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VLA TEST MEMO 206

SNR IMPROVEMENTS WITH FULL COMPLEX CORRELATION

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ABSTRACT

The VLA correlator has twice the number of multipliers than are necessary for continuum observations. These can be used to produce full complex correlation. This improves the SNR by about 9% for 50 MHz continuum and a couple of percent for 25 MHz continuum observations as expected. It is suggested that the ONLINE software be implemented to take advantage of this.

INTRODUCTION

The sampling theorem for complex signals requires that they must be sampled only at the bandwidth, and not at twice the bandwidth rate. Also the VLA correlator has twice the number of multipliers than are necessary for the continuum work. These can be used to generate full complex correlation by combining them. We are taking advantage of this to increase the continuum bandwidth to about 80 MHz/IF (VLA Eectronics Memo. 227, VLA Test Memo. 205), bandwidth being limited by the IF and baseband electronics. Another advantage of the complex correlation is that the 100 MHz sampling rate for 50 MHz bandwidth signals is twice the minimum sampling rate for full complex correlation. For a 3 level by 3 level correlator, as in the VLA, the expected improvement in SNR for double the minimum sampling rate over the minimum sampling rate is about 9% and for four times the minimum sampling rate the expected improvement is about 12%. This is seen in the test results presented below.

TEST RESULTS

To explain various correlation products consider a two antenna interferometer of Fig. 1 with quadrature samplers as in the VLA. The two sets of correlation products can be defined as:

(1) $A_1 = cos1 * cos2 + i * cos1 * sin2$, and (2) $A_2 = sin1 * sin2 + i * sin1 * cos2$.

The first set is presently used in the VLA and the second set is NOT used. The two pairs of the correlation products can be combined to give full complex correlator output as:

$A = cos1 * cos2 + sin1 * sin2 + i * (cos1 * sin2 - sin1 * cos2)$.

I used an interferometer formed by antennas 13 and 16 to observe 3C84 and a blank field 5° north of it at X-band. We used 3.3 sec integration for the blank field observations and recorded all three quantities A_1, A_2, and A. Data on the blank field were obtained for about 40 min for each bandwidth. A summary of the average and rms of the quantities A_1, A_2, and A for continuum observations using bandwidths of 50 MHz, and 25 MHz is given in Table 1. From the results in Table 1, it is seen that the improvements in the SNR for the full complex correlation over using only one set of correlator products for continuum observations are:

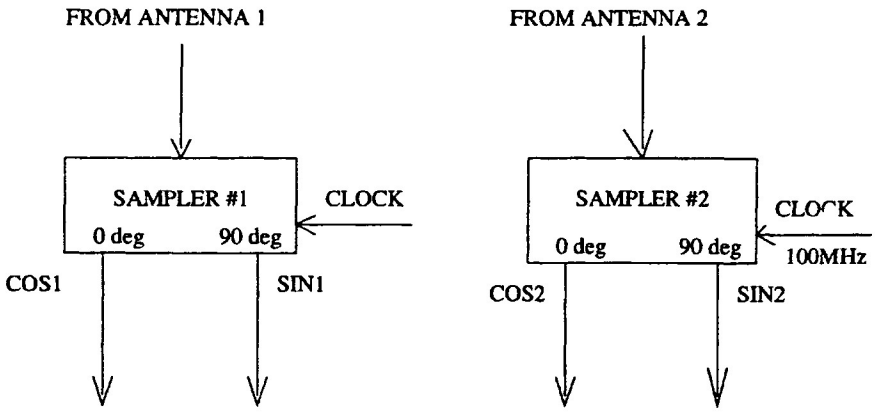
[(0.00153+0.00159)/2]/0.00144 = 1.083 for 50 MHz bandwidth, and

[(0.00192+0.00191)/2]/0.00183 = 1.047 for 25 MHz bandwidth.

This is consistant with the expected SNR improvements as described above.

CONCLUSION

With full complex correlation we gain about 9% in SNR for 50 MHz bandwidth and a couple of percent in SNR for 25 MHz bandwidth over what we get at present. Though this is only a modest gain in the SNR over what we get now, it is almost free, because generating full complex correlation is any way required for increasing the bandwidth beyond present 50 MHz/IF. I suggest that the capability of measuring the full complex correlation for all the continuum observations be implemented in the ONLINE software at an early date.



$$A1 = \cos1*\cos2 + i\ \cos1*\sin2$$
$$A2 = \sin1*\sin2 + i\ \sin1*\cos2$$
$$A = \cos1*\cos2+\sin1*\sin2 + i\ (\ \cos1*\sin2 - \sin1*\cos2\ )$$

Fig . 1 Block diagram to define various correlator products for a two antenna interferometer with quadrature samplers as in the VLA.

TABLE 1 Summary of average and rms values of various correlation products for continuum observations using 50 MHz and 25 MHz bandwidths on 3C84 and a blank field 5 deg north of it.

BW	SOURCE		|A1|	|A2|	|A|	SNR IMPROVEMENT (|A1|+|A2|)/2|A|
50MHz	3C84	Av	13.702	13.400	27.14	
	BLANK	RMS	.02096	.02136	.03909	
		RMS/Av	.00153	.00156	.00144	1.083
25MHz	3C84	Av	14.41	14.100	28.500	
	BLANK	RMS	.02763	.02686	.05204	
		RMS/Av	.00192	.00191	.00183	1.047