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A digital single-dish backend for the new triple-band receiver at Metsähovi radio observatory

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Aalto University Metsähovi radio observatory operates a 14-m radio telescope that currently uses mainly 22 and 37 GHz receivers for single-dish monitoring of active galactic nuclei and the Sun. In the near future, a major upgrade is expected through a new triple-band receiver designed and built by the Max-Planck institute für Radioastronomie that is expected to arrive in late 2025. It will be capable of observing simultaneously at three wide frequency bands in full polarization: K (18−26 GHz), Q (34−50 GHz), W1 (80−96 GHz), and W2 (100−116 GHz). This setup allows us to observe, to our knowledge, the widest instantaneous bandwidth for single-dish observations in the world, greatly enhancing the sensitivity of the telescope. Here we discuss the initial steps towards the implementation of a digital polarization backend to sample and process the wide bandwidth.

The implementation of the backend is achieved through the utilization of the Radio Frequency System on Chip (RFSoC) boards with fast samplers to digitize the radio signal from the receiver, and carry out the signal conditioning (filtering, calibration) in the FPGA part of the board. The firmware design utilized the CASPER (Collaboration for Astronomy Signal Processing and Electronics Research) tools, making it easy to test and modify. The output of the correlation polarimeter are the auto- and cross-correlation products of the linear polarizations over the available bandwidth in the backend.

As a first step, we are producing a prototype design that we can test using individual RFSoC boards. We have successfully implemented and tested the simple correlator design on a ZCU111 (Gen-1) RFSoc board using tone signals and partially correlated noise. Next we will test compensation of analog IQ and interleaving errors. The goal is to process two 8 GHz wide IF bands within one RFSoC. In this contribution, we will show our initial results from the prototype design and the steps towards the implementation of the full backend.

References

[1] Metsähovi radio telescope current receivers: https://www.aalto.fi/en/services/metsahovis-main-receivers