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Prototype Aperture Array Beamforming for the Expanded GMRT: Some Results from System-level Simulation and Raw Voltage Analysis

Kaushal D. Buch[(1)], Sreekar Sai Ranganathan[(2)], Bela S. Dixit[(1)], Ajithkumar B.[(1)], and Jayaram N. Chengalur.[(1)]
(1) Giant Metrewave Radio Telescope, NCRA-TIFR, Pune, 410504, Maharashtra, India, e-mail: kdbuch@gmrt.ncra.tifr.res.in; dixitbela@gmail.com; ajit@ncra.tifr.res.in, chengalu@ncra.tifr.res.in
(2) Indian Institute of Technology Madras, Chennai, India; e-mail: sreekarsr99@gmail.com

The expanded GMRT project [1] aims to look at future expansions to the existing GMRT. One of the aspects being pursued is focal plane array (FPA) beamforming to increase the field of view. We have built a prototype FPGA-based aperture array beamformer and have tested it in a free-space range using the 144-element FPA from ASTRON. In parallel, we carried out a system-level simulation of the aperture array beamformer by modelling the antenna array, RF systems, components of the test range, and the signal processing system. We have modelled practical non-idealities such as mutual coupling among antennas in the FPA, and show the performance of optimal beamforming strategies including the maxSNR method. We will describe the simulation model and show a comparison of simulation results with the experimental results from the FPGA-based beamformer. The simulation framework is designed such that any arbitrary beamforming algorithm can be directly plugged in without changing any other part of the system. This enables quick testing and development of optimal strategies before practical implementation. Since the simulation environment is modular, we can create different experiments by changing the antenna element response, array size, and noise levels as per our requirements.

The FPGA-based prototype beamformer digitizes 64 antenna inputs which are fed to a single Xilinx Virtex-5 FPGA on ROACH-1 board. We implemented a packetizer to send the digitized raw voltage data from these inputs to the acquisition system through 10 Gigabit Ethernet ports. This acquired data was used for studying the optimal beamforming algorithms and also for debugging the real-time beamforming carried out on the ROACH-1 board. We present results from raw voltage analysis carried out for radiation testing in the free-space test range. The tests carried out in this mode include multiple beamforming, beamsteering, nulling, on and off-source correlation, and maxSNR beamforming.

1. Patra et al., “The expanded Giant Metrewave Radio Telescope”, MNRAS, 483, 3007-3021, 2019.