VLB ARRAY MEMO No. 406

VLBA Electronics Memo No. 29

NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

November 19, 1984

To: VLBA Electronics Group

From: Dick Thompson

Subject: VLBA Electronics Meeting, November 8, 1984

Attendees: Balister, Bradley, Brundage, Campbell, D'Addario, Dill, Kellermann, Latasa, Mauzy, Moffet, Napier, Norrod, Oty, Schlecht, Sebring, Thompson, Walker, Weinreb.

Feeds

There was a lengthy discussion on the possibility of using a single feed to cover both the 4.8 GHz and 6 GHz (optional) bands. Since the 4.8 GHz band is expected to be probably the most heavily used band in the early years, there was considerable reluctance to accept any significant degradation at 4.8 GHz. If, however, one can design the feed to cover the 6.035 GHz OH lines without suffering more than, say, 2% degradation at the 4.8 GHz band it seems worthwhile to do so. Separate receivers would be used for both bands, since there would be significant degradation in performance if making the polarizer and amplifiers cover both bands. Subsequent consideration of the feed problem by P.J. Napier indicates that it would not be possible to use the full broadband feed design because the phase center is then near the throat of the horn. This would require the horn aperture to be located well above the vertex plane where it could interfere with radiation to other feeds. Thus the best solution appears to be to use the narrow band design optimized for 4.8 GHz, and at the same time take any steps that would improve the performance at 6 GHz at which it may also have usable gain.

Front Ends and Cryogenics

R. Latasa reported that the 8.4 GHz front end that had been sent to the VLA site in August was finally installed on an antenna a few days ago, but now has to be taken down for maintenance. It has been operated in the lab at the VLA for about one month (approx. 700 hours) and in all has required maintenance on five occasions since August 20. This has largely been associated with wear of the top carbon bushing and brass plug. For comparison, the MTBF for the model-1020 refrigerators on the VLA is a little over 10,000 hours, and units have run for as long as 43 months (30,000 hours) between maintenance.

R. Norrod reported that the four model 22 refrigerators in the test setup at Green Bank continue to operate, although one of them sounds as though it will soon require attention. In the tests of the L-band front end, a cool down to 12.5 K in 11 hours has now been achieved. A 2-watt load on the second stage increased the temperature to 18.5 K.

The latest tests of the HEMTs were summarized by S. Weinreb. A receiver temperature of 8.5 K at 8.4 GHz has been achieved with a General Electric HEMT cooled to 15 K.

There was considerable discussion about the possibility of combining more than one front end in a Dewar so as to reduce the number of refrigerators. A. T. Moffet pointed out that the optimum arrangement may be intermediate between the all-in-one-Dewar arrangement of the VLA and the individual Dewar arrangement planned for the VLBA. The following notes reflect my (D.T.'s) current feeling on the matter.

The main consideration is that of minimizing down time as a result of cryogenic failure. Down time can be measured in terms of the number of hours per antenna and per receiving band that front ends are inoperative. Let us assume that for a given receiving band the probability of failure at any time depends upon the reliability of the refrigerator that cools it, which should be largely independent of whether or not the same refrigerator is cooling another front end. If there are n front ends (receiving bands) per refrigerator the down time counts as n hours for each hour that a refrigerator is down. On the other hand the number of refrigerator failures per year will be reduced by a factor n relative to the case of one refrigerator per receiving band. Thus the value of n should have no gross effect upon the total down time. The arguments in favor of $n > 1$ are that it decreases the overall man-hours required for refrigerator repair, and it would allow the possibility of using the larger model 350 refrigerator which at this tinme appears to be more reliable than the model 22 refrigerator on which the $n = 1$ design is based. A serious disadvantage of the $n > 1$ design is that a failure at an antenna puts several frequency bands out of action, and thus restricts alternate scheduling. The $n = 1$ scheme also has the obvious advantages of minimizing the weight of the front end packages for handling and shipping, minimizing the lengths of waveguide from the feeds to the amplifiers, and generally allowing greater flexibility in construction, retrofits, maintenance, etc. The present experience with the model 22 indicates that changes in quality control and/or design are required. C.I.T. appear to be willing to work on this problem. It remains to be seen whether they will find it practicable and profitable to bring the unit up to a level that provides 10,000 hours MTBF. I believe that the advantages of the $n = 1$ design clearly outweigh the disadvantages, and

the majority of opinions expressed at the meeting supported this view. However, we should recognize that there is some possibility that NRAO may have to redesign part of the model 22 units, either in-house or through a consultant, and retrofit the refrigerator units, if the standard CTI design does not achieve a sufficiently high MTBF. With 80 units in the array this might cost on the order of $50,000. Current information on the model 22 indicates that the problem is in the reciprocating linkage between the motor and the displacers.

Local Oscillator

The occurence of 500 MHz harmonics in the output of the 2-16 GHz synthesizer has been pointed out by R. Mauzy. These are generated in the harmonic mixer, and leak out of the mixer input port and through the directional coupler, and will appear in the oscillator output with an estimated power level of about -75 dB m. These should be detectable only in the narrowest spectral line mode, and only when the fringe frequency goes through zero. They do not warrant any design modification at this time. Space should be left within the module for the addition of switched isolators or amplifiers if further isolation is found to be necessary.