A Highly Efficient and Compact Cross-Correlator for Synthetic Aperture Radiometry from GEO.

The lack of data on temperature and moisture distributions within highly dynamic weather formations such as cloud formations has motivated efforts directed at deploying microwave radiometers in geostationary earth orbit (GEO). The cloud penetrating ability of microwave radiometers, as compared to optical instruments, as well as the high temporal resolution made possible by GEO could fill this gap. Aperture synthesis by interferometry has been suggested as a solution to the very large aperture needed for reaching required image resolution at the relatively long wavelengths and distance to earth from GEO. We present a cross-correlator for the purpose of sampling and cross-correlating the signals in such a space-borne interferometric imager.

Two application specific integrated circuits (ASIC) were developed; an 8-channel comparator ASIC and a 64-channel digital cross-correlator ASIC. The comparator, used for digitizing of input signals, has features such as per-channel offset calibration, bias control pins, clock return and flip-flop sampling. The features are specifically useful in a cross correlator system where low power consumption is one of the main objectives targeted. The digital cross-correlator, which performs pair-wise cross-correlation between all inputs, also targeted low power/performance ratio.

Eight comparator and one cross-correlator ASIC were integrated on a single printed circuit board (PCB) together with clock distribution, power conditioning, programmable offset calibration and readout & control logic. The board measures 136 by 136 mm and weighs 135 g.

Both ASICs as well as the assembled PCB has been tested. The digital cross-correlator ASIC has shown a power/performance ratio of 0.13 mW/prod/GHz where top speeds of at least 2.5 GHz can be reached. Radiation testing hints at single event upset rates of around 1 upset/day in GEO and total ionizing dose tolerance of beyond 100 krad.

The comparator shows crosstalk isolation in the -50 dB range and common mode rejection of around 30 dB. Sample rates of 4.5 GS/s with a power consumption of 48 mW/channel or 1 GS/s with a power consumption of 17 mW/channel have been demonstrated.

The assembled board has been tested to perform cross-correlations and sampling at up to 1.6 GHz, currently limited by the clock distribution circuit. It has been tested within an interferometer system, successfully performing sun observations.

The correlator sets a new standard for portability as well as power/performance ratio. Test results as well as the compactness of the design demonstrate that interferometric imaging from GEO has now become a real possibility. A next generation cross-correlator ASIC has already been designed, doubling the number of input channels, and is expected to further reduce power dissipation.

Keywords: Cross-correlator, Low power, Integrated circuits, Microwave radiometer, Aperture Synthesis