The Tidbinbilla Interferometer

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Originally printed in the Proceedings of the Astronomical Society of Australia, *this article discusses a proposal to operate a two-element interferometer using the 64-m and 26-m antennas of the Tidbinbilla Deep Space Station.*

The reliable detection and identification of weak, small-diameter radio sources require an instrument with both high sensitivity and high positional accuracy.

The 3.9-m Anglo-Australian telescope is a powerful complementary optical tool for studying weak radio sources, but for unambiguous optical identifications, radio positional measurements to within $\sim$1-2″ arc are highly desirable and often essential. Although some southern hemisphere radio telescopes (the Fleurs synthesis telescope and the Molonglo Cross) provide positional accuracy at or near this level, their sensitivity is generally not high enough to permit rapid searches for sources having flux densities in the millijansky range. The Tidbinbilla interferometer system, largely utilizing existing JPL facilities, will provide an instrument having a combination of sensitivity and positional measurement accuracy unequalled in the southern hemisphere, and with very little capital outlay.

It is proposed to operate a two-element interferometer using the 64-m and 26-m antennas of the Tidbinbilla Deep Space Station near Canberra, A.C.T. operating at a frequency of 2.3 GHz. With a north-south baseline of $\sim$1500 λ, a positional measurement accuracy approaching 1″ arc appears to be achievable with good sky coverage; the sensitivity of $\sim$1.6 mJy/h^{-1} means that sources with flux densities to $\sim$10 mJy may be reliably detected and positions measured in a few minutes' observing.

The parameters of the system are as follows:

Operating frequency	2.3 GHz
Baseline length	200 m (north-south)
Lobe separation	$2'.3$ arc
Predetection bandwidth	12 MHz
Effective system temperature	25 K
IF frequency	70 MHz
Sensitivity	$\sim$1.6 mJy/h^{-1} (5 × r.m.s. noise)

A block diagram of the system is shown in Fig. 1. The receiver first stages consist of low-noise travelling wave masers having bandwidths of $\sim$40 MHz. These are normally employed for spacecraft down-links at the station. The 2.22 GHz local oscillator system (Fig. 2) employs a system which has been previously described by Little (1969). The local oscillator signals at the two receivers are derived from phase-locked cavity oscillators. The input reference frequency (96.52 MHz) for these oscillators is synthesized from two signals near 48 MHz (but differing slightly in frequency) which are exchanged along a common cable link between the two receivers. The phase changes in the 96.52 MHz signal resulting from thermal and mechanical effects in this line then depend only on the frequency difference between the two ~48 MHz signals. This difference is chosen to be suitably small (~0.5 MHz).

A stepped compensating delay, inserted into one arm of the interferometer (see Fig. 1), consists of lengths of low-loss 1.3-cm-diameter styroflex coaxial cable. These lengths are chosen to be binary multiples of one wavelength at the intermediate frequency of 70 MHz. This choice of a minimum delay step eliminates extra phasing requirements and results in an average gain error of $< 1\%$ due to operation off the peak of the correlation envelope. The worst phase error of the delay line system is $< 1^\circ$. The total delay is determined by the configuration of coaxial switches, and will be computer-controlled to facilitate source tracking.

The instrument will be operated as a correlation interferometer, the sine and cosine products being sampled once per second and recorded for later analysis. A small amount of on-line processing may be possible with the facilities available. It will also be possible to monitor gain changes, since each aerial system can operate as a noise-adding radiometer.

The receiver systems are currently under development at the CSIRO Division of Radiophysics, and preliminary measurements of the delay line and local oscillator systems and the site cables suggest that a phase stability to within $\sim 1^\circ$ should be achievable with temperature control of the receiver packages. Figure 3 shows the measured variation of phase for the local oscillator system with some thermal lagging, but no temperature stabilization. The average drift rate is $< 2^\circ$ h^{-1}, with fluctuations of $\lesssim 1^\circ$. A phase error of 1° corresponds to a positional error of $\sim 0''.4$ arc at the zenith, so that the target positional measurement capability of $\sim 1''$ arc appears to be within sight. It is expected that a working system can be established within a few months.

Possible future developments include the extension of the system to include the Honeysuckle Creek 26-m antenna, approximately 16 km south, by means of a microwave link, and a fourfold increase in operating frequency. This would provide an instrument with an absolute positional measurement accuracy of $< 0''.01$ arc. Potential applications of such a system could include the determination of a southern hemisphere astrometric grid from radio measurements and a search for positional shifts in nearby stars due to planetary companions.

