VLA ELECTRONICS MEMO #114

PHASE QUADRATURE REQUIREMENTS

B. G. Clark

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The question has arisen as to the requirement of accuracy in the phase quadrature network used to derive sine and cosine signals for the correlator. If a signal $A(\omega) \cos \omega t$ is present in the cosine channel and $A(\omega) \sin (\omega t - \delta)$ in the sine channel of one antenna, and $A(\omega) \cos (\omega t - \phi)$ in the other antenna, the correlator cosine and sine outputs are, respectively

$$A_C = A(\omega) \cos\phi$$
$$A_S = A(\omega) (\sin\phi \cos\delta - \cos\phi \sin\delta)$$

whence the estimated amplitude is

$$A_E = \sqrt{A_C^2 + A_S^2}$$
$$= A(1 - (1-\cos\delta) \sin^2\phi - 2 \sin\phi \cos\phi \sin\delta \cos\delta)^{\frac{1}{2}}$$
$$\approx A(1 - \frac{\delta}{2} \sin 2\phi).$$

For 1% amplitude stability, therefore, at any phase ϕ, we must have

$$\frac{1}{B} \int \delta \, df < .02 \text{ radian} = 1.1$$

over any bandwidth of interest. If we alocate 0.75 to phase errors in the generating network and 0.75 to the relative time error of the samplers we can find the required time stability. For this case,

$$\delta = f\ \Delta\tau$$

$$\frac{1}{50}\int_0^{50} f\ \Delta\tau\ df < 0.75$$

$$\Delta\tau < 83\ \text{ps}\ .$$

This requirement on the relative timing of the sine and cosine sample pulses is more stringent than the 400 ps discussed in VLA Electronics Memo #112, which, however, remains the tolerance of the two samples jittering in synchronism.

This requirement is clearly very stringent. We need at least the capability of measuring the quadrature defect during the correlator test time. This, however, may not be sufficient, and we may be forced to incorporate one of the following schemes:

1) Continuous measurement of δ by multiplying sine and cosine components, and correction by computer, adding δA_c to A_s. This is a laborious and annoying task for the computer to perform.

2) Continuous measurement of δ and use of the answer to feed back to control the phase of the sine component. Control could be accomplished most easily by altering slightly the timing of the sine sampling pulse, or possibly by adding a controlled percentage of the cosine signal to the sine. Care must be taken to separate this effect from the sampling level errors discussed in VLA Electronics Memo #112.

3) Use of correlated chirps generated at the antennas during correlator test times for measurement of both delay error and quadrature defect, for use either by feed back or for computer correction. Correlator test times would then have to be scheduled sufficiently frequently to remove variations in timings.