Widths of IF filters required for spectral line observation with GMRT

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In a recent note from the GMRT Electronic Lab. it was proposed to have 5 IF filters in the GMRT going from 16 MHz to 1 MHz in binary steps, and the question was raised whether smaller IF bandwidths would be required for GMRT observations. The point of this note (based on discussions with K. Anantharamiah and Ravi Subrahmanya) is to show that much narrower bandwidths will be required for spectral observations.

In the normal mode of observing the GMRT FX correlator allows one to make upto 512 point FFT giving a frequency resolution equal to the input bandwidth divided by 256. By software reconfiguring the correlator it should be possible to increase the 512 point FFT to 2048, at the expense of polarisation information and perhaps by sacrificing a few antennas. However, since we do not yet have a clear picture of the proposed configuration of the GMRT correlator, we will ignore for the moment this possibility and proceed assuming only 512 point FFT is possible. The conclusions can be changed suitably if larger FFTs are possible.

Widths of radio frequency lines are typically about 10 km/s and allowing for extreme cases one need a resolution of 0.5 to 1 km/s to measure the line profiles. Taking 1 km/s as a working number, and using the relation

$$\Delta\nu/\nu = \Delta v/c$$

the required frequency resolution is 1 kHz/(wavelength in metres). At 327 MHz the frequency resolution is 1.1 kHz and to prevent aliasing in the FX correlator, the input baseband signal has to limited to a width of 256x1.1=281.5 kHz. For the detection of lines at 30 MHz, the bandwidth of the input signal has to be limited to 25.6 kHz.

Thus for spectral line observations at 30 MHz, one needs IF bandwidths of 25.6 kHz which is a factor 2^6 smaller than what has been proposed. We need an extra 6 binary steps in the IF bandwidth. If the FX correlator allows 2048 point FFTs, this 6 binary steps can be reduced to 4. If one wants to be very conservative and specifies that the velocity resolution should be 0.5 instead of 1 km/s, one needs an extra step.

An addititional point for discussion:

Previously (around Jan 1990) our thinking was that since the optical fibre link required ALCs with very small (millsec) time constants, the noise calibration signal would be demodulated and measured at the antenna itself using the full 16 MHz,and that the bandwidth of the IF would be limited just before the sampler of the correlator. When Anantharamiah came to Pune recently, he had pointed out that for spectral observations, the noise calibration should be done in the same band as the observtions, since otherwise it is not reliable. Because of this comment, consideration was being given to having 2 IF filters, one at the antenna, just before the first ALC and the total power detector and a second one just before the sample. Now that it seems possible to increase the time constant of the ALC before the optical fibre link to around 1s or so, (see Shivraj's note), one could do away with the first IF filter if one modulates the noise generator at a high enough frequency so that the modulation propagates through the fibre. Demodulation and measurement of the noise signal should be done after the second IF filter just before the sampler. This would imply some synchronisation between the modulation at the antenna and demodulation at the central station, which should not be a problem since this is required anyway for the Walsh function demodulation.