VLBA Electronics Memo No. 32

Front Ends for 23 and 43 GHz

A. R. Thompson
4 December 1984

The plan outlined below for development and procurement of the 23 GHz and 43 GHz front ends results largely from a discussion on 3 December 1984 between M. Balister, L. R. D'Addario, A. R. Kerr, A. R. Thompson and S. Weinreb.

23 GHz

The nominal frequency range of this band is 22.2-24.6 GHz (VLBA Memo No. 295). The present plan is to use a HEMT (high electron mobility transistor) amplifier cooled to 15 K. This would produce an estimated receiver temperature of 45 K, resulting in a system temperature of approximately 70 K.* These figures are based upon tests of the HEMTs procured to date under development contracts with Cornell and G.E. No specific problems are forseen in achieving the above performance, but HEMTs have not yet become available in production quantities. As a fallback position, GASFET amplifiers could be used but would result in a receiver temperature of approximately 70 K.

Prototype design of the amplifiers will begin in the latter half of 1985 and should be complete by the end of 1986. This work will be done by the Central Electronics Lab in Charlottesville. Construction of front ends will start in 1987 and installation will be completed in 1989.

43 GHz

The nominal frequency range for this band is 42.3-43.5 GHz. The frequencies of the four SiO lines run from 42.519 to 43.424 GHz. The proposed front end here is an SIS mixer for which the estimated

---

* The receiver and system temperatures quoted in this memorandum provide an approximate comparison with those in the VLBA proposal and project book. Note that all of these apply to receiver temperatures at the band center, and to minimum antenna temperatures that occur for observations at the zenith in good weather. In practice the antenna temperature at 23 GHz could vary up to about 250 K for poor weather and low elevation angles. Discussion of performance considering only the minimum antenna temperatures tends to overemphasize the importance of the receiver contribution.

receiver temperature is 40 K, and the system temperature is 75 K. A rough estimate of the receiver temperature for a cooled GASFET amplifier is 150 K. Various junction materials will be investigated. Possible sources of junctions are Hypres, NBS (Boulder) and R. Mattauch (UVA). We plan to pursue a single sideband design with the image terminated in a cold load if necessary.

The timing plan for the development and procurement is similar to that for the 23 GHz system. Development will begin as soon as funds are avilable in 1985, prototypes of junctions and other components will be tested by the end of 1985, and a prototype front end should be completed by the end of 1986. This phase of the work will be performed in Charlottesville and L. R. D'Addario will be the engineer in charge. During the same period development of a suitable cryogenic system, Dewar, etc. will be performed in Green Bank by M. Balister and C. Brockway. Construction of the front ends will occur in 1987-9, probably at Green Bank.

Development and Construction Costs

An approximate estimate of development and construction is given below in 1985 k$. The manpower figures are man-quarters. Construction costs per antenna are $30 k for 23 GHz and $50 k for 43 GHz.

	1985	1986	1987	1988	1989
23 GHz development	50				
23 GHz construction			90	90	120
43 GHz development	50	50			
43 GHz construction				250	250
SIS Engineer (head)	2	3	2	2	
SIS Engineer (assistant)	2	4	2	2	
F.E. System Engineer		2	2	3	2
SIS Technician	2	4	2	2	
System Technician		2	2	3	3

The sum of the hardware and manpower costs outlined above is about 75% of the original estimate of $1.8 m (total) for maser front ends for these two frequency bands. The original maser system would have used a single Dewar for both frequencies, and required less development than the SIS mixer.

Choice of the Proposed System Instead of Masers

In the initial proposal for the VLB array the use of masers at 22 and 43 GHz was suggested. Experience with maintenance of a 23 GHz maser at the VLA indicates that maser front ends are hardly a feasible option in the VLBA situation. The mean time between failures, or between required maintenance, must exceed 10,000 hours for satisfactory operation of the VLB array. With seven or more cryogenically cooled front ends on each antenna 10,000 hours MTBF for each one corresponds to one failure every six days. The HEMT at 23 GHz should provide reliability comparable to that of the other transistor front ends, which is essentially limited by the 15 K cryogenic system. The SIS mixer is more of an unknown quantity, but it requires a lower cooling power than a maser by a factor of about 10. The SIS front end package will be smaller and lighter than a maser, and much more convenient to remove and ship to the operations center for maintenance. The SIS mixer offers approximately the same system temperature as a maser at 43 GHz. It is also worth noting that a maser is not a feasible option at 86 GHz, to which it is eventually hoped to extend the coverage of the array. At this frequency an SIS mixer offers the best performance amongst currently known devices. Thus the experience with SIS mixers and their cryogenics at 43 GHz will be a valuable step towards implementing the higher frequency band.