A T ...

AT/20.1.1./013

Overall Systems & Performance
Technical Notes & Reports

MILLISECOND INTEGRATION TIMES ON THE COMPACT ARRAY

Graham J. Nelson

11 July 1985

Introduction

There is a requirement, particularly for solar and stellar observations, to be able to observe on the CA with the maximum possible time resolution. The data required from these observations are a selection of: flux, spectral index, polarization (usually circular only) and one dimensional position. This document explores the data rates and other system implications of implementing this option. The related problem of pulsar observations will be discussed in a separate document.

Worst Case

To explore the worst case situation we assume a 16 MHz clock rate for the XCELL chip and that observations are being carried out with a 128 MHz bandwidth in the 2 bit mode. We further assume that all 8 products are required on each of 15 baselines and that the integration time is to equal the XCELL chip readout time of 2 ms.

The output from the correlator to the array processor is in the form of 8 x 15 correlation functions per 2 milliseconds, each of 64 lags. The total data rate is therefore $8 \times 15 \times 64 \times 500 = 3.8 \times 10^6$ (16 bit) words/sec.

The correlation functions would normally be converted to complex spectra with 16 frequencies using an array processor to perform the FFT. To assess the minimum computing time involved we note that the AP500 array processor does a 1024 point complex FFT in 4.7 ms. If we scale the processing time for shorter correlation functions as n log n we find that it takes more than 5 seconds to process 1 second of data.

Areas of Compromise

The worst case situation is clearly not realisable but the following options to reduce to data rate and the required processing are available.

1. Increase integration time
2. Reduce products per baseline
3. Reduce number of baselines
4. Output correlation data to disk and only process short intervals of data during actual solar or stellar flares
5. Derive sine and cosine terms for a single frequency channel from the zero and ±1 lagged products without performing an FFT.

Option 5 offers the greatest improvement both in data rate and processing time. In addition it results in no degradation of the data because frequency smearing is not a problem in a one dimensional image derived from at most 15 points in the u,v plane.

Data Rate

The required data rate from correlator to array processor using option 5 is $\frac{3}{64} \times 3.8 \times 10^6 = 1.8 \times 10^5$ (16 bit) words/sec.

This is well within the capabilites of the AP500 array processor. After processing, the data is reduced from 3 correlation coefficients to a sine and cosine term and only 2 (I and V) of the 4 Stokes parameters will normally be required. The words will presumably now be 32 bits long. The output data rate therefore becomes $1.8 \times 10^5 \times \frac{2}{3} \times \frac{2}{4} = 6 \times 10^4$ (32 bit) words/sec.

Processing Time

Based on estimates given by Andrew Hunt (AT/24.1.1./007) for operations with the AP500 processor we can estimate the time required to process the 15 x 8 x 3 correlation coefficients per integration period into 15 x 4 sets of u,v pairs.

DC offset subtraction	0.1 ms
Van Vleck correction	0.5
Calculate sin term $(\frac{\pi}{2}(C(1)-C(-1)))$	0.07
Corrections	0.07
Form Stokes parameters	~2.3
	3.04 ms

The time to form the Stokes parameters assumes the full correction scheme outlined by Max Komesaroff. In the usual case where only strong circular polarization is expected only complex gain corrections will be required and the Stokes processing time will be at least halved. For this low dynamic range data the Van Vleck correction is also probably unnecessary. A total processing time of < 2 m sec might then be involved.

Memory Requirements

The memory requirements in the modules and in the array processor are trivial in this application. Storage for 64 words is required in each module and only 360 words are transmitted to the array processor each integration period.

Recording Requirements

The processing time indicates that a minimum integration period of ~ 2 msec can be achieved. The output data rate from the correlator is then 60K (32 bit) words/second.

In most cases it will not be necessary to record all of this data. For example the data might be averaged in one of the VAX computers for a period of say 10 seconds. Some suitable criterion would then be applied to the correlation coefficients on the shortest baseline to determine whether either the 10 second or the 2 msec data should be recorded.

Other System Implications

Any 90° or 180° phase switching that might be implemented to reduce images, LO breakthrough and DC offsets may need to be turned off during observations of this sort. This should not present a problem as the dynamic range of the one dimensional data is already small.

There is a problem with implementing the Automatic Level Controllers at the samplers during impulsive solar bursts. The requirement would be to switch attenuators in synchronism with the ~ 2 msec integration period. An alternative is to use only one bit sampling and slower switching of attenuators based on the normal long term averages of signal level. The main aim is to be able to keep track of long term changes in T_{sys} and Gain for each channel. The actual rapid variation in signal level needs to be monitored separately. This requires 2 msec sampling of the Automatic Level Control signals from at least one antenna.

Comparison of data rates from millisecond one dimensional observations and worst case two dimensional mapping data

Observation	Data Rate (words/sec)	Data Rate Bytes/sec
τ = 2 mS one dimensional processed data	60K	240K
τ = 1S 16384 channels	246K	984K
τ = 5S 16384 channels	49K	197K