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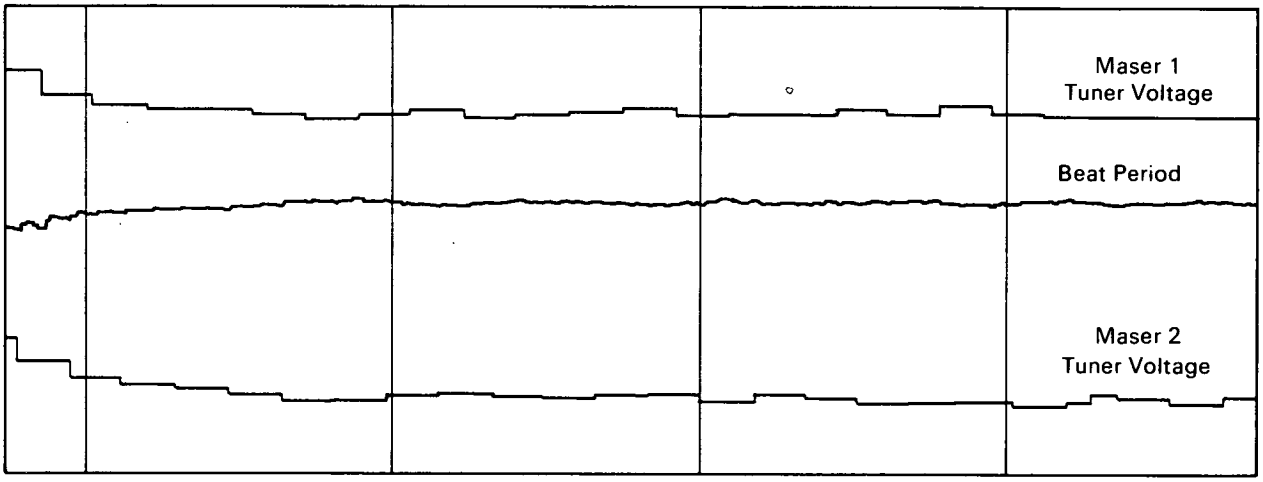
# NASA TECH BRIEF



## System Automatically Tunes Hydrogen Masers




An automatic tuning system has been developed that permits frequency synchronization between two hydrogen masers. Although the system was originally designed to match a space-borne clock performance with that of a ground-based clock to test the so-called "red shift" (or effect of gravity on time predicted in Einstein's general theory of relativity), it should be of interest to organizations concerned with industrial and educational research programs. Additionally, this system, used in conjunction with radio astronomy for long-baseline interferometer experiments, should interest the astrophysical community as a new tool for investigation of distant phenomena in the universe.

A typical tuning run is illustrated in the figure. The tuning varactor voltage for maser 1 is recorded on the upper track of a strip chart recorder, and that for maser 2 on the lower track. Full scale for both tracks is 2.0 V and each major time increment in the time axis is 10 minutes. The center track displays an analog record of a digital measurement of the beat frequency between the two masers with a full-scale range of $2.5 \times 10^{-11}$. Synthesizers in phase-lock loops in system electronics are offset by 0.6 Hz and 100-period averages are taken to provide an observation time for each measurement of 166 seconds. Maser 1 is deliberately detuned by arbitrarily setting the tuning diode voltage to 5.0 V. The corresponding initial frequency error was about $3.8 \times 10^{-12}$. Similarly, maser 2 was offset about $5.5 \times 10^{-12}$ by setting its tuning diode voltage to an arbitrary 4.0 V.

The loop gain on each tuner is deliberately reduced to effectively demonstrate the tuning operation. The correction process operates smoothly, as shown by the recording, alternating from maser 1 to maser 2. After 150 minutes, the initial total error of $8 \times 10^{-12}$ is reduced to less than $5 \times 10^{-13}$. Of particular interest are the fluctuations in the beat period, due to pressure changes, which can be seen clearly for the first

(continued overleaf)

60 minutes of the recording. These fluctuations damp out rapidly, as expected, when proper tuning is approached.

**Note:**

The following documentation may be obtained from:

Clearinghouse for Federal Scientific
and Technical Information
Springfield, Virginia 22151
Single document price $3.00
(or microfiche $0.65)

Reference:
NASA-CR-94937 (N68-25901), Atomic Hydrogen Maser for Space Vehicle Application

**Patent status:**

No patent action is contemplated by NASA.

Source: R. F. C. Vessot and M. W. Levine of
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