BIMA
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Proposal for a Wide-Band Digital Correlator

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Abstract

The goal of the wide-band digital proposal is to build a system using readily available, off the shelf parts. There are four elements to the wide-band digital correlator proposal. First, a sampler of unique design is proposed to digitize an 8 GHz bandwidth signal. Second, an 80 channel digital correlator is proposed. Third, a digital delay line is proposed to replace the existing analog delay. And finally, a finite impulse response filter is proposed to replace the existing single-sideband mixer and third LO.

Discussion

The sampler uses an unusual approach to gain wide bandwidth. Potentially the approach can be used to produce bandwidths in excess of 100 GHz. Such a sampler should be of great interest to the mm array project as well as the radio astronomy community in general. While the approach is new and therefore represents a risk, an example close to what is needed has, in fact, already been produced by the LLNL for the study of transients. While the LLNL has been rather circumspect in its' description of the sampler, they have expressed the willingness to share the technology with other government funded groups. Potentially, the development work already done by the LLNL will save us a great deal of time.

The estimated time required to develop the sampler is 1 to 1.5 years. The estimated parts cost for 10 samplers is approximately $35K.

The digital correlator is a straight-forward design. Using 100 MHz logic, each baseline will have 12800 two bit multiplies for a total of 80 channels. The high speed and high density of modern field programmable logic makes this correlator practical. 1024 two bit multiplies are done on each card of our present correlator and all of the logic on one card can now be placed in one chip. Economies in the amount of logic required will be made by consolidating some of the accumulator logic.

The estimated time required to develop the digital correlator is 2 years. The estimated parts cost for 45 baselines including interfacing to our present system is $80K.

The digital delay line is very straight forward and does not represent new technology. It is the best way to do it in every respect. It does not change its gain or pass-band shape with a change in delay. It is not effected by changes in temperature. It can change its delay instantly in the middle of an integration with no adverse affect. It is inexpensive and quick to develop.

There is a potential savings in overall development time of the wide-band project. W. C. Erickson of the University of Maryland has expressed interest in a digital delay line project. (BIMA Memoranda Series #24) If the University of Maryland develops the delay line in parallel with a Berkeley effort a savings in development time will be realized.

The estimated time required to develop the digital delay line is 1 year. The estimated parts cost for 10 antennas including interfacing to our present system is $30K.

The finite impulse response filter represents a method whereby the current narrow-band correlator may be integrated into the new wide-band system. It replaces Doug's down-conversion scheme which would be required in an analog system. It accomplishes full tune-ability over the entire 8GHz bandwidth of the IF as does Doug's most costly analog design. Each of the four windows in the present system could be tuned to anywhere in the 8 GHz IF. The finite impulse response filter also replaces the existing 3rd LO, the single side-band mixers and the samplers. It provides a little less than 30 dB image rejection. More image rejection may be provided if desired.

The estimated time required to develop the finite impulse response filter is 2 years. The estimated parts cost for 80 filters including interfacing to our present system is $150K.

An alternative approach may be to use the existing analog delay with Doug's least expensive down conversion scheme in front of it. Observing with the current system would be restricted to a fixed 1 GHz window in the 8 GHz IF of the new wide-band system.

The possibility of a digital delay is so attractive that Doug's down conversion scheme could be used with a separate digital delay between the existing samplers and digital correlator as yet another alternative. Once again, observing would be restricted to a fixed 1 GHz window in the 8 GHz IF but the precision and stability of a digital delay would be available for high resolution observing.

There will be added costs for cable and connectors to interconnect the above systems. The estimated cost is $25K.

The total cost of the above system is estimated to be $320K. If the sampler, digital delay and correlator are developed concurrently then the overall development time should be no more than 5 years with as little as 4 years a possibility. If Maryland were to develop the digital delay then overall development time could be reduced to between 3 and 4 years.

For purposes of comparison with the analog correlator alone, the price of the digital correlator alone is only $120K. This price estimate includes the sampler, the correlator, cabling and interfacing to our computer system.