The Metrewavelength Sky
ASI Conference Series, 2014, Vol. 13, pp 379 – 380
Edited by J. N. Chengalur & Y. Gupta

Design of an integrated front end receiver for array of precision spectrometers for epoch of recombination

Agaram Raghunathan* and R. Somashekar
Raman Research Institute, C.V. Raman Avenue, Sadashivanagar Bangalore 560080, India

Abstract. APSERA is an array of precision spectrometers being built for the detection of Epoch of RecombinAtion (ERA) signal. This enables accurate determination of some key parameters of the universe and provide better understanding of its thermal history. Observationally this task is challenging since the estimated magnitude of the signal is 8 to 9 orders weaker than CMBR temperature. To detect such a signal, a radio receiver should have low noise, high gain and high dynamic range characteristics with a ripple free passband. A compact, uncooled LNA having a noise figure less than a dB and ripple free gain and return loss characteristics is being designed in the frequency range 2-4 GHz for APSERA. We describe in the present paper, the simulation and protying experience along with the results obtained.

Keywords : Low-Noise amplifier

1. Introduction

Epoch of Recombination (ERA) refers to the period in cosmological evolution of the universe when charged particles recombined to form neutral atoms like hydrogen and helium. The photons released during this process are expected to alter the CMBR temperature resulting in the fluctuations in its spectrum. These fluctuations are red-shifted due to the cosmological expansion and ought to be observable at cm and mm wavelengths.The magnitude of these fluctuations is 10^{-9} K several orders of magnitude weaker than the CMBR temperature. An array of precision spectrometeres is being built to detect these fluctuations. In the present paper, we discuss the design of the low-noise amplifier for APSERA in section II and present priliminary results obtained in section III.

*email: raghu@rri.res.in,som@rri.res.in

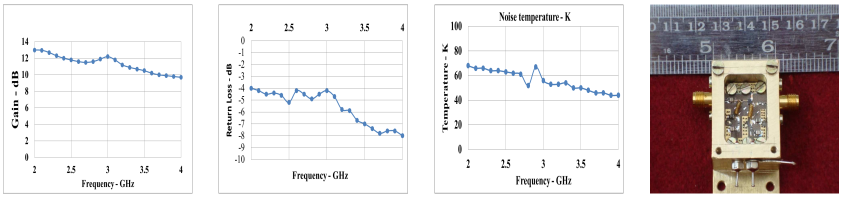

Figure 1. Gain,Return loss and Noise temperature characteristics of LNA and photograph of prototype LNA.

2. Design of Low-Noise amplifier

Detection of cosmological signal such as ERA requires a receiver having a low-noise, high dynamic range and low intermodulation products. In addition, the internal reflections of receiver noise also should vary smoothly as a function of frequency since they predominantly produce ripples in the pass-band of the operating frequency range. This requires minimum path length (a small fraction of the wavelength corresponding to the operating bandwidth) between the antenna and the low-noise amplifier. However, for better impedance match and low noise performance, a wider matching section is required. Meeting these conflicting requirements simultaneously,we have designed a single stage low noise amplifier using a low noise NE5310 hetero junction FET in the frequency range 2-4 GHz. Short transmission lines were used while keeping in mind the overall dimension of the amplifier. They were shaped appropriately to counteract the adverse effect caused by the reduction of their lengths on the noise and impedance characteristics. Simulation was carried out using Genesys- an RF and microwave simulation software and circuit elements were optimized to meet the design requirements.Co-simulation was performed using momentum analysis in order to take into effect the influence of foot prints of passive elements on the circuit performance.

3. Measurements and results

The prototype amplifier built was characterized for its input return loss and gain using scalar network analyser and noise figure meter. The amplifier has a gain of about 12 dB and a return loss of about 4 dB at the band centre frequency with a linear variation across the band (Refer Fig.1). The minimum noise temperature achieved is about 50 K. The shift in the frequency corresponding to the min. noise temperature compared to simulation results is attributed to the tolerance in the circuit elements and parasitic of the printed circuit board.

4. Acknowledgement

The authors thank Sandhya, K.B. Raghavendra Rao and gopal of Radio Astronomy laboratory of the Raman Researach Instittute for assisting in the characterization of the low-noise amplifier. The mechanical group headed by Durai fabricated the LNA chassis.