National Radio Astronomy Observatory
Socorro, NM 87801

VLA TEST MEMO 205

VLA BANDWIDTH EXPANSION

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ABSTRACT

The IF A electronics of antennas 13 and 16 has been modified to achieve more than 80 MHz bandwidth. The resulting improvement in the SNR for increase in the bandwidth from 50 MHz to 80 MHz for the continuum observations is as expected.

INTRODUCTION

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. Advantage of this is that the sampling theorem for complex signals requires that they must be sampled only at the bandwidth, and not at twice the bandwidth rate. Thus with the 100MHz VLA samplers it is possible to almost double the continuum bandwidth as was proposed in VLA Electronincs Memo. 227. There it was suggested that with some modifications to the existing electronics at IF and baseband it should be possible to increase the bandwidth to about 85 MHz/IF. It was decided that the increase in the bandwidth and resulting improvement in the SNR should be demonstrated with modifications to electronics of one IF on two antennas using interferometer tests. This memo describes the modifications and the test results.

MODIFICATIONS

The hardware modifications made to demonstrate the bandwidth increase for IF A on each of the two antennas (Ants. 13 and 16) are shown in Fig. 1. The modifications made are:

1) F8: Change IF A bandpass filter from 1325/60 MHz to 1330/85 MHz.
2) T3: (a) Bias IF A SSB mixer diodes to get better rejection for $(2f_l - f_r)$ component. Here f_l is LO signal frequency from the Fluke Synthesizer, and f_r is input signal frequency.
   (b) Add a 90 MHz notch filter in series with the existing 80 MHz lowpass filter for IF A to reject 90 MHz Fluke LO leaking to the baseband.
3) T4: Replace external ("JPL") filter by 80 MHz lowpass filter and 26 dB attenuator
4) Screen room wall filter: Bypass the 70 MHz lowpass filter
5) Sampler: Use sampler having good quadrature performance out to about 80 MHz (see Fig. 2).

With the above modifications the IF spectra at the T2 Receive (BNC front panel) monitor points for the two antennas are shown in Fig. 3. The spectra at the sampler rack inputs for 50 MHz bandwidth setting and wide bandwidth setting (with Fluke Synthesizer set at 90 MHz) for the two antennas are shown in Fig. 4. If the signal bandwidth for the 50 MHz setting in Figs. 4 (a) and (b) is considered 50 MHz, then by the same measure the signal bandwidth for the wide bandwidth setting in Figs. 4 (c) and (d) seems to be at least about 80 MHz.

INTERFEROMETER TESTS AND RESULTS

To explain various correlation products consider a two antenna interferometer as shown in Fig. 5 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:

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

We used 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 of the 50 MHz and wideband observations. 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 wide bandwidth is given in Table 1. From the results in Table 1 it is seen that the improvement in the SNR for the wide bandwidth using full complex correlator over using only one set for 50 MHz bandwidth, as we use now, is [(0.00153+0.00159)/2]/0.00123 = 1.268. This is as expected for the increase in the bandwidth from 50 MHz to about 80 MHz. This demonstrates that increasing the VLA bandwidth for one IF works and it improves the SNR as expected.

WHAT NEXT

The next thing to do is to demonstrate that the bandwidth expansion works for all four IFs. For this purpose it is desirable that all four IFs in three antennas are modified. This will require following modifications (see Fig. 1):

Antenna Electronics -

F7: Add 1030/90 MHz bandpass Filters - one for each IF

F8: Replace channel bandpass filters - one for each IF;

L7: Seperate phase switching Walsh Function for each L7 (VLA Electronics Memo. 227)

Control Building Electronics -

T3: At input of T3 add a 1500/600MHz bandpass filter (One Filter), Bias SSB Mixers to improve $(2f_r - f_l)$ rejection, and add a 90 MHz LO rejection Notch filter in IF A (One Filter)

T4: Replace External ("JPL") filters by suitable (26 dB) attenuators

Screen room Wall Filters: Replace by 80 MHz lowpass filters

Sampler: Adjust sampler performance, especially quadrature, good out to 80 MHz

Online Software -

Provide seperate Phase switching Walsh Functions to AC and BD L7s

Modify data acquisition to produce complex correlation data

CONCLUSION

Increasing the bandwidth to 80 MHz for IF A works, and the resulting improvement in the SNR over 50 MHz bandwidth for continuum observations is as expected. Next step is to demonstrate that the idea works for all four IFs. For this we have proposed to modify all four IFs in three antennas.

