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Low-cost, Ultra-wideband, Differential Low-Noise Amplifier for Interferometric Radio Telescopes

Da Costa S.*(1), Vanderlinde K.(1)(2)
(1) David A. Dunlap Department of Astronomy and Astrophysics, University of Toronto, Toronto, Canada
(2) Dunlap Institute of Astronomy and Astrophysics, University of Toronto, Toronto, Canada

Many feeds used in radio astronomy are inherently differential, naturally providing a 100 Ω input impedance. Conventional designs rely on lossy baluns to match standard 50 Ω single-ended receiver systems. Balun losses are becoming significant given the increasing sensitivity requirements for next-generation radio telescopes. Combined with the signal attenuation and cost associated with traditional 50 Ω coaxial cables, these challenges are driving interest in differential signal transmission techniques [1]. Through the use of a differential amplifier, a pre-amplification balun is no longer needed, making differential signal components an intriguing alternative to conventional single-ended options.

We present a differential low-noise amplifier (LNA) design that is low-cost and ultra-wideband with a noise figure less than 0.3 dB across a 10:1 bandwidth. A differential topology has been implemented using grounded coplanar waveguide with single-ended surface-mount components. This is made possible by amplifying each polarity of the differential signal separately against a common ground. The design is cost effective at approximately $15 USD per LNA, and the exclusive use of commercially available surface-mount components facilitates mass production. The amplifier is multi-staged, making use of a Qorvo QPL9547 LNA as the first stage, resulting in a compact design measuring 3 cm by 5 cm, with a minimum noise figure of 0.23 dB and noise match of 135 Ω at 900 MHz.

Through in-lab testing, gains above 30 dB and noise temperatures below 30 K have been obtained across a 125-1625 MHz frequency range using a constant 130 Ω differential load. To study applications of the amplifier, it was installed on a Vivaldi feed which measures a differential impedance close to 110 Ω across its operating bandwidth of 300-1500 MHz [2]. The Vivaldi feed paired with the differential LNA was tested at ambient temperature, on-sky, using the Hot-Cold Testing Facility located at the Dominion Radio Astrophysical Observatory [3]. Results demonstrate noise temperatures below 40 K across the 300-1500 MHz band and as low as 25 K in associated sub-bands.

Relevant results and recent progress from the design and testing of the differential LNA will be presented.

References

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