Instrumentation and Radiometry for the REACH 21cm Experiment

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The Radio Experiment for the Analysis of Cosmic Hydrogen (REACH) [1] has been designed to measure the impact on the 21-cm line of neutral hydrogen in the intergalactic medium (IGM) arising from X-ray and UV emission from the first bright objects. It is a "global" experiment focused on detecting the spatial and time averaged 21-cm signal which is four to five orders of magnitude smaller than the bright foregrounds at frequencies in the region of 50-200MHz. As such, the experiment relies on unprecedented levels of instrumental calibration which can help remove systematics that would ordinarily hinder such a measurement.

The radiometer system described consist of high quality RF components such as a well matched LNA, switching electronics and calibration loads to enable measurement of so-called noise wave parameters which are linear analogues of standardized noise parameters. These parameters are used to describe the noise generated and reflected by the first amplifier down to *mK* levels.

The REACH radiometer relies on a fast Bayesian pipeline [2] to determine physical calibration coefficients which can describe the systematics. The calibration system uses several critical sources at the input of the system and takes measurements of reflection coefficients, power spectral densities and temperature. The system automates this process and when used in the field, could calibrate the absolute temperature measured by the antenna down to sub-kelvin levels across a wide bandwidth. A major advantage of this approach is that the uncertainties in the measurement system can be properly modelled. A block diagram of the REACH radiometer is shown in Figure 1.

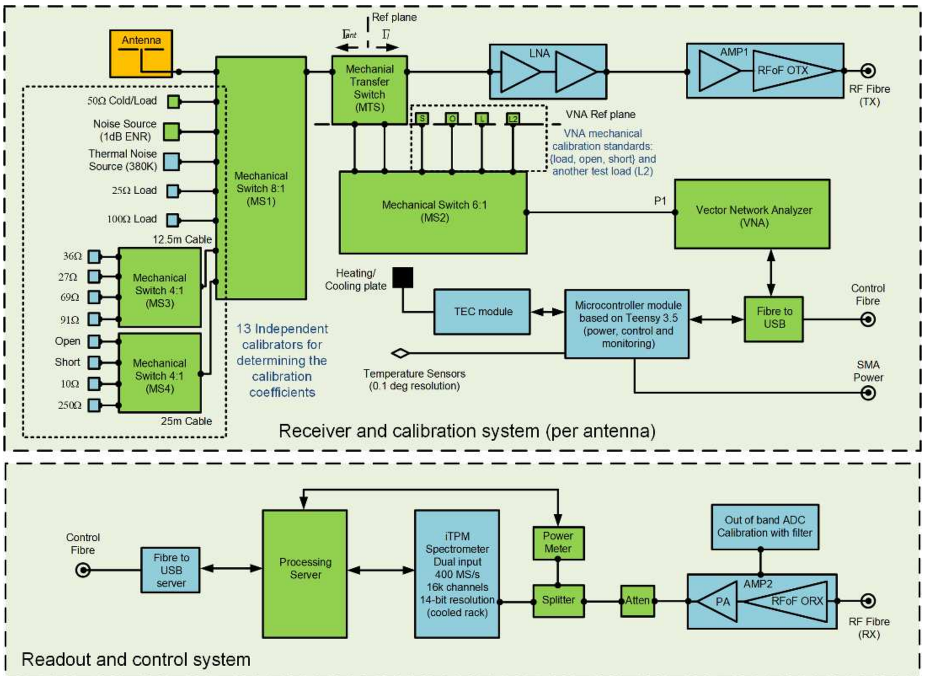

Figure 1. REACH receiver, calibration, and readout system.

1. E. de Lera Acedo, "REACH: Radio Experiment for the Analysis of Cosmic Hydrogen," ICEAA 2019, pp. 0626-0629, Sep. 2019, doi: 10.1109/ICEAA.2019.8879199.
2. I. L. V. Roque, W. J. Handley, and N. Razavi-Ghods, "Bayesian noise wave calibration for 21-cm global experiments," MNRAS, vol. 505, no. 2, pp. 2638–2646, Aug. 2021, doi: 10.1093/mnras/stab1453.