NATIONAL RADIO ASTRONOMY OBSERVATORY

A 32-CHANNEL IF SCHEME FOR THE VLBA

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Introduction

Considerable discussion has revolved around the number of simultaneous IF channels to be available in the VLBA. Shaffer (VLBA Memo 148) has set out the arguments for at least twelve double sideband channels. Walker (VLBA Memo 151) states the case for fewer wide bandwidth channels that can be rapidly frequency switched. The Haystack Group (VLBA Memo 164) suggests a compromise of sixteen double sideband channels (32 samplers) each having a maximum bandwidth of 25 MHz (800 MHz total available bandwidth). This would provide four wide bandwidth (up to 25 MHz) channels for spectral line observations or up to sixteen double sideband channels at proportionately narrower bandwidth for geodesey and astrometry. This memo outlines the design changes and cost increment to implement such a scheme within the proposed VLBA.

Block Diagram

Figure 1 is a copy of figure IV-7 which appeared in the VLBA proposal and shows the basic changes (shaded areas) necessary to implement this scheme. The fine grain frequency selection (10 kHz steps) is moved into the video converter, but the rapid frequency switching capability is retained in the IF processor with coarse (10 MHz) steps. The full front-end bandwidth of up to 1200 MHz is presented to each IF processor which selects a 200 MHz band to be presented to a group of four video converters. Each video converter in the group can position its pair of sidebands anywhere in the 200 MHz band in 10 kHz increments.

Each sideband will have nine selectable bandwidths ranging from 25 MHz down to about 100 kHz. Each sideband will then be one-bit, 2 level sampled and presented to the formatter for multiplexing onto the recorder(s).

Design Analysis

The particular IF processor scheme shown in Figure 1 was chosen because it is relatively free of spurious responses, and thus does not need band switching or tracking filters to control spurious generation. Two types of spurious mechanisms are present, however. The first is a discrete line which will be generated by mixing of the two local oscillators. This will generate a spurious CW signal in the 300-500 MHz output band for variable LO (f_A) frequencies of 2.70 to 2.90 GHz. This corresponds to IF input frequencies from 600 to 1000 MHz. The strength of this signal is controlled by the skirt selectivity of the 2 GHz bandpass filter. This signal can be moved out of the video sideband bands with coordinated frequency changes in f_A and f_C.

The second spurious mechanism is that of harmonics of the IF input frequency which fall within the passband of the 2 GHz bandpass filter. Again, these responses can be controlled by coordinated selection of f_A and f_C. The spurious responses are summarized in Table 1.

TABLE 1

Spurious Responses of IF Processor
(to fourth order)

Spurious Mechanism	f_A (GHz)	f_{IF} (MHz)
$f_A - f_B$	2.70-2.90	600-1000
$2 \times f_{IF}$	2.85-3.15	950-1050
$3 \times f_{IF}$	2.53-2.80	630- 700
$4 \times f_{IF}$	2.37-2.63	475- 525

The equation for setting the sky frequency to the lower band edge of a video sideband is as follows:

$$f_{sky} = f_{LO} + f_A - f_B + f_C \pm f_{LBE}$$

where

f_{LO} = the first LO, which except for 1.3 cm band is fixed, and is given in Table 2.

f_A = IF processor variable LO, $2.3 \leq f_A \leq 3.5$ GHz in 10 MHz steps; $\approx$ 10 msec switching time.

f_B = IF processor fixed LO; $f_B = 2.4$ GHz.

f_C = Video converter LO, $300 \leq f_C \leq 500$ MHz in 10 kHz steps; $\approx$ 500 msec switching time.

f_{LBE} = Lower band edge frequency of sidebands, probably 1 kHz.

As an example, assume a sky frequency of 1373 MHz is to be placed on the lower band edge of the video band. We then have:

$$f_{sky} = 1.373 \times 10^9 \text{ Hz}$$

$$f_{LO} = 10^9 \text{ Hz}$$

then:

$$f_A + f_C = 2.773 \times 10^9 \pm 10^3 \text{ Hz}$$

and:

$$2.30 \leq f_A \leq 2.47 \times 10^9 \text{ Hz}$$

$$303 \leq f_C \leq 473 \times 10^6 \text{ Hz}$$

From Table I the spurious exclusions are

$$4 \times f_{IF} \text{ for } f_A > 2.37 \times 10^9 \text{ Hz}$$

Thus, choose:

$$2.30 \leq f_A \leq 2.37 \times 10^9 \text{ Hz}$$

$$473 \leq f_C \leq 403 \times 10^6 \text{ Hz}$$

TABLE 2

Sky and First LO Frequencies for VLBA Receivers

Band (cm)	f_{sky} (GHz)	f_{LO} (GHz)
90	0.312- 0.342	0
50	0.58 - 0.64	0
18/21	1.35 - 1.75	1.0
13	2.175- 2.425	1.85
3.6	8.0 - 8.8	7.4
6	4.9 - 6.1	4.6
2.8	10.2 -11.2	9.9
2	14.9 -15.9	14.6
1.3	21.3 -25.6	21 to 24.1 in 0.9 or 1.1 GHz steps
0.7	42.5 -43.5	42.0

