessories

Operators manual
Calibration certificate

Optional accessories

Option 22: 19" rack-mount kit
Option 27: Carrying case

Specifications subject to change without notice

9. Guarantee Statement

The Warranty Statement is part of the folder *Important Information* that is included with the shipment.

10. Sales and Service office

- For additional product information, customer support and service, please contact Pendulum at the following address:

Altaria Services Sp.z.o.o.
ul. Lotnicza 37
80-297 Banino
Poland

Visiting address: as above

Phone: +48 (58)681 89 01
Fax: +48 (58)684 86 49
Email: info@pendulum.se

12. Declaration of Conformity

The complete text with formal statements concerning product identification, manufacturer and standards used for type testing is available on request.