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16 January 1985

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To: VLBA Acquisition Group

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Subject: <u>Is Efficient Encoding of 3-level Data Worth the Extra Cost and Complexity?</u>

1] Examples of potential continuum modes:

If 3-level data is efficiently encoded it might be used for most continuum as well as spectral line experiments. The table below shows some potential setups for normal continuum observing.

	A	B	C	D
Quantization	2-level	3-level	3-level	3-level
# Channels	8	5	5	4
BW/Channel MHz	8	8	8	8
Sample Rate Ms/s	16	16	16	16
# Tracks/Pass	32	32	20	32
Speed	135	135	216	108
Total Rate Mb/s	128	128	128	102
SNR	1.00	0.99	0.99	0.90

A] This is a simple 2-level mode suitable for most continuum observing.

B] This mode is not really practical since it has an odd number of frequency channels and hence cannot be equally split between RCP and LCP. In addition, very flexible multiplexing would be required to get the data onto 32 tracks.

C] Same as B] but without the need for very flexible multiplexing. Now the problem is that because only 20 tracks are recorded per pass much of the tape cannot be recorded unless the mode later changes to 12 tracks per pass. This set-up is likely to waste a substantial amount of tape and we may end up no better off than using simple encoding of 3-level data.

D] This mode doesn't require very flexible multiplexing but it results in a 10% SNR loss unless we change 8 MHz bandwidth to 10 MHz.

2] Cost of implementation:

Efficient encoding alone might cost 100 chips per formatter and a comparable number per DPS for a total cost of (20 formatter + 20 DPS) approximately about $40,000 - excluding design costs. Efficient encoding and the very flexible multiplexing needed to implement B] are estimated to cost about 1000 chips per formatter and DPS or about $400,000 - excluding design costs. Adding filters to support 10 MHz bandwidth would cost approximately $10,000 (assuming we put these filters only in the USB channels of all 16 converters and each station).

3] Reduction in archive?

Is Craig Walker's claim that the use of 3-level continuum will save hardware and archive tape really correct? If much spectral line observing requires 512 spectral channels then spectral line must dominate the archive even if the dump rates are no faster than continuum and if fewer frequency channels are used.

4] 3-level performance:

Even with the efficient 3-level 8 bits/5 samples encoding the sensitivity for 3-level will be slightly worse than 2-level for rectangular bandpass functions. When filter losses are considered the 3-level case may be 1-2% worse.

5] UHF observations:

Whenever the available spectrum free of interference is limited (such as at UHF), inefficiently coded 3-level data can be used. In this case, the number of tracks required is likely to be small so that there is no increase in tape consumption compared to observing at interference-free higher frequencies.

6] Tape error propagation:

Another difficulty with the efficient encoding of 3-level is the problem of error propagation. For example, a single error within an 8 bit byte will, in most cases, result in the incorrect decoding of 3 or more of the 5 samples. Since the data error rates will be increased by the efficient encoding it might turn out that it is better to increase the longitudinal recording density (which also increases the error rate) to make up for the less efficient simple encoding of 3-level data.

7] Field of view and delay beam:

Experiments which require an extremely wide field of view are best handled with many narrow bandwidth channels. There is some advantage to using 3-level data in this case but it is not overwhelming. For example, 8 correlator lags per 8 MHz bandwidth channel provides a field of view of about 5 arcseconds. Even if only one delay beam is analysed from the 32 MHz synthesized bandwidth in the 2-level Example A, the field of view is 200 mas which is adequate for most objects. If all the correlator output is archived the available field of view is the same for all the examples given. Some experiments can benefit by deliberately observing with a wide synthesized bandwidth. For example, the dynamic range for the detection of a weak object adjacent to a strong object, can be improved by placing the strong object in a different delay beam. Alternately the wide bandwidth can be viewed as increasing the uv coverage by making the narrow uv tracks into wide uv bands.