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To: VLBA Correlator Group

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Subject: Clipping Correction and Fringe Rotation at the Processor

When post quantization fringe rotation is carried out over an integral or large number of cycles the clipping or quantization correction can be ignored without significant detrimental effects. The reason being that the harmonics generated in quantization are rotating at harmonics of the natural (pre-rotation) fringe frequency and are filtered out in the fringe rotation. As a consequence of the above, it is sufficient to apply the small signal quantization correction factor (i.e. $\pi/2$ for 2-level) regardless of the correlation coefficient. Even if the signals are 100% correlated the cross-spectrum is not corrupted in phase and suffers only a small (<10% worst case with 100% correlation and 2-level quantization) amplitude scaling error*.

I have checked the above hypothesis by software simulation of the Mark II/Mark III Correlator. One might expect small departures because the 3-level rotation harmonics will mix with the quantization harmonics - but at the level 0.5 degrees of phase I was unable to see the effect in the test cases I examined which were as follows:

1] Flat continuum spectrum with 100% correlation

2] A narrow spectral line with 100% correlation

In both these cases I tried a range of residual phases and saw no dependence on residual phase. (By contrast, simulation shows that errors of 6 degrees can occur in a system in which fringe rotation is done at the antennas and 2-level cross-correlation without Van-Vleck correction).

Another interesting test case that needs further simulation (given sufficient CPU cycles) is that of a weak spectral line in the presence of a strong (almost 100% correlated) spectral line. In this case the dynamic range should be limited only by the product of the spectral filter (sinc for uniform weighting) and the fringe rate filter (also a sinc function). In simulations I have verified this result for a dynamic range limited by the noise level in the correlation of 100,000 bits. If this result holds up for large amounts of data, there will be no advantage to diluting a strong maser line with noise. The case of the strong maser line is, of course, best handled by increasing the observing bandwidth to maintain low system temperature. This is also the case which will require high spectral resolution.

*By "scaling" error, I mean that the scaling of spectral lines are in error - but there are no spurious lines generated.