VLB ARRAY MEMO No. 382

NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia 22903

August 27, 1984

MEMORANDUM:

TO: VLBA Members

FROM: S. Weinreb

SUBJECT: Revised Specifications for VLBA Hydrogen Maser

A revised specification for the VLBA hydrogen maser frequency standard is attached. The specification includes modifications to the June 21, 1984 specification suggested by D'Addario, Beno and Moffet. Please give any comments you may have to Dick Thompson. Because of funding delays, requests for proposals cannot be sent out until April 1, 1985.

Attachment:
Specification A53307N1

NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia 22903

DRAFT

SPECIFICATION: A53307N1

TITLE: Hydrogen Maser Frequency Standard

DATE: August 27, 1984

PREPARED BY: A. Clemmet APPROVED BY: A.R. Thompson

1.0 General

These specifications pertain to a hydrogen maser frequency standard which consists of, but is not limited to, the following electro-mechanical and electrical assemblies:

1) Hydrogen atom dissociator.
2) State selector magnet.
3) Quartz storage bulb.
4) Resonant RF cavity.
5) Aligning magnetic field solenoid.
6) Thermal heaters and insulation.
7) Magnetic isolation shields.
8) Vacuum chambers and pumping systems.
9) Gas pressure controller.
10) Magnetic field controller.
11) Thermal controllers.
12) Maser-cavity RF output isolator.
13) Low-noise, 1.4 GHz FET amplifier.
14) RF mixers, frequency multipliers and dividers.

15) Frequency synthesizer.

16) Phase detector, loop filter and phase-locked crystal oscillator.

17) 5 MHz and 100 MHz buffer amplifiers

18) Power supplies.

19) Hydrogen gas cylinder

The above assemblies shall be mounted in a suitable mechanical package and integrated with an appropriate control panel.

2.0 Electrical

2.1 RF Output

The maser receiver shall have at least two isolated 100 MHz sinusoidal outputs and two isolated 5 MHz sinusoidal outputs. The output frequency shall be adjustable to a resolution of at least 1 part in 10^{13} and the output levels shall have a nominal value of 1 volt RMS into a 50 ohm load. The isolation between the two outputs shall be greater than 90 dB at 5 MHz and greater than 70 dB at 100 MHz. The level of 5 MHz sidebands on the 100 MHz output shall be less than -60 dB below the 100 MHz output level. The maser physics package shall have a 1420 MHz output $\geq$ -105 dBM.

2.2 Monitor Outputs

The maser package shall provide front panel metering and a multiplexed DC output in the $\pm$ 10 volt DC range to provide monitoring information on the internal operation parameters. The multiplexer shall be controllable from external TTL logic levels to allow monitoring by an external monitor system. The output requirements of this section may also be met by a digital data output.

2.3 Short-Term Stability

The phase fluctuations of <u>each</u> standard integrated over the frequency range of 1 Hz to 1 MHz shall be less than 0.60 ps rms for the 100 MHz output

and less than 1.4 ps for the 5 MHz output. The definition and measurement method for the phase fluctuations are given in Reference [1]. Special precautions should be taken to insure that DC/DC power converters used in the frequency standard do not contribute to this noise.

2.4 Stability

The frequency stability of the 100 MHz output, as measured by the standard Allan variance method [2], shall be equal to or better than shown by the curve in Figure 1. The cutoff frequency of the measuring system shall be 1 Hz.

The stability data may be corrected using a temperature coefficient, measured for compliance to paragraph 3.0, multiplied by the change of a monitored temperature. For the 10,000 second data point, 10 samples of data will be considered sufficient and a factor of 1.6 may be applied to the allowable root Allan variance to account for statistical fluctuations. However, if this factor is required to meet specifications, NRAO shall have the option of requesting a repeat of the test.

2.5 Power Requirements

Primary power shall be 22 to 30 volts DC. Under normal operating conditions power drain shall be less than 100 watts. During warm-up periods maximum power drain shall be less than 200 watts. A provision for switching from one battery supply to another without interruption of the maser should be provided. The proposal should make recommendations for power during transportation such as a small battery for the vac-ion pump.

3.0 Temperature

The fractional frequency change of the 100 MHz output shall be less than $30 \times 10^{-15}/^{\circ}C$ when the ambient temperature is varied from 20° to 30° celsius (68° to 86° F).

3.1 Pressure

The fractional frequency change of the 5 MHz output shall be less than 10×10^{-15} per inch of mercury (4×10^{-16}/mm Hg) when the ambient pressure is varied from 24 to 31 inches (610 to 787 mm) barometric pressure.

3.2 Magnetic Field

The fractional frequency change of the 5 MHz output shall be less than 200×10^{-15} per gauss when the ambient magnetic field in any direction is varied $\pm$ 0.2 gauss.

3.3 Vibration

The hydrogen maser shall be designed for operation in an environment where mechanical disturbances are small and infrequent. It shall, however, be rugged enough to permit resumption of normal operation after transport by commercial carriers without requiring reassembly or repair.

4.0 Controls

The hydrogen maser frequency standard shall have user accessible controls for appropriate operation of the system. Controls affecting maser operation shall be protected from inadvertent operation.

5.0 Mechanical

The size of the hydrogen maser package shall not be more than 24 x 48 x 57 inches (61 x 122 x 145 cm) and the weight shall not exceed 400 pounds (182 kg). Metric threads may be used, although unified form threads are preferred. The package shall be on casters and shall include lifting eyes.