ACKNOWLEDGEMENTS

I thank Barry Clark for helpful discussions, Frontend and LO/IF groups, and Chuck Broadwell for making modifications to the electronics of antennas 13 and 16 for the tests, and Ken Sowinski for modifying the data acquisition program to record both sets of correlation products.

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

BW	SOURCE		|A1|	|A2|	|A|
50MHz	3C84	Av	13.702	13.400	27.14
	BLANK	RMS	.02096	.02136	.03909
		RMS/Av	.00153	.00159	
WIDE	3C84	Av	13.584	13.349	26.924
	BLANK	RMS	.01998	.02046	.03316
		RMS/Av			.00123

SNR IMPROVEMENT FOR WIDEBAND OVER 50MHz BANDWIDTH
= (RMS/Av for 50 MHz)/(RMS/Av for WIDEBAND for complex correlator)
=[(.00153+.00159)/2]/.00123
=1.268

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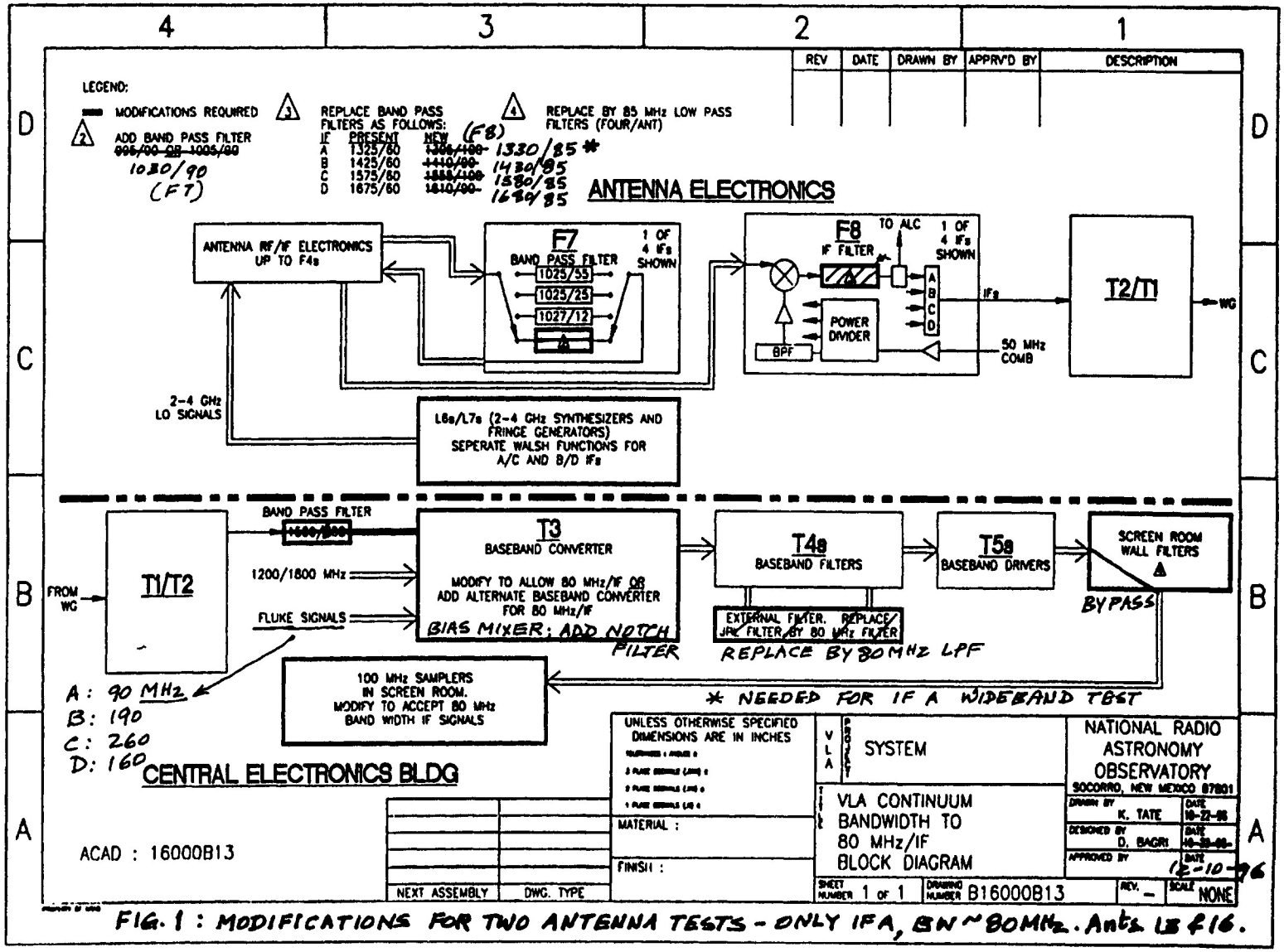
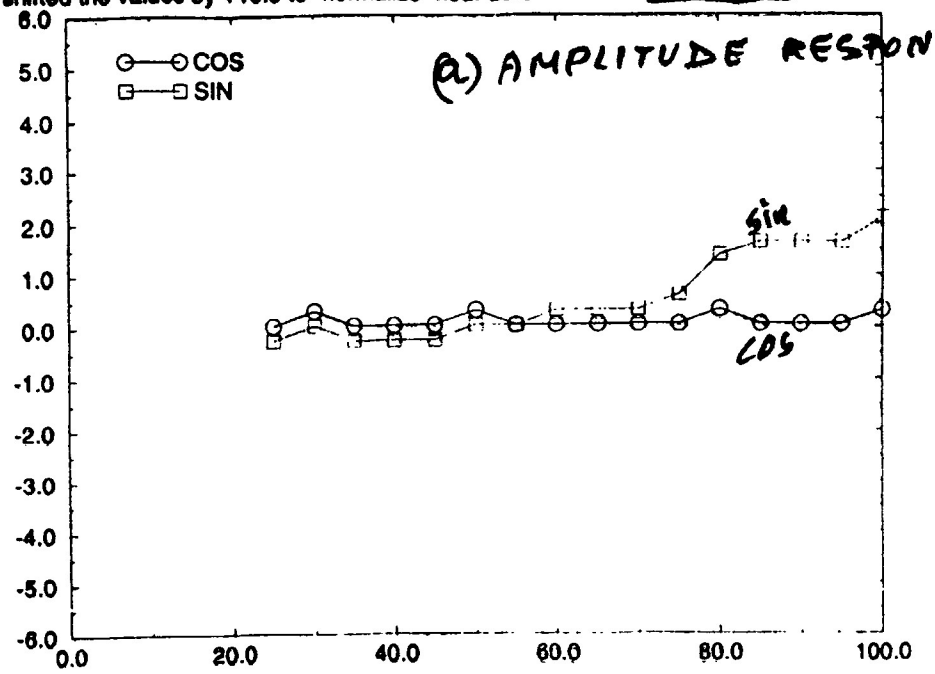


FIG. 1 : MODIFICATIONS FOR TWO ANTENNA TESTS - ONLY IFA, BW ~80MHz. Ants. 15 & 16.

measured COS and SIN with vector voltmeter from 20 to 100 MHz
put the RMS values in the graph, then took 20*log(rms) of both
then shifted the values by +10.5 to "normalize" near zero

SAMPLER RESPONSE



results look very similiar to the 4DEC96 tests using the digital scope

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11 DEC 96 Sampler SN A1 tests PLUS 4 DEC tests also
measured COS and SIN with vector voltmeter from 20 to 100 MHz