Cost/Implementation

The cost increment to the VLBA construction budget for this IF scheme is outlined in Figure 2. (Note that this $600 K does not include any cost impacts to equipment further down the data stream, such as the formatter or correlator). The addition of 12 more video converters is the principal cost item. The mode selector up stream from the IF Processor is necessary to switch configurations.

It will provide one IF on each polarization of two front-end bands (straight thru), or four IF's on one polarization of one front-end band or the intermediate two on two modes. The second mode selector allows connection of video converters in groups of 4 to any of the four IF processor outputs (4, 8, 12, or 16 video converters on one IF processor). This will aid in remote trouble shooting and fault correction without local operator assistance and seems to be worth the small increment in cost. Channel dropping is best implemented after sampling, probably in the formatter. It is anticipated that all video converters will be identical and have the full complement of low pass filters so that no special spares provisioning will be required.

It is recommended that implementation be phased in within budgetary constraints. Each station would have rack space and wiring for 16 video converters but would be equipped with a minimum of four. A few selected stations could be equipped with the full complement as soon as is possible, with the remaining stations being upgraded with plug-in modules as money is available. In that regard, about $45 K to $50 K per station can be deferred by not installing the additional 12 video converter modules.

Conclusion

This scheme provides broad bandwidth channels for spectral line observations as well as fast frequency switching and/or multiple channel fixed frequency spacing for bandwidth synthesis. It also provides a total bandwidth capability which exceeds the proposed recorder capabilities by nearly an order of magnitude. The major drawback is the three-fold increase in the number of video converters employed in the system with its accompanying cost and reliability considerations.