Acknowledgment

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Reference

1. Little, A. G., *IEEE Trans. Antennas Propag.*, AP-17, 5, p. 547 (1969).

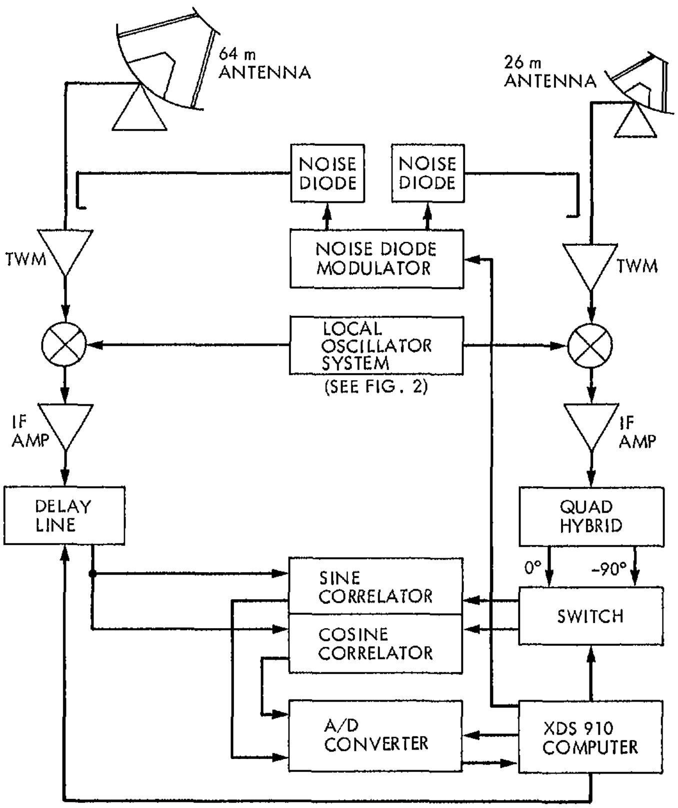

Fig. 1. Schematic diagram of the Tidbinbilla interferometer

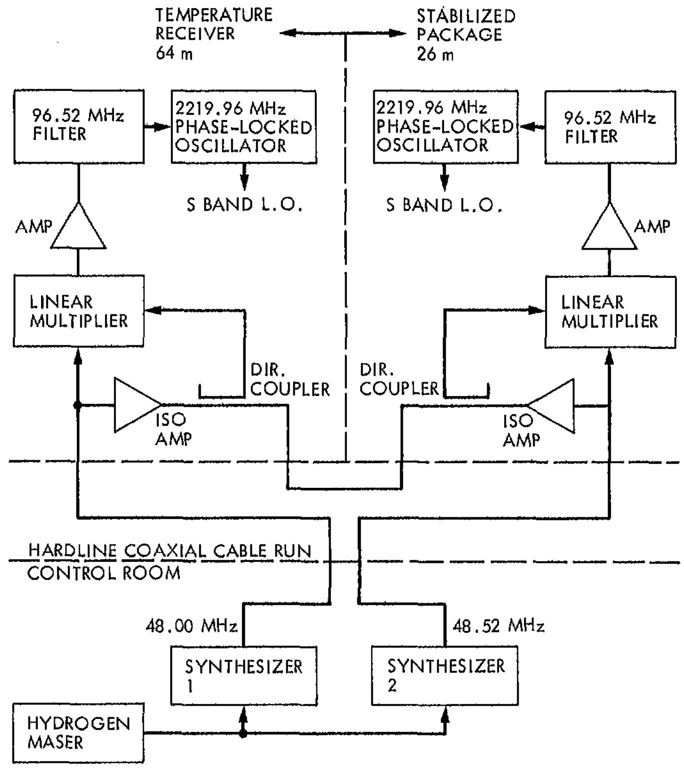

Fig. 2. Schematic diagram of the local oscillator distribution system

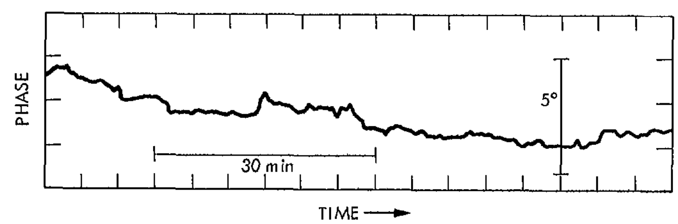

Fig. 3. Typical record of relative phase difference between the outputs of the local oscillator system, measured over a 90-min period. For this test no temperature stabilization was used, although the system was thermally lagged