

Wide-band Hybrid Single-Ended and Differential LNA Designs Using GaAs pHEMTs and Comparison with In-house InP pHEMT Based LNA Design

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Abstract. This work presents single-ended and differential MIC LNA designs to meet the requirements for the Square Kilometre Array (SKA) at the low frequency band ranging from 0.3-1.0 GHz Hall (2004). A series of single-ended MIC LNAs on 50Ω system, with various topologies have been designed to study their NF, gain, SWR, power and stability characteristics. Subsequently, differential LNAs using commercial GaAs pHEMTs were designed and optimised for the Orthogonal Ring Antenna (ORA); the proposed antennas for the phased array of the SKA. Test structures have been developed to measure the four-port differential LNAs using two-port Vector Network Analyser (VNA) and Noise Figure Analyser (NFA). The measurement techniques were presented in Abidi & Leete (1999); Belostotski & Haslett (2008). The above results were then compared with the low-power double stage differential to single-ended MIC LNA design Arshad et al. (2009) developed using an in-house fabricated novel InGaAs/InAlAs/InP pHEMTs Bouloukou et al. (2006).

1. Introduction

This work presents LNA designs for the low frequency band of SKA. The optimum goal of this work is to achieve a low-power, low noise differential to single-ended amplifier using commercially available GaAs pHEMTs as well as in-house developed InP based pHEMTs. The first design discussed here is a single-ended MIC LNA that has been fabricated and measured. Secondly a differential to single-ended MIC LNA design using commercial GaAs pHEMTs is presented which is further compared to a similar topology LNA realised using InP based pHEMTs.

2. Hybrid single-ended MIC LNA

The hybrid single-ended MIC LNA was designed and optimised at frequency range of 0.5-2GHz. The MIC LNA using GaAs transistors were fabricated and measured using in-house facilities. The simulated gain and Noise Figure are compared with the measured data. Results show that both are in acceptable tolerance. The measured Noise Figure of < 0.7dB is achieved from 0.5-1.0 GHz as shown in Fig 1.

At the same frequency, the measured gain is in range of 15dB to 20dB as depicted in Fig 2. The design demonstrates stability without oscillation over entire desired frequency range. The power consumption of this LNA is 280mW.

3. Differential to Single-Ended LNA Design Using Commercial GaAs pHEMTs

In this double stage design, commercial GaAs transistors from Avago Technologies were used. Transistor ATF_54143 (E-mode pHEMT) were used as amplifiers while transistor

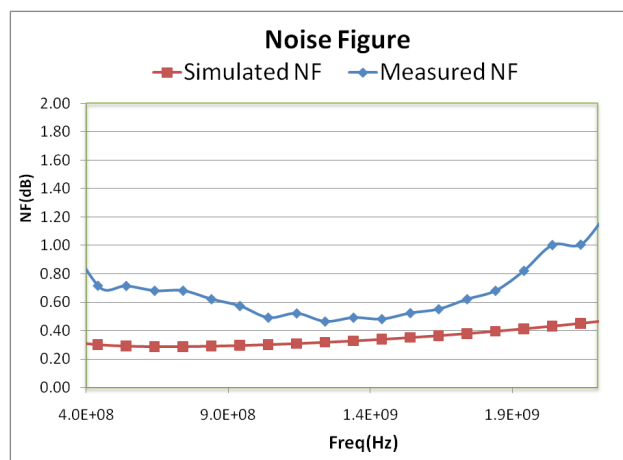


Fig. 1: Simulated and Measured NF on single-ended single stage MIC LNA

ATF_35143 (D-mode pHEMT) were used as active loads. Both transistors have 800μm gate width.

The first stage is a Differential to Single-Ended conversion stage using self biased topology while, the second stage act as a gain plus stability boosting stage. The design is optimized for the band 0.3-1.0GHz.

The simulation results on Noise Figure and gain response are presented in Fig 3 and Fig 4, respectively.

The figures show that NF and NFmin were both < 0.5dB for the frequency band of interest. The simulations predict an unconditionally stable design consuming 650mW of power.