6.0 Test Procedure

The test and acceptance procedure shall be designed by Subcontractor to demonstrate compliance with this specification and operating performance. Test procedures shall be submitted for review prior to commencement of testing.

For acceptance testing of stability in Socorro, NM, NRAO will provide a precision phase comparator, A/D converter, and computer with software for Allan variance computation.

7.0 Maintenance

Two copies of operating and maintenance manuals shall be supplied with each maser.

The proposal shall describe a maintenance system for maintaining nine operating masers and one spare with a downtime of < 0.3% per maser (i.e., a three-day failure requiring either on-site repair or replacement by the spare maser once every three years per standard or once every four months for the nine-maser system). The maintenance system shall include one full-time NRAO senior technician trained by the maser manufacturer. The proposal shall describe the cost and time required for this training and present a list of recommended specialized maintenance equipment. The location and organization which can perform major overhaul tasks shall be described, along with the expected frequency of these overhauls over a 15-year lifetime.

8.0 Reference

[1] S. Weinreb, "Short-Term Phase Stability Requirements for Interferometer Coherence," NRAO Electronics Division Internal Report No. 233, June 1983.

[2] Time and Frequency Theory and Fundamentals, NBS Monograph 140, pp. 166-190.

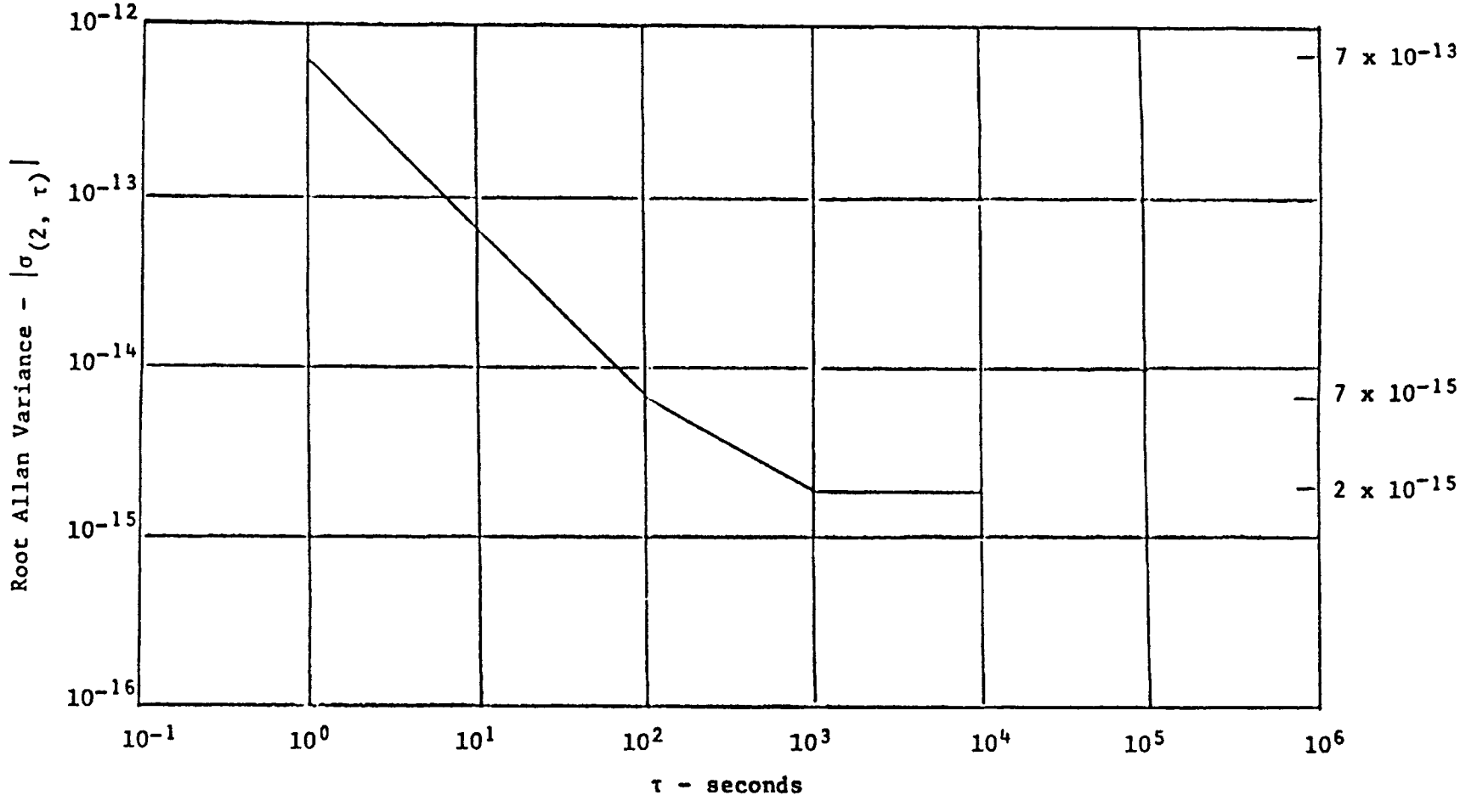

Fig. 1. Frequency stabilty of 100 MHz output of each maser.