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Sparrow: A digital receiver designed for radio cosmology experiments

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One of the critical building blocks of any radio astronomy instrument, including those designed to observe the Cosmic Dawn and Epoch of Reionization, is the digital backend, a system that converts the analog signals into either synchronized packets or performs some "F-step" in order to output spectral (channelized) data prior to further analysis. A good example of such a system is given in [1]. This processing is often undertaken after some lengthy analog signal transport from the antenna. For these sensitive experiments, cable reflections and temperature effects are a real concern, not easily mitigated unless digitization at the antenna can be permitted. Whilst higher frequency dish-based instruments often use digitization at the feed (such as MeetKAT), the general perception is that this is complicated and costly to implement at low frequencies.

With this in mind, we have designed a novel low-cost data-acquisition platform that can digitize a pair of analog inputs at up to 400MHz of bandwidth and 12 bits resolution. The platform is designed to output data over digital fibre using multiple 10Gb/s Ethernet links. It also offers a small form-factor in order to slot directly inside the antenna and uses the White Rabbit protocol to synchronize the sampling times of multiple boards. This modular platform can be used in a *large-N* arrays or for single antenna experiments. Furthermore, we have leveraged the use of ultra-quiet DC power converters, to dramatically reduce radiated and conducted emission on the board, removing the risk of self-RFI. We hope to develop this platform with a basic software package offering plug-and-play functionality to the radio Cosmology community.

1. J. Hickish, N. Razavi-Ghods et al., "A digital correlator upgrade for the Arcminute MicroKelvin Imager," *MNRAS*, vol. 475, no. 4, pp. 5677–5687, Apr. 2018, doi: 10.1093/mnras/sty074.