ALMA Memo # 392

A Cross Multiply Accumulate Unit for FX Correlators

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1. Introduction

FX correlators enjoy an advantage over XF correlators because they need fewer computations. However, the amount of storage needed is the same for both. In XF correlators recirculation is used to achieve larger lag ranges over reduced bandwidths. The extra storage needed for the larger lag range is implemented in external low cost RAM. In FX correlators the first stage storage is implemented within the ASIC or FPGA performing the cross multiplication. This RAM is much more expensive than external RAM. This reduces the cost advantage of FX correlators when compared to an XF implementation. In this memo, a frequency channel reordering scheme is described which allows most storage in FX correlators to be implemented in external RAM. This frequency channel reordering is the FX-correlator analogue of recirculation in XF correlators and allows a considerable reduction in the cost of FX correlators.

2. Recirculation in XF correlators

First, let us consider recirculation in an XF correlator. At the highest bandwidth the data rate into the cross-multiply accumulator (XMAC) of an XF correlator is equal to the maximum clock speed. If the bandwidth is reduced so is the clock speed leading to under-use of the XMAC. This capacity is recovered by clocking the low speed data into a temporary store and passing this data through the XMAC multiple times. For each pass of the data through the XMAC one of the inputs is delayed. Thus, each pass of the data through the XMAC generates a set of correlations at different values of delay. If the bandwidth is reduced by a factor N then the number of correlations generated per baseline increases by N. This results in an increase in frequency resolution by a factor N^2.

A second benefit of recirculation is that the extra storage for the increased number of lags can be implemented in cheap external RAM. This is achieved by buffering the lag data within the XMAC at the end of each accumulation. The accumulators in the XMAC are cleared and the cycle starts again. While the new lag data is being accumulated, the buffered data can be accumulated into the external memory. The XMAC can operate at its full potential and on-chip memory is minimised.

3. Channel Reordering in FX correlators

In FX correlators, it is a simple matter to maintain full usage of the XMAC units as frequency resolution is increased. Increase the number of frequency channels without