Interoffice

National Radio Astronomy Observatory

Charlottesville, Virginia

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VLB ARRAY MEMO No. 52

Subject: VLBA Proposal - Front End System

Front End System

We have considered several types of low-noise front ends to satisfy the sensitivity requirements. Appendix I* covers this comparison in some detail. Table I summarizes the proposed front end type and performance for the various proposed VLBA frequencies.

In order to obtain the minimum possible downtime for any observing frequency, we are proposing to package individually each GASFET front end in its own dewar. Cooled dual polarization waveguide transitions will be integrated into the dewar to minimize the added noise due to loss between the feed and GASFET amplifiers. This technique of cooling the dual polarization transitions has been successfully used by other radio astronomy observatories over relatively narrow bandwidths. NRAO is currently supporting development of a wide band dual polarization transition which is ideally suited for the wider bandwidths needed by the 1.55 GHz front end. This plan will result in 6 cooled GASFET receiver packages, each with its own refrigerator, mounted on the end of its respective feed horn.

The two maser receivers will be mounted on a single 4K refrigerator. Since the 22.2 and 43 GHz feed output flanges are close together, this will not result in a loss in performance due to long input lines. The use of a common 4K refrigerator and dewar will result in a cost saving of approximately 50k$ per antenna.

NRAO has developed a 43 GHz maser which is currently being used by Haystack Observatory. The system noise temperature is 90K including a contribution from the radome at that site. We are proposing that the 43 GHz front end be single channel due to lower maser gain, higher pump power requirements and lack of a suitable low-noise second stage, compared to the 22 GHz maser which will be dual channel. If a second channel is considered of great importance, some development would be required to overcome the current shortcomings.

*to be written by Craig Moore.

Figure 1 shows the proposed receiving system components that will be in the vertex cabin. The IF output frequency bands will lie in the range 250-1500 MHz. Since 9 frequencies are dual polarization and 43 GHz is single, there will be 19 IF outputs. These signals will go to an IF switching matrix to connect the front ends in use to the 4 IF input distributor in the record terminal.

A phase calibrator consisting of frequency pickets with 5 MHz spacing will be placed at the vertex to radiate into the Cassegrain feeds. This system will permit calibration of the delay through a complete receiver channel. The vertex phase calibrator will be optimized for the S and X-band frequencies but will possibly be useable up to 22 GHz. A solid state noise source will be coupled into each feed horn with nearly equal intensity at the two polarizations. The added noise intensity will be approximately 3 times the system temperature -- strong enough to allow the system to be used as a noise adding radiometer with 25% duty cycle for periodic pointing checks. The noise intensity will also be reduced to approximately 10% of the system temperature for measurement of source and system temperatures.

Cryogenic System

The front end system proposed for the VLB array requires one 4K refrigerator and six 20K refrigerators per antenna.

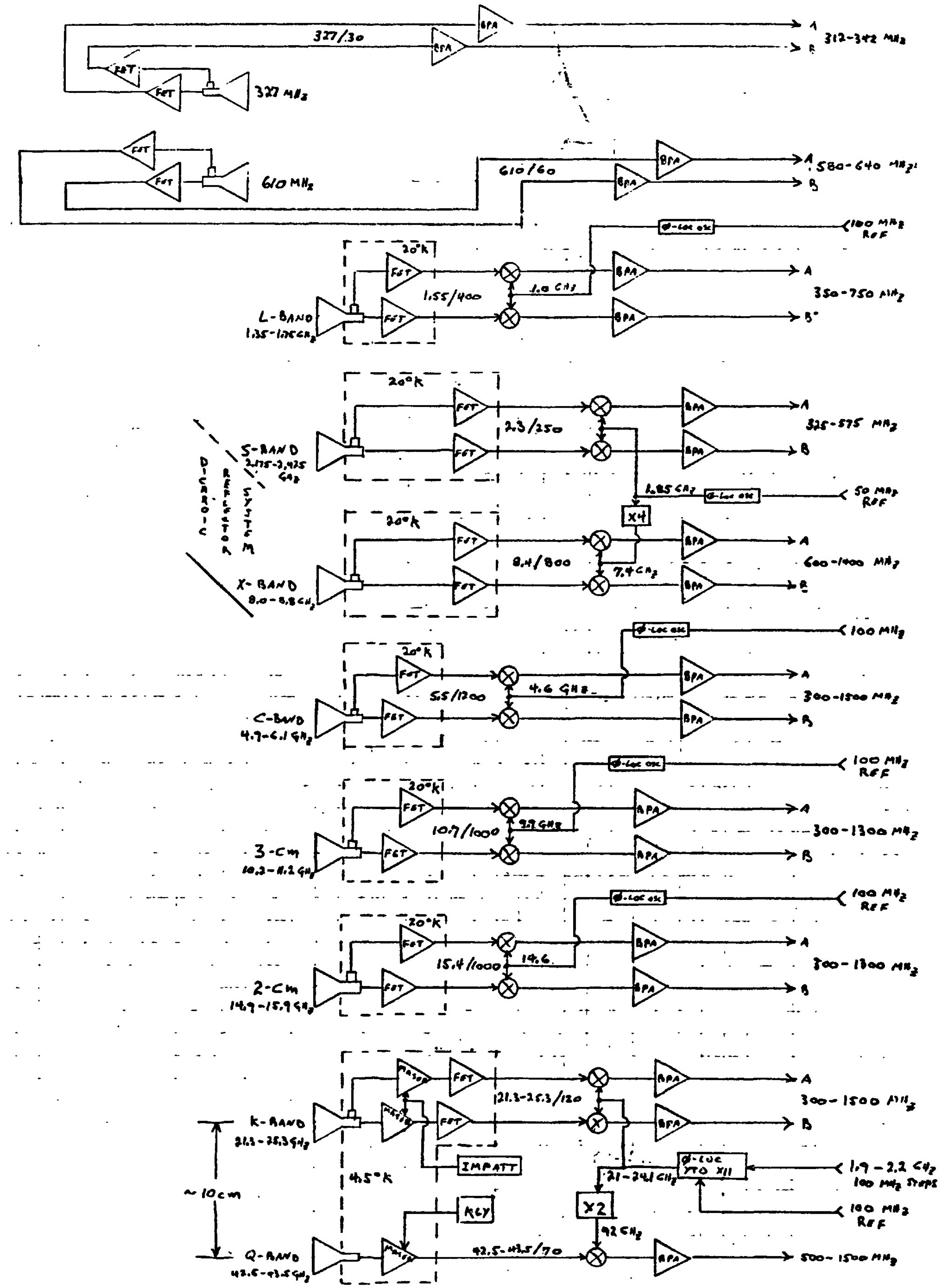
We are proposing to use CTI Model 350CP refrigerators; these have a 3W load capability and similar reliability as the larger CTI Model 1020 unit used at the VLA and other observatories. The 3W load capability is sufficient and the smaller unit is significantly cheaper than the 1020 unit. We also propose to use three CTI 1020 style compressors to drive the six 20K front ends. If one compressor fails, at least four of the six front ends can be kept cold; electrically controlled valves can be used to interchange compressors and receivers to keep the required frequencies operational.

