Modification of Mark 3A Systems to Increase Compatibility With VLBA.

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In what may prove to be one of the most commonly used operating modes, the VLBA recording system records data at a rate of 128 Mb/s from 8 baseband channels, accomodating a total signal bandwidth of 64 MHz with two-level sampling, or 32 MHz with four-level sampling. On playback the data are correlated on a single pass, with playback at twice the recording speed to provide a speedup factor of two. For data recorded on an unmodifies Mark 3A system, the use of eight basebands and one pass at the correlator limits the effective bandwidth to 32 MHz. This memo suggests how Mark 3A systems could be modified to be compatible with the VLBA mode described above in both bandwidth and speedup factor, by increasing the effective bandwidth to 8 MHz per baseband channel. The effective total bandwidth is then 56 MHz since Mark 3A uses only 28 recording heads. These possibilities were discussed at the VLBA Advisory Committee meeting in Nov. 1988, and briefly outlined by Alan Rogers in VLBA Aquisition Memo 117.

(1) Four-Level Sampling. In four-level sampling the quantization efficiency factor is 0.88, compared with 2/pi for two level. Going to four levels would increase the SNR by 1.38, which is equivalent to a bandwidth increase of 1.9. For simplicity let us think of this as doubling the bandwidth. Thus the suggestion is to modify Mark 3A to record seven 4 MHz-wide bands with two bits per sample. To do this one would build an add-on unit that would accept seven 4 MHz-wide baseband signals and output twenty-eight 4 Mb/s bit streams. Sampling each signal would produce two 8 Mb/s streams, and these would each be converted to two 4 Mb/s streams. The 28 bit streams would be fed to the Mark 3A formatter at some point that bypasses the existing samplers in the formatter. The sampling clock would be synchronized to the 4 MHz clock in the formatter. Fourteen of the outputs would carry data from the first half of each cycle of the 4 MHz clock and fourteen from the second half, and there should be no ambiguity in the interpretation of the timing. The present baseband amplifiers in the Mark 3A system have the output level controled by an attenuator with 1 dB steps, so it would be necessary to insert an analog stage with an ALC loop to control the signal level more precisely at each sampler input. The sampler module designed by Alan Rogers for the VLBA can handle eight baseband signals for four-level sampling, with clock rates up to 32 MHz, and would need only the addition of the ALC stages at the inputs and the bit stream dividers on the outputs to perform the functions envisaged for the add-on unit. The cost of the sampler module is approximately $3400, of which about half is for hardware and half for manpower. Some switching circuitry would be required to allow interchange between standard Mark 3A modes and the modified mode, and also some control and computer-interface circuitry. The overall cost should not be much more than $10,000 per unit plus a one-time design effort of about one man year by an experienced engineer.

(2) Increase of Bandwidth to 8 MHz. An alternative method of matching one of the VLBA modes would be to increase the baseband bandwidth to 8 MHz and retain the two-level sampling. The Mark 3A baseband converters include provision for an additional externally mounted filter, and an 8 MHz filter could be inserted there or could replace an internal filter for some bandwidth

rarely used. Again the sampling could probably best be done by building an additional unit based on the VLBA sampler design. A 16 MHz sampling clock would be used, and the 16 MHz sampled data bit-streams would each be divided into four 4 MHz streams. For two-level sampling the additional ALC circuits would not be necessary. The cost would be similar to that for the first option discussed.

The first scheme has the advantage of providing a 1.38 increase in SNR for spectral line observations where increased bandwidth is not necessarily useful. The increase in sensitivity without increasing bandwidth is also helpful in situations where bandwidth is limited by interference. But if one were going to the effort of designing the four-level add-on unit it would certainly be worth the small increase in complexity to include the extra serial-to-parallel stages to allow handling of 8 MHz bandwidths. The combined capability would allow an effective two-level bandwidth of 112 MHz by running the recorder at twice the normal speed. There would then be three modes almost fully compatible with the VLBA: (1) 4 MHz bandwidths with 4-level sampling, (2) 8 MHz bandwidths with 2-level sampling, and (3) 8 MHz bandwidths, 4-level sampling and 256 Mb/s recording rate. These would not be fully compatible with the VLBA system because the Mark 3A system provides only 28 recorded tracks. Whether it would be worthwhile to implement the other four tracks on the headstacks is another question.