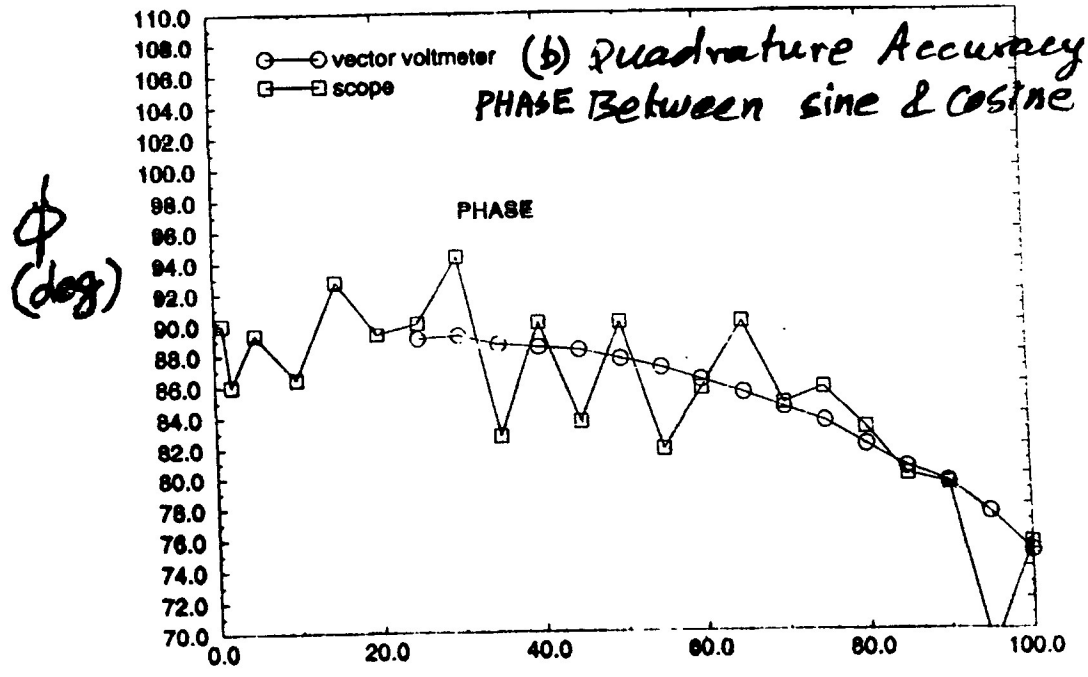
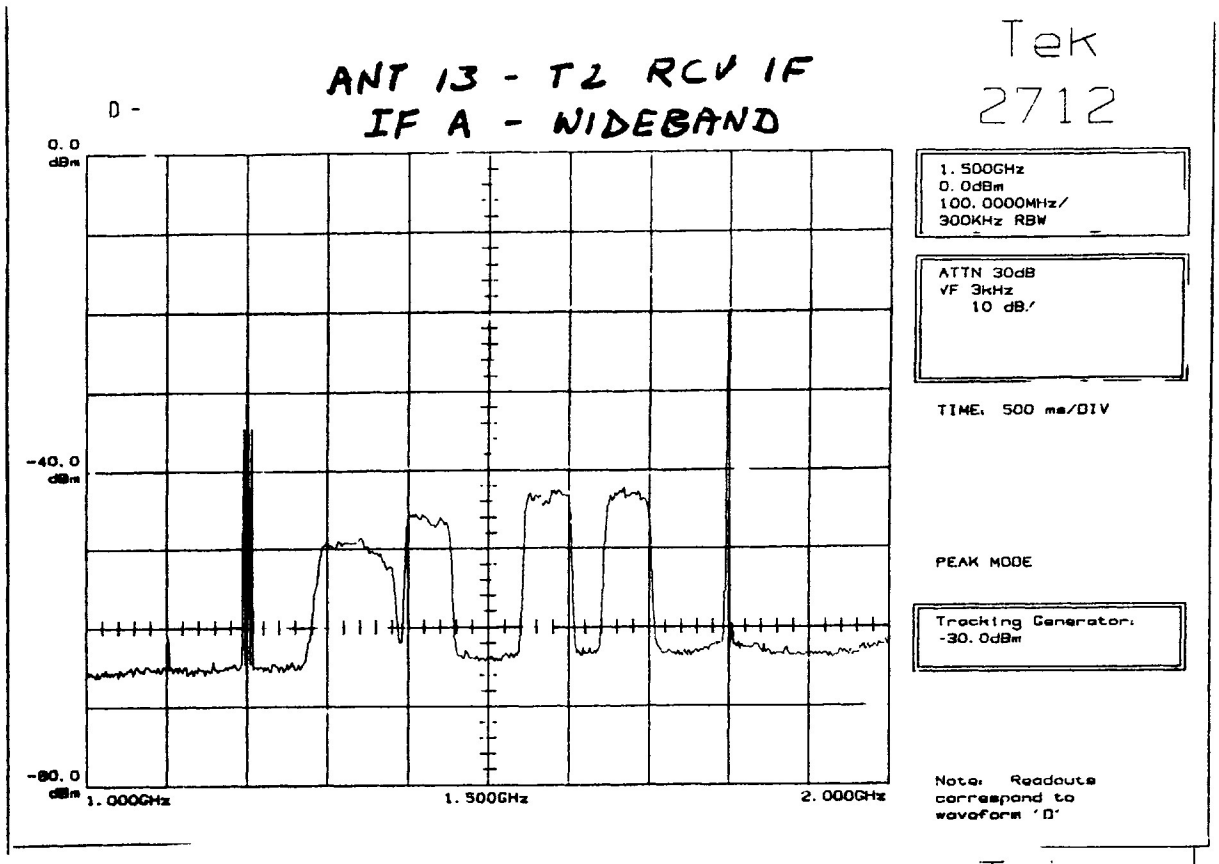


