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The GMRT Correlator and non interferometric observations

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The GMRT is expected to be fairly versatile instrument that is capable of more than routine synthesis observations. Already there are proposals for doing pulsar search (Deshpande and others) using incoherent and de dispersive addition of the outputs of the 30 antennas and pulsar timing (Thakker) using the coherent (phased) output of the antennas in the central square. The output of the phased central array would also be of interest for other observations like VLBI. As was clear from the Electronics Lab talks given by both Deshpande and Thakker, the flow of the signals for the pulsar observations is sufficiently similar to that for synthesis observations that it is reasonable to expect that it should be possible to tap the signal at some intermediate point in the correlator system and feed it to the respective pulsar machine. Otherwise, a lot redundant electronics will have to be built which could dampen the interest in these projects. The purpose of this note is to highlight the requirements of the pulsar observations so that we can start some discussion on whether it is possible for the correlator group to meet these requirements. While from the astronomical point of view one would urge that the correlator have all possible flexibility, the ultimate decision on what flexibility can be provided will have to be based on engineering considerations. Since we have decided in our last meeting to stick closely to the VLBA design and layout for the FFT and multiplier cards, I think that we are in a position to critically discuss the pulsar requirements since all that is involved is the back plane wiring.

The input for Deshpande’s pulsar machine are 30 (one for each antenna) 64 or 128 point FFTs, which in the pulsar machine are squared to get power, de dispersed and summed to get a time series that is then searched for a periodic signal. The integration period for the input signals could be of order a millisec or more and the natural place to get these signals is after the FFT cards, where the short term integrator can give the required integration. Thus to accommodate this pulsar machine one needs that the output of the FFT cards goes in addition to the multiplier cards, also to the pulsar machine which could be achieved either through multiplexing or by having two permanent paths. An additional problem that exists is that this pulsar machine requires 32 MHz bandwidth which requires 2 independent FFT cards for each antenna, one of which is never connected to the multiplier cards.

For Thakker's pulsar timing machine, the input is a time series (at 32 mega samples per second) corresponding to the output of the phased array of antennas (4 or 6 in the first phase). This time series is Fourier transformed in the pulsar machine itself since the required frequency resolution is higher than available in the correlator FFT card, and de dispersed and analysed to get the pulse profile. Since this machine expects just a time series as the input, in principle, one could tap the signals before the correlator. However, to phase the array and get the output corresponding to that of a single large dish, one has to compensate for the propagation delay and perform fringe stopping. Delay compensation is presently being done in the sampler card, just before ITT card and giving second output from (or multiplexing the output of) the sampler card should not be too difficult, since this card is being designed locally. However, tapping the signal at this point is satisfactory only if the fringe stopping is done at the second local oscillator and not on the FFT card. If the fringe stopping is to be done on the ITT card then, the signal has to be taken through the ITT card in a straight through (no FFT) mode and passed to the pulsar machine that adds the outputs of all the antennas and proceeds with its processing. This has a disadvantage that because of fractional sample delay errors, the phasing will not be equally good at all frequencies in the band. Alternately, one could pass the signal through the ITT card, perform FFT and FSD corrections and send the FFT to the pulsar machine that coherently adds the transforms from all the antennas, performs an inverse FFT to recover the time series and proceeds as before. I suspect that there may be even smarter ways of doing this, but it seems that even in this case one needs to have a signal coming out after the FFT card.

What is required is a critical discussion on the feasibility of giving this output. This cannot be postponed to the second phase of the correlator system since Thakker's pulsar timing machine is proposed for the first phase of the GMRT when only 4 or 6 antennas are working and it should be made clear to him as early as possible what he can expect from the general electronics and what he has to build. Since the basic units of the correlator system, the FFT and the multiplier cards have been decided, it should be possible to make a schematic diagram showing the mounting of the cards and their interconnections and showing also where and how (if at all) the signals for the pulsar machines can be tapped. This would not only be extremely useful for designing the pulsar machines, but would also help in making clear the problems involved in mounting and connecting the correlator cards so that we can if necessary get more information, clarification or help.