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Low Temperature Front-End for Weak Signal Detection in Radio Astronomy

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Radio astronomy faces common challenges: the signals from cosmic radio sources are extremely weak, and their observation is highly susceptible to noise and interference along the propagation paths. These factors significantly increase the difficulty of detection and identification. To address the need for high-throughput weak signal detection in radio astronomy, a low temperature front-end for weak signal receiving is currently under development. This front-end is part of a software-hardware collaborative real-time computing system designed specifically for the detection of the high-throughput weak signals.

The target weak signals must have a sufficient signal-to-noise ratio before entering the digital system to enable subsequent high-throughput computing processes. Therefore, the front-end analog signal receiving system must exhibit very low noise when amplifying weak signals to achieve high-sensitivity receiving and processing. Low noise amplifier arrays are employed to design the front end for weak signal detection, ensuring extremely low-noise amplification of the target signals prior to processing it. The front-end unit is designed, and the low-temperature circuit effects of semiconductor materials is leveraged to design RF circuits with extremely low noise, thereby realizing extremely low-noise amplification of weak signals. The low-temperature environment is also utilized to mitigate the noise impact of the analog signal receiving link.

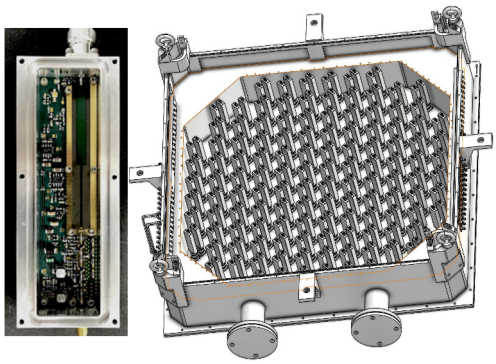

Figure 1. Low temperautre front end array and unit

We have investigated the low-temperature behavior of semiconductor devices, successfully designed the amplifier-unit circuit, and constructed the overall implementation scheme of the front-end system.

1. J. Shi and S. Weinreb, “Room-Temperature Low-Noise Amplifier With 11-K Average Noise From 0.6 to 2 GHz,” *IEEE Microwave and Wireless Technology Letters*, **33**, 11, Nov. 2023, pp. 1540-1543, doi: 10.1109/LMWT.2023.3315269.