Dr. Wesseling

NATIONAL RADIO ASTRONOMY OBSERVATORY

MEMORANDUM

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IG No. 1567

To: IG File

From: K. H. Wesseling KW

Subject: Interferometer Expandability from the Point of View of the Local Oscillator System

1. The local oscillator system consists of a master oscillator in the control building and four slave local oscillators, one at each of the telescopes (85-1, 85-2 and 85-3), and one presently in the control building delivering the LO reference signal for the 42-foot telescope. Also in the control building are four identical phase controllers. These units measure the roundtrip phase over the cable to each one of the telescopes and control the position of a phase shifter to correct for measured changes in cable phase length.

It requires only a minor expenditure and constructional effort to modify the No. 4 slave oscillator for operation in the frontend box of a telescope. Simple other solutions exist for providing the 42-foot telescope with a reference signal of proven stability (see IG 03466, fig. 1).

2. All four slave oscillators now in operation have a second output at 1347.5 MHz and at a 1 W power level. It can be used as a phase-locked local oscillator and pump signal for a second receiver. Possible second receiver center frequencies are 1347.5 MHz (smaller atmospheric disturbances on interferometer fringe phase), 1407.5 MHz (H-line, with 60 MHz IF), or 5390 MHz or higher (better resolving power).

3. A signal-to-noise ratio calculation for the LO-system is given in the appendix. It follows that a maximum separation of 3 km between an antenna and the control building is possible. No measurable deterioration in system performance will occur at that distance.

4. It is concluded that the present LO-system is compatible with longer baseline, second frequency, and four telescope operations.

KHW/cjd

Distribution:

IG File (3)	M. Balister
J. Coe	L. D. Gore
L. Howell	S. Weinreb
W. Kuhlken	K. Wesseling
B. Pasternak	Scientific Staff

APPENDIX
to
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1. Computation of the allowable signal attenuation:

Transmitted signal level	:	0.5 W = +27 dBm
Mixer noise	:	1200 °K
Receiver kTB, for B = 10^4 Hz[1]	:	1.7×10^{-16} W = -127 dBm
Signal level required for 4° RMS phase noise (35 dB S/N)	:	5×10^{-13} W = -93 dBm
Follows:		
Maximum allowable signal att.	:	120 dB

2. Phase locked oscillator IF gain margin:

Input signal level	:	-93 dBm
Signal level into phase comparator	:	+16 dBm
Required gain	:	110 dB
Available gain	:	115 dB
Follows:		
Gain margin	:	5 dB

3. Computation of phase controller S/N ratio:

Transmitted signal level	:	+27 dBm
Signal attenuation	:	120 dB
Mixer noise	:	1200 ° K
Receiver kTB, for B = 3 Hz	:	-163 dBm
Follows:		
Resulting S/N ratio	:	70 dB
Resulting RMS phase error	:	0.02 degrees

[1] Present B = 2.5×10^5 Hz for an increased AFC-loop acquisition range. Recent incorporation in the AFC-loop of an automatic search circuit eliminates the need for such a large AFC-loop bandwidth.

4. Maximum possible telescope separation from control building:

A total of 120 dB attenuation can be tolerated. Allowing a generous 20 dB attenuation for systems and telescope cable losses, a length of 3000 m of 1 5/8" Spiroline coaxial cable at 1400 MHz transmission frequency can be used.

5. Extra phase controller phase noise, due to master oscillator short-term frequency instabilities:

Master oscillator $\Delta f/f$ (1 second)	:	2×10^{-9}
Roundtrip cable length	:	27,000 wavelengths
RMS phase noise	:	0.02 degrees