AT/17.3.1/012

MAXIMUM USABLE PHASE RATES ON THE AT

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1 INTRODUCTION

This note is intended to clarify some points raised by Jim Roberts in AT/17.3.1/011.

It is important to identify the hierarchy of phase stability requirements. Consider a two element interferometer with independent local oscillators, and fringe tracking performed at the antenna. In the following discussion 'appreciably' means 'more than a few tens of degrees'.

1. The phase must not rotate appreciably in one integration period, otherwise there will be decorrelation, causing loss of signal-to-noise.

2. The phase must not rotate appreciably in the averaging interval necessary for self calibration. This period may be as short as one integration for strong sources, but may be minutes for weak sources. In general, it should be as large as possible to increase signal-to-noise in the gain solution, and to minimise computing time. However, it cannot exceed the timescale of atmospheric changes, which is typically a few minutes at high frequencies.

3. If absolute positions are required, the phase must not rotate appreciably in the time between calibrations. This time has a lower bound imposed by the telescope slewing time, and in practice might be about ten minutes.

4. The <u>rate</u> of phase change (i.e. drift in frequency) must not exceed about 0.05Hz in the interval between real-time-fringe-checks, which will probably take place about once per day. This condition must be satisfied to prevent the other three conditions being violated as a result of frequency drift.

2 PERFORMANCE OF THE LBA AT 115GHZ

Suppose we have two antennas with oscillators which are just within the AT standard of an Allan variance of 2E-12/t. JAR shows that this specification gives a phase error of 1 radian in 300s at 80GHz, and concludes that "such standards would hardly be useful for 115GHz observations". Whilst this is true if absolute positions are

required, it is not necessarily true if only maps are required. Thus, observations of a source at 115GHz using this system would have an rms phase error of 1.4 degrees in a 5-second integration, and 17 degrees in a SELFCAL averaging interval of 30s. The resulting maps, provided they contain at least one component which is strong enough for SELFCAL, will therefore not be degraded by the oscillators.

If there is any doubt of the usefulness of such a result, one only has to look at the astronomy found in MERLIN and VLBI maps, nearly all of which have been produced without absolute positions. Furthermore, an absolute position could in principle be obtained with such a system by calibrating every 2 minutes or so (since the problem only arises on the higher frequency, and hence newer and faster, dishes), although then the signal-to-noise is reduced by the large fraction of time spent slewing.

An additional worry is the long-term drift of the oscillators. The system above could drift in frequency by as much as 0.01Hz/day. Thus if the oscillators were initially calibrated using the real-time-fringe-check facility, they would be drifting by 0.01 Hz, or 18 degrees in a 5s integration by the end of the day. Again, this rate causes insignificant (1.3%) decorrelation, the effects of which can again be removed by SELFCAL. Doing a real-time-fringe-check once or twice per day would be sufficient to keep the oscillators within an acceptable tolerance. In the case of satellite distributed LO's, this problem does not of course arise anyway.

3 SUMMARY

The limits on phase stability for mapping purposes are primarily:

1. The phase must not change by more than tens of degrees in one integration period (typically 5s).

2. For weak sources, the phase must not change by more than tens of degrees in one SELFCAL period (typically 1 minute).

3. The frequency must not drift by more than 0.05Hz in one interval between real-time-fringe-checks (typically 12-24h).

These conditions are all met by the proposed AT specification for frequency bands up to 115GHz.

In addition, the following condition must be met for measurements of absolute position:

1. The phase changes in the interval between calibrations (typically 10 minutes) must not depart from linearity by more than a few tens of degrees.

This condition is not met by the AT specification at 115GHz, but is met at the lower frequency bands.