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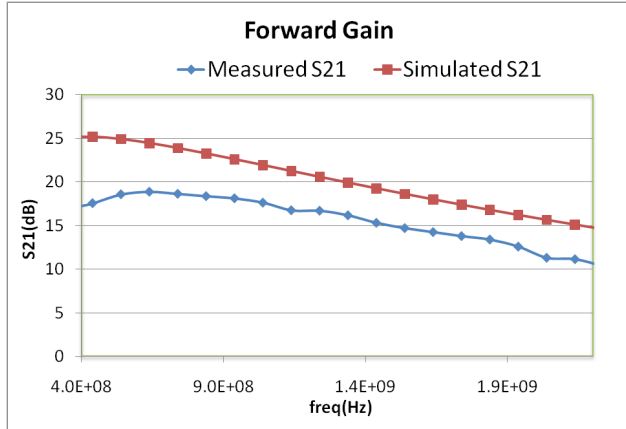


Fig. 2: Simulated and measured forward gain (S21) of single-ended single stage MIC LNA

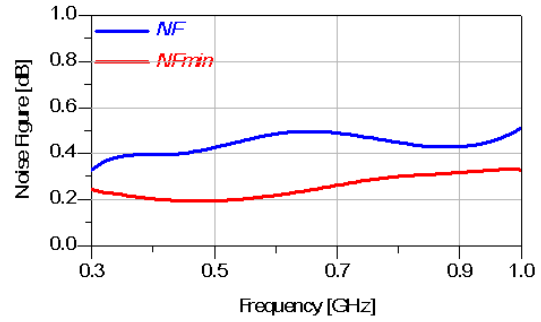


Fig. 5: Simulated NF and NFmin of in-house InP pHEMT

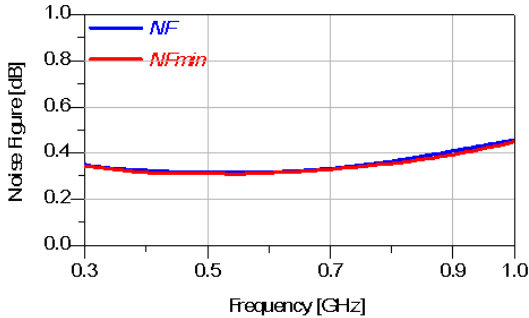


Fig. 3: Simulated NF and NFmin for differential LNA

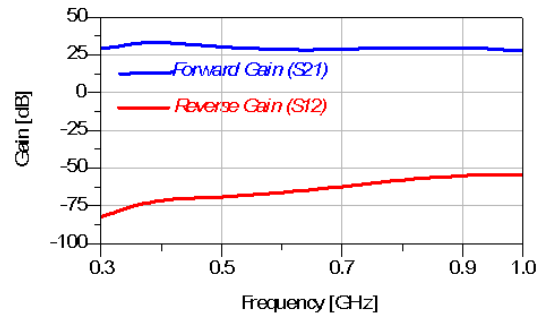


Fig. 6: Simulated forward (S21) and reverse (S12) gains of in-house InP pHEMT

4. Differential To Single-Ended LNA Design Using In-House InP pHEMTs

In this part, the LNA is designed based on in-house InP pHEMT with varying gate width. However, only 4x200 μ m device results are presented.

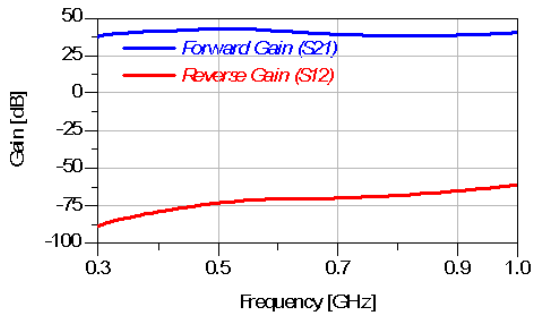


Fig. 4: Simulated forward (S21) and reverse (S12) gain of the differential LNA

For comparison purposed, the topology is similar to that of the differential LNA using Commercial GaAs pHEMTs. The designs are optimised for low noise and low power performance.

The Noise Figure shown in Fig 5 were as good as the previous LNA where both were < 0.5dB over the entire frequency range considered.

The LNA gains shown in Fig 6 were comparable with the LNA using commercial GaAs pHEMTs.

In this design the total power consumption was 125mW which is far less than the previous GaAs LNA design by a factor of ~ 5.

5. Conclusions

The work presented here has highlighted and demonstrated designs and measurements on differential to single-ended LNA design. The InP transistor designs have shown comparable or lower Noise Figure, NFmin and gain with superior power consumption as compared to GaAs based designs by a factor of ~ 5.

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