VLB ARRAY MEMO No. 298

BANDWIDTHS AND SAMPLING RATES RECONSIDERED

Larry R. D'Addario
5 December 1983

Background

In VLBA Memo #196, Rogers et al. report the decision of a study committee that the receiving system should provide a large number of baseband channels, and that each should have a wide range of bandwidths. A total of 16 baseband converters ("video converters") with upper and lower sideband outputs is specified, making 32 channels; for each channel, 11 bandwidths are specified, making a total of 352 filters per station if the full system is implemented. Sampling rates are also specified, with one at two times each nominal bandwidth. The memo gives no justification for the chosen bandwidths and sampling rates, but discussions show that the 4 Mb/s rate was chosen for MkIII compatability, and that the 24 Mb/s and 48 Mb/s rates were intended (erroneously) for VLA compatability. For further background, see Memos #186 and 192.

This scheme has the following problems:

(1) Too many filters are specified. These filters are bulky, and it will be hard to fit all of them into reasonable-sized modules. Being the narrowest bandwidth devices in the signal chain, they will make a large contribution to the delay instability if they are not well controlled in temperature; this becomes difficult if there are so many that they are spread out all over a rack. Finally, they are a significant cost item. For all these reasons, an effort should be made to cut down the number of bandwidths per channel.

(2) None of the sampling rates specified is a multiple or submultiple of an L.O. reference frequency. The reference frequencies are expected to include 5 MHz or 10 MHz, 100 MHz, and 500 MHz. This means that the sampling clock must be synthesized from the available frequencies. Like any other local oscillator, this clock must be phase stable, and this will be much easier to achieve if it can be generated in a simple way from stable references.

(3) None of the sampling rates is compatable with the VLA. The VLA samples at 100 MHz, and submultiples of this would be compatable. It should be sufficient to support VLA compatability at the fastest sampling rate only.

(4) It should be sufficient to support MkIII compatability at the "standard" sampling rate of 4 Mb/s, rather than at all possible MkIII sampling rates.

Proposal

In view of this, I would like to propose the following alternative:

A. Support only the following 8 sampling rates:

50.0 25.0 12.5 6.25 4.00 1.5625 0.78125 0.390625 MHz.

B. Let the sampling rate selection and filter selection be separated, so that sampling at other than twice the bandwidth is allowed.

C. Provide space for only the following 8 filters:

25.0 12.5 6.25 3.125 2.00 0.781 0.391 0.196 MHz.

These are approximate 10-dB bandwidths; the 3-dB bandwidths will depend on the filter type and number of poles.

D. Install the 25.0 and 12.5 MHz filters in only 8 of the 32 channels. This will allow the maximum recording rate (200 Mb/s) to be supported with the widest channel bandwidth; additional wide-bandwidth channels could not be used.

E. Perform 2-bit quantization at all sampling rates. There is no reason to impose a restriction on the digitizer, which should work the same way at all sampling rates. If this generates a total data rate which is more than can be recorded, then the magnitude bits need not be recorded; but this is a function of the recorder. If the correlator cannot process 2-bit data at high rates, then the magnitude bits can be ignored; but this is a function of the correlator.

Discussion

The sampling rates are chosen to be submultiples of the 100 MHz reference frequency which should be available from the maser. The one exception is 4.00 MHz, which is included for MkIII compatability, and which will have to be synthesized. Notice that 3.125 MHz is omitted, since it is fairly close to 4.00 MHz. The nominal filter bandwidths are then each half of a sampling rate.

This leads to 208 filters per station. This is still a large number, but it is a big improvement. Consideration should be given to eliminating still one more bandwidth, since not every factor of two may need to be covered. It seems to me that 12.5 MHz and 3.125 MHz are reasonable candidates for elimination.

Furthermore, the correlator group would very much like to eliminate the two highest sampling rates, since this would significantly simplify the correlator design. In fact, those rates may not be needed; with 32 channels, the high-data-rate mode of 200 Mb/s total is obtained at 6.25 Mb/s per channel. Higher sampling rates can only be supported with fewer channels in use. The arguments for supporting such modes need to be re-examined: For continuum work, fewer correlators are needed with fewer channels, provided that each correlator is fast enough, so the highest data rate per channel should match the correlator speed. The VLBA correlator is expected to be able to handle 12.5 Mb/s, and possibly 25 Mb/s, but not 50 Mb/s. The VLA correlator handles 100 Mb/s and may sometimes be used with VLBA station data; it has only 4 input channels, so the full 200 Mb/s rate can only be processed if the 50 Mb/s channel rate is available (this is 25 megasamples/s at 2 bits/sample). Another argument states that continuum observations are better calibrated with fewer, wideband channels; this seems to be debatable, and those who feel that it's true need to explain it in more detail. It seems to me that unless strong arguments can be made to the contrary, we will probably set the maximum sampling rate somewhere between 12.5 and 16 MHz. This allows two more filters to be eliminated, making 6 per channel or 92 per station.