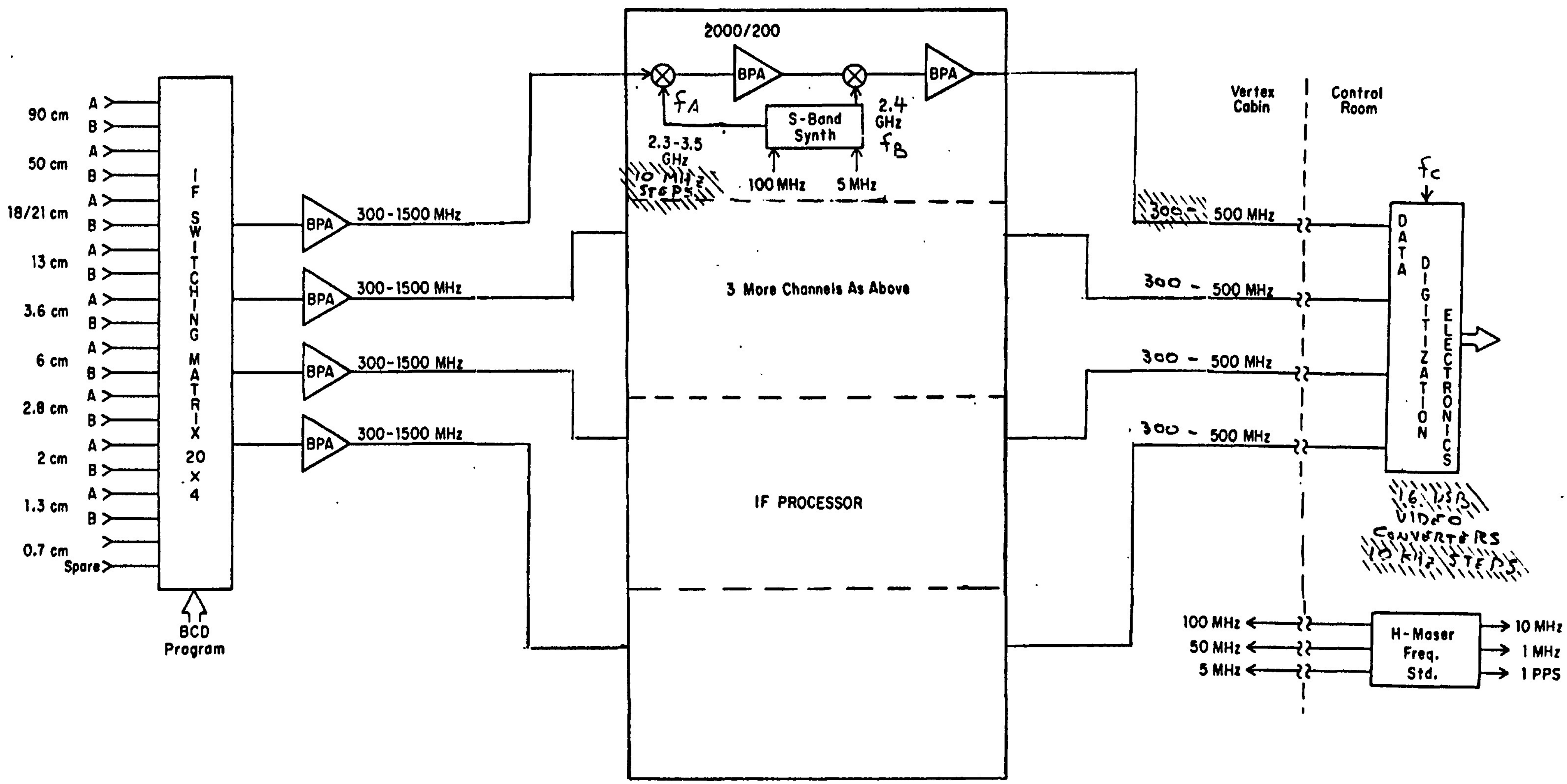
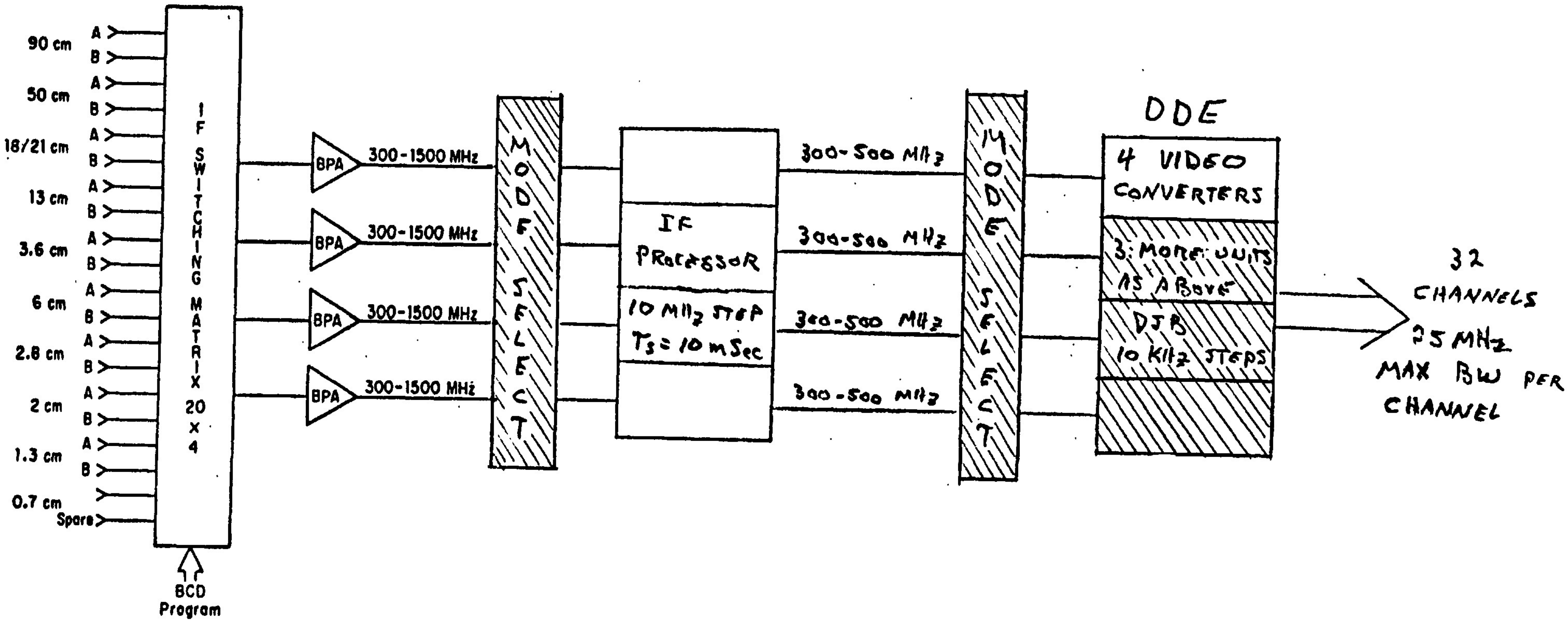


Figure 1: Block Diagram of IF Scheme.



COST INCREASE

2	MODE SELECT	\$6 k
12	VIDEO CONVERTERS	\$39 k
	ASSEMBLY 6 MM	\$14.5 k
		\$60k / STATION

Figure 2: IF Scheme Design and Cost Increment.