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Towards an Optimal Real-time Broadband RFI Filter for the Upgraded GMRT

Broadband Radio Frequency Interference (RFI) is one of the main reasons for corruption of astronomical data observed using the Upgraded GMRT (uGMRT) at frequencies below 700 MHz. A real-time RFI excision system, operating on Nyquist-sampled digital time-series per antenna and polarization, has been implemented as part of the GMRT Wideband Backend (GWB). The system, implemented on FPGA, computes robust standard deviation and detection threshold using Median-of-MAD (MoM) estimator. The RFI samples are replaced by digital noise samples. We describe the techniques for simultaneous acquisition of data with and without the filter for the interferometer and beamformer modes of uGMRT and present results from the tests. We show the effect of filtering on the signal-to-noise ratio, cross-correlation function and closure phase for the interferometric data. The system-level aspects and the tests carried out to fine-tune the filtering parameters would be described.

To understand the filtering performance on imaging, we carried out test observations on calibrator radio sources and extended sources from June 2018 to August 2019. Typically 1 – 5% of the samples (at 2.5ns time resolution) are found to be affected by broadband RFI filter during monsoon when the broadband RFI is stronger. Our offline data processing pipeline used for imaging utilizes the Common Astronomy Software Applications (CASA) software tasks customized for use with the uGMRT data. The spatial cross-correlation spectrum (visibilities) at short baselines show significant improvement in the form of the reduced standard deviation on the visibilities by factors of two or more and consequently improved image fidelity. We have also quantified the decorrelation introduced in the data due to the digital noise replacement. We are currently testing a strategy for optimizing the filter based on the engineering and imaging test results. The online RFI filtering system is planned to be released for the users of the uGMRT.