FIG.2 SAMPLER QUADRATURE RESPONSE
(a) AMPLITUDE (b) PHASE



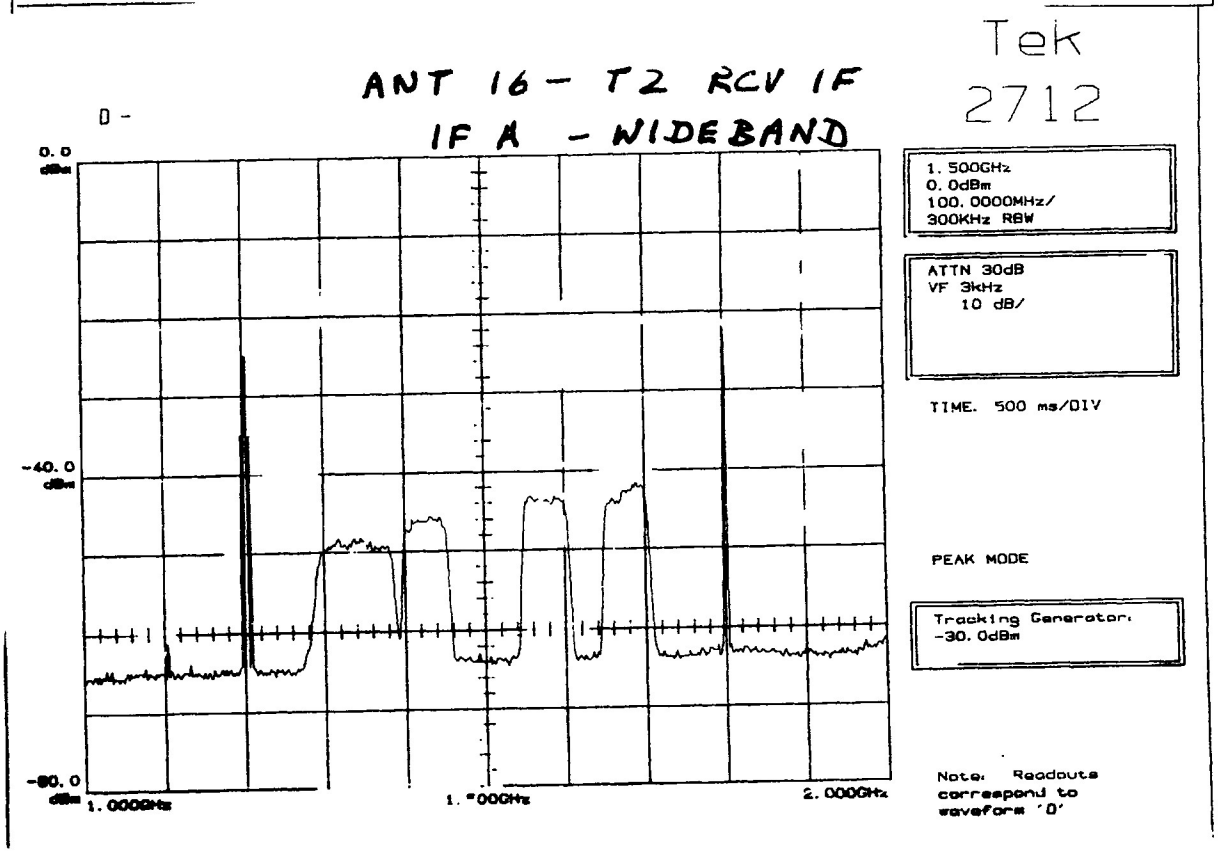
