VLB ARRAY MEMO No. 164

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TO: VLBA Coordinator & Science Groups

FROM: Haystack VLBI Group

Subject: VLBI "Channelization"

History: The VLBA study document (May 1982) proposed that only 4 independent I.F. channels be recorded. This proposal, while adequate (and perhaps desirable) for most normal astronomy experiments is not well suited for astrometric and geodetic experiments. As a result of the realization that accurate calibration of the VLBA through precise astrometric and geodetic experiments might make the array fully coherent for many experiments there was an attempt to fix up the VLBA's astrometric capability by proposing that frequency switching be added. Meanwhile many in the VLBI community suggested that an upgraded (or evolved) MK III system would be a better choice. A debate on the choice of type and number of channels has since taken place during which it has become clear that both the 4-channel and the MK III proposals have advantages for specific experiments.

New Proposal: We at Haystack now feel strongly that the VLBA should adopt a system which has all the advantages of both the 4-channel and MK III channel schemes. This system is proposal #3 in Table 1. We list the advantages and disadvantages of the 3 proposals as follows:

Advantages of proposal #1 (4 25-MHz channels)

a) Simplicity for user

The calibration of spectral line experiments is somewhat simplified when the desired band is continuously covered. For continuum studies there is little difference between a few wide bands and many narrow bands since the method of dividing the total bandwidth into many channels is largely transparent to the user.

Advantages of proposal #2 (32 8-MHz channels)

a) Bandwidth synthesis can be done without frequency switching

Bandwidth synthesis requires about 6 frequency channels per wavelength band to obtain a good "delay resolution function". For example the Polaris observations use 8 frequencies at X-band and 6 frequencies at S-band. Frequency switching can be used but the resulting aliasing in the fringe frequency domain makes bandwidth synthesis on pulsars especially difficult. The fringe frequency aliasing problem is severely compounded when there are multiple sources in the beam.

b) Lower dispersion loss in pulsar VLBI

More pulse energy can be captured with many narrow band channels than with a few wide band channels without the need for de-dispersing filters or other complication at data-acquisition.

c) MK III compatibility means compatibility with an already-installed world-wide base of acquisition and processing systems

There are now about 10 MK III acquisition terminals in the United States and 4 overseas. These numbers are expected to increase substantially during 1983 as terminals presently being constructed are completed. In addition the Japanese have developed a MK III compatible system known as K3. The MK III is presently being upgraded to 224 Mbits/sec and density upgrade development work is well underway.

d) Better performance in the presence of interference

Splitting up a wideband into many smaller bands offers significant advantages in avoiding interference. The narrow channels can be placed to avoid specific frequencies which have strong interference and, if interference should occur in one or more of the frequency bands, these bands can be discarded without losing an entire frequency or polarization. This method of interference avoidance has already been used in several MK III experiments and is especially useful at 300 and 600 MHz where there are few clear channels.

Advantages of proposal #3 (Expandable to 32 25-MHz channels, including Mark III compatible mode)

a) Has all the advantages of proposals #1 and #2

b) Has a large available bandwidth margin for future recording systems

Disadvantages of proposal #1

a) Requires frequency switching for astrometry/geodesy

Disadvantages of proposal #2 & 3

a) More expensive, NRAO estimates approximately $500,000 additional for the array

Summary:

We, at Haystack, feel that it is very important to choose an architecture for the data acquisition system that will satisfy all foreseeable needs. While it should be possible to upgrade receivers as the state of the art improves it may be far more difficult and expensive to make changes in the basic architecture because such changes will require major new engineering and software development.

Background material: see VLBA memos 137, 138, 140, 141, 142, 148, 151

	Proposal #1	Proposal #2	Proposal #3
Max. # channels	4	32	32
Max. # bands[1]	4	16	16
Max bandwidth per channel	25 MHz	8 MHz	25 MHz
Other bandwidths	12.5, 6.25, 3.12, 1.56 0.78, 0.39, 0.19, 0.10 MHz	4, 2, 1, 0.5 0.25, 0.125 MHz	16, 8, 4, 2, 1, 0.5 0.25, 0.125 MHz
Max. available bandwidth for recording[2]	100 MHz	256 MHz	800 MHz

TABLE 1 VLBI CHANNELIZATION PROPOSALS

Notes: 1 # I.F. to video converters
2 Allowing for expansion for future recording or satellite link technology