VLBA ACQUISITION MEMO #354

NATIONAL RADIO ASTRONOMY OBSERVATORY

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Local Oscillator Phase Stability Specification for the Baseband Converter Modules.

A. R. Thompson

March 11, 1993

Recent measurements of the phase noise in the 500-1000 MHz local oscillator in VLBA-type Baseband Converter Modules (module type T122) have shown that the rms phase noise exceeds the formal specification, and cannot be reduced by any simple circuit adjustment procedure. However, the increased phase noise is not sufficient to cause any significant degradation in performance of the modules in operation in the VLBA. It is concluded that the original specification is too tight and should be relaxed in accordance with the laboratory measurements on the modules. The main relevant details are as follows.

The Baseband Converter modules (BBC's) were designed by Alan Rogers at Haystack Observatory in the mid-1980's, and a specification of < 2 deg. rms was placed on the LO phase stability over the 500-1000 MHz tuning range. This figure was chosen to reflect the measurements made at that time on carefully designed and adjusted units. The specification is not an upper limit on the phase noise that would be acceptable with regard to performance of the modules in the array. Tests of BBC's made during construction at NRAO concentrated on sideband separation and frequency responses. LO phase noise was judged from a spectrum analyzer check and detailed measurements were not routinely made. Inconsistency between the achievable phase noise and the specification was pointed out in 1992 by John Webber in testing units made at Interferometrics, Inc. The measured rms values were typically 2°-3° at 500 MHz LO frequency, 2°-4° at 750 MHz and 3°-5° at 1000 MHz. Further details of these results are given in a letter from J.C. Webber to Peter Napier dated Jan. 12, 1993. Measurements were then made at NRAO by Larry Beno, and these are described in a memo dated Feb. 10 1993, which is appended herewith. These measurements at NRAO confirm the results as measured at Interferometrics. There is evidence that the FET used in the oscillator (Mitsubishi MFG-1402) varies from batch to batch in the phase noise characteristics, and that recent batches have resulted in oscillators with more noise than those in the early BBC's.

An rms noise of 5° in each BBC of an interferometer pair will result in 7° of rms noise in the relative phases of two signals to be cross correlated. The resulting degradation in the amplitude of the visibility is less that 1%. The phase error introduced will depend on the spectrum of the phase fluctuations which are largely concentrated in the range 100 Hz to 10 kHz. For a data averaging time of 10 sec. the resulting error in the visibility phase is likely to be a small fraction of 1°. Alan Rogers has stated that the

original specification of < 2° is very conservative and has pointed out that in the Mark III VLBI system the specification on the phase stability of the baseband oscillator is < 4° for 100-450 MHz and < 9° for 450-500 MHz (letter from A.E.E. Rogers to J.C. Webber dated Dec. 22 1992).

As a result of the measurements etc. discussed above, it is agreed that the original specification with constant rms phase noise across the band will now be changed to a graded specification increasing with frequency across the band as defined by the following rms values: < 3° at 500 MHz, < 4° at 750 MHz, and < 5° at 1000 MHz.

Interoffice

NATIONAL RADIO ASTRONOMY OBSERVATORY

Socorro, New Mexico

February 10, 1993

To: P. Napier

From: L. Beno

Subject: VLBA BBC Phase Noise

Table I shows the results of BBC Phase Noise measured at the AOC facility. The HP 3048 system was used with an HP 8657B synthesizer as the reference. The BBC and 8657B reference was from a common 5MHz source. Data was taken from 100Hz to 100KHz but the predominate noise is contained between 1KHz and 10KHz from the carrier. Unfortunately the 3048 system has a software bug that adds significant errors from 10KHz to 100KHz. The Phase Noise results were derived from integrated noise from 100Hz to 10KHz. The additional noise from 10KHz to 100KHz is typically less than 0.2°. Noise from the 8657B synthesizer contributes about 0.22° rms at 600 MHz.

In conclusion the results obtained by J. Weber of Interferometrics seem consistent with NRAO's. The proposed phase noise specification change of 3° @ 500MHz, 4° @ 750 MHz and 5° @ 1000MHz is a bit conservative but not impractical with the present design.

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Table I
Phase Noise - Degrees rms

BBC#	500MHz 2.2° ave	750MHz 3.1° ave	1000MHz 3.6° ave
47	1.6°	2.4°	2.9°
59	2.2°	4.3°	3.5
67	1.7°	3.4°	4.3°
05	2.6°	2.6°	3.1°
114	2.4°	4.4°	7.0°*
123	2.2°	2.6°	6.5°*
130	2.2°	3.1°	3.9°
131	2.1°	2.4°	3.5°
132	2.4°	2.4°	3.5°
133	2.2°	3.1°	2.7°
134	2.6°	3.5°	3.5°
141	2.2°	2.8°	3.3°
136	2.9°	3.4°	3.4°
097	2.1°	3.0°	5.1°*
129	2.1°	2.9°	3.4°
01	1.9°	2.9°	3.5°

* Not included in average - require repair