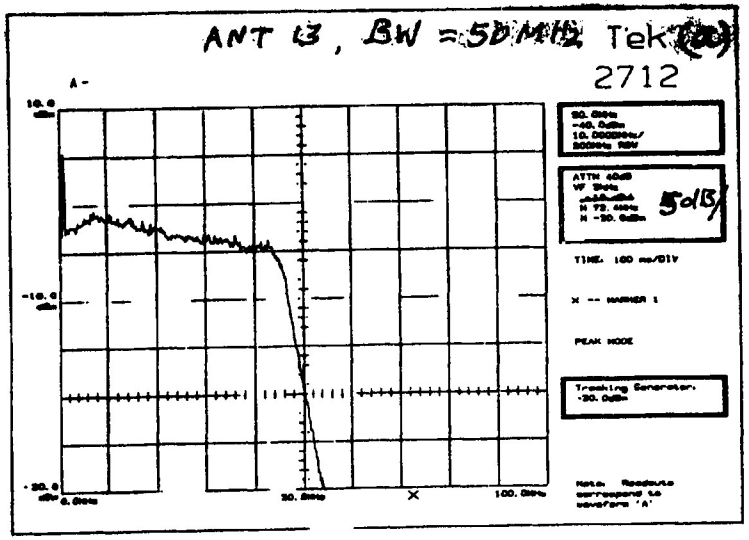
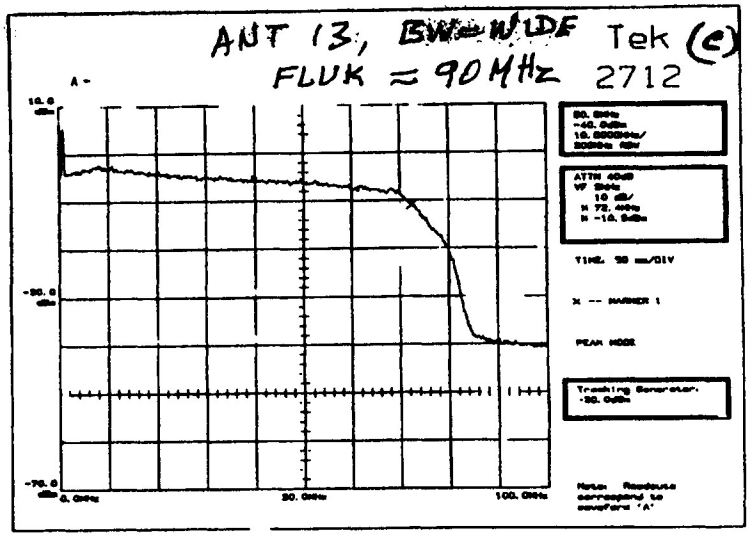