The 4K refrigerator used to cool the two masers would be the JPL/NRAO Joule-Thompson circuit on a CTI 1020 refrigerator. This system is now marketed by CTI and Cryosystems, Inc. The reliability of these 4K systems is close to that obtained with the 20K systems.

TABLE I

Frequency GHz	Instantaneous Bandwidth MHz	Front End Type	Physical Temp	Receiver Noise Temp 1981	Receiver Noise Temp 1986	Antenna Noise Temp*	1986 System Noise Temp	Notes
0.33	30	GASFET	300	40	30	35	65	Prime
0.61	60	GASFET	300	45	30	30	60	Prime
1.55	400	GASFET	20	12	9	20	29	Cassegrain
2.3	250	GASFET	20	15	11	20	30	Cassegrain
5.5	1,200	GASFET	20	20	17	20	37	Cassegrain
8.4	800	GASFET	20	30	20	20	40	Cassegrain
10.7	1,000	GASFET	20	35	25	20	45	Cassegrain
15.4	1,000	GASFET	20	55	40	25	65	Cassegrain
22.2	120	Maser	4	10	10	35	45	Cassegrain
43	70	Maser	4	35	30	40	70	Cassegrain

*Noise due to atmosphere, antenna spillover and feed losses.



KEY: X/Y
X = CENTER FREQ. - MHz OR GHz
Y = 1dB BW - MHz

RECEIVER/LO BLOCK DIAGRAM
VLB ARRAY PROPOSAL
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Figure 1.

FRONT END COSTS

Cryogenic Costs		Materials $k	Labor (Man Months)	
20K Cryogenics				
Refrigerators	6 x 6K	36		
Compressors	3 x 8K	24		
4K Cryogenics				
Refrigerator and Compressor		50		
Helium Lines				
4K and 20K systems		20		
Total Cryogenics				130k
300K Front End Costs				
327 and 610 GASFET's Dual Pol.	4 x 1K	4	2	
Local Oscillator	2 x 0.5K	1	2	
Mixer IF Amplifier	4 x 0.25	1	2	
Labor		19		
Total 300K Front Ends				25k
20K Front End Costs				
Dewars, input lines, etc.		20	6	
GASFET Amplifiers at 1.55, 2.3, 5.5, 8.4, 10.7 and 15.4 GHz 6 frequencies x 2 polarizations		12	6	
Local Oscillator System		20	9	
Mixer/IF		12		
Labor		66		
Total 20K Front Ends				130k
4K Front End Costs				
Dewar, input lines, etc.		20	6	
Masers 22, 43 GHz		20	12	
Solid state and klystron pumps		20		
Local Oscillator System		10	6	
Mixer/IF		10		
Labor		76		
Total 4K Front Ends				156k
Miscellaneous				
IF Switching matrix		5		
System noise calibration		15		
Phase Calibration		15		
Power Supplies, etc.		10		
Total Miscellaneous				45k
TOTAL FRONT END SYSTEM PER ANTENNA				486k