Gain Stabilization Techniques for PAPER

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PAPER (Precision Array to Probe the Epoch of Reionization) is a low frequency array operating over the frequency range of 120-180 MHz that is being developed to detect the statistical fluctuations in the Neutral Hydrogen (HI) 21cm signal of the Epoch of Reionization (EoR) and to detect the very rare, largest scale structures towards the end of reionization. Currently, a 16-element array located at the Galford meadow site in Green Bank, WV is operational and serves as the prototype for the final instrument consisting of 128 elements to be located in Western Australia. Each element of the array consists of a sleeved dipole antenna, a pseudo-differential amplifier, which is connected at the feed point of the antenna, a 75 ohm RG-6/U coaxial cable and a receiver board consisting of gain and filter stages.

One of the major goals of this instrument is to achieve excellent instrumentation stability with sensitivity at mK level, which is necessary in order to detect the faint EoR signal. Achieving mK level sensitivity demands that all instrument components and sub-systems are designed and constructed with the utmost care so that systematic errors can be managed through either mitigation or modeling techniques. The receiver gain stability plays an important role in getting reliable observational data. The receiver gain is mainly affected by the ambient temperature. Our lab experiments have verified that the gain of the receiver board and that of the amplifier depends monotonically on temperature and is repeatable. In order to maintain a constant physical temperature of the receivers, which are located in the central electronics hut, a temperature stabilized box with RFI shielded enclosure is being developed. This temperature control box utilizes a PELTIER cooler.

We plan to monitor the physical temperature of each amplifier in the array and apply gain corrections in post processing. We have adopted an adaptive canceling approach to correct for the unwanted gain variations. We plan a series of experiments to precisely measure the total power out of the amplifier in a controlled environment in order to analyze the system stability when active temperature monitoring is applied. We present the software simulations and the preliminary results of gain stabilization using adaptive canceling technique.