FIG. 3 : RECEIVED 1-2 GHz IF FROM ANTENNAS 13 & 16
(AT T2 FRONT PANEL BNC MONITOR)
FOR WIDEBAND OPERATION OF IF A

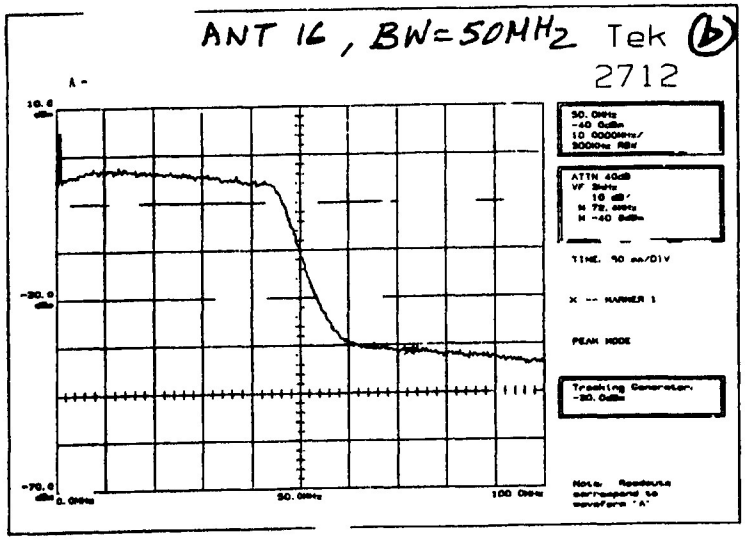
FIG. 4: SPECTRUM OF SIGNAL AT THE INPUT OF SAMPLER RACK - ANTs. 13 & 16
(a) & (b) FOR 50 MHz and (c) & (d) FOR WIDE BAND WIDTH OPERATION

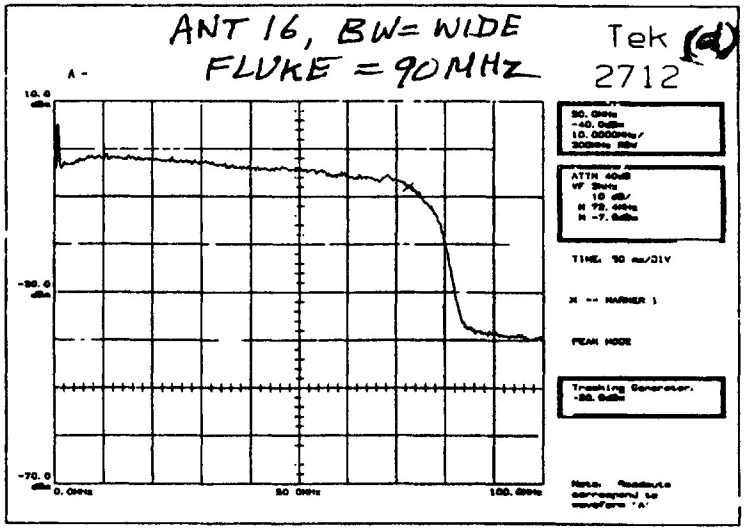


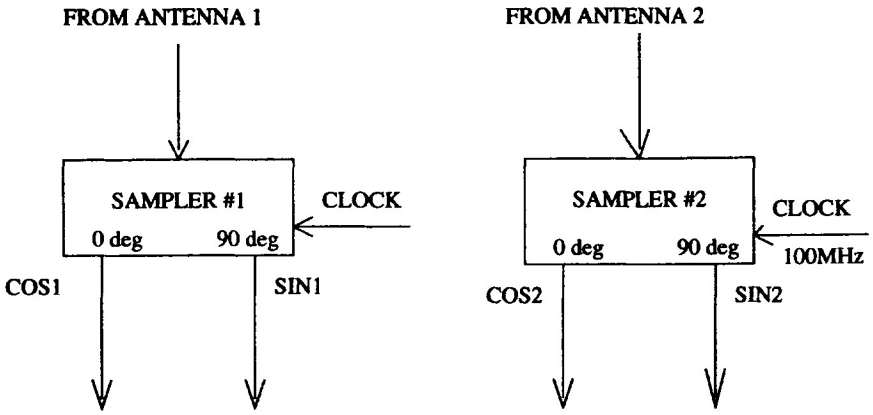
970318 ANT 16A @ SAMPLER RACK INPUT



- 970318 ANT 16A @ SAMPLER RACK INPUT







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

Fig . 5 Block diagram to define various correlator products for a two antenna interferometer with quadrature samplers as in the VLA.