UWB-LNA with Resistive Feedback and Shunt Peaking using 0.18μm

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Abstract— ***Ultra-wideband (UWB) technology is used for short range high speed wireless interconnection systems. In wireless receivers, noise figure is one the parameter that needs while designing LNA. In this paper, inductive degeneration LNA is proposed for UWB applications using resistive feedback and shunt inductive peaking techniques. LNA without and with peaking networks are designed in wideband amplifiers. The resistive shunt feedback provides wideband input matching and shunt inductive peaking provides small noise figure. The proposed work is implemented and simulated in 0.18μm CMOS technology for UWB frequency range. Noise figure at 3.1 GHz frequency is 22.4dB for resistive feedback without shunt inductive peaking LNA and 19.9 dB for resistive feedback with shunt inductive peaking LNA.***

Index Terms— *Ultra wideband (UWB), Low noise amplifier (LNA), inductive degeneration, resistive shunt feedback, Shunt inductive peaking.*

I. INTRODUCTION

Wireless technology has become an inevitable part of our life. RF technology is important for the applications that require high operational frequencies which allow both large numbers of independent channels as well as significant available bandwidth per-channel for high speed communication. RF circuits and transceivers must deal with numerous trade-offs. Demand for higher performance, lower cost and greater functionality are the reasons that cause RF design challenges. In RF receiver section, low noise amplifier (LNA) plays a significant role[1][2]. By the time it reaches the receiver antenna, the amplitude of desired signals will be poor. Then the LNA will boost the amplitude of such poor signals and hence rest of the receiver chain can drive them without introducing much interference. In comparison with the boosted signal amplitude, any other interference is made so small. Thereby, maintaining strength and robustness of the signal.

The main design parameters of LNA are Noise Figure (NF), Gain, Input Return Loss, Impedance matching, Power consumption, Bandwidth, Stability, and Linearity etc. Ultra-Wideband (UWB) provides an interesting new technology for short range ultra-high speed communications in the frequency band 3.1 GHz to 10.6GHz. Using this technology, it is possible to transmit more 100 megabits of data per second within a short distance. The benefits of UWB cover minimum power utilization, immunity for multi-path fading etc. The low power transmission of the UWB is the key characteristic that might allow it to co-occur with other standards for wireless networking that includes 802.11 LAN, 802.16 MAN and WAN. According to high UWB requirements, the interest in designing appropriate UWB devices has gone up. Especially, the receiver part has come in the centre of attention and many UWB front-end have been designed so far. Design of a UWB front end LNA involves many challenges [3][4][5].

Conventional methods provide restricted bandwidth enhancements to convene the vital requirements of faster implementations and applications without higher power utilization and design complexity. LNA design should meet different challenges and all the design parameters are equally important and always independent on each others. This work emphasizes on the design specifications, performance metrics, tradeoffs of LNA design. A basic LNA of inductive degeneration topology is initially designed and resistive feedback has been applied to generate shunt resistive feedback LNA which yields a minimum noise figure comparatively. For bandwidth extension, inductive shunt peaking technique is employed on shunt resistive feedback LNA. In this work, we have an ultra wideband low-noise amplifier design which employs shunt inductive peaking on LNA in 0.18μm CMOS technology.

II. SYSTEM DESCRIPTION

A. Design Specifications

The field of UWB technology is of high demand these days because of the huge desire for data rates and speed which it can provide. According to high UWB requirements, the interest in designing appropriate WB devices has increased. Especially, the receiver part has come in the centre of attention and many UWB front-end have been designed in the past few years. LNA is considered the backbone of the UWB receiver. The design specifications includes frequency band of operation, desired noise figure (NF), selection of topology, technology used and gain requirements. These specifications determine the LNA design and hence choosing specifications is a very crucial step in RF receiver design.

III. 3.1-5GHZ RF UWB LNA DESIGN

The design and implementation steps followed in the design and simulation of two different LNAs are mentioned below. Two topologies such as common source degeneration [15] [16] [17] and resistive feedback structure [18] [19] are simulated. For the study, these UWB LNA's are compared.

A. Design Of Shunt Resistive Feedback LNA

Cascode inductive degeneration LNA has been initially designed. To improve noise figure (NF) and stability, a resistive feedback is included. The shunt resistive feedback is introduced as shown in Figure (1) and is simulated for UWB frequency range. It has good NF and the LNA is stable in frequency band 3.1-5GHz lower UWB band.

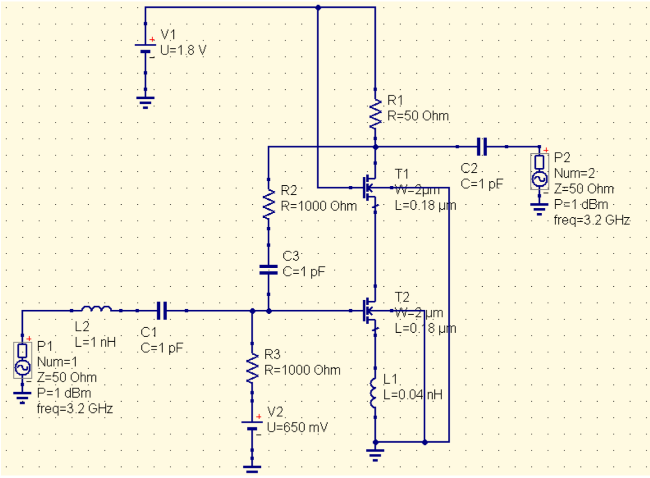

Figure (1): Schematic of shunt resistance feedback without shunt inductive peaking LNA

B. *Design of LNA With shunt inductive peaking*

By connecting the inductor in series with the load resistance, we might achieve better performance than with the series peaking. The circuit is a standard common source topology with an inductor in series with the resistor. The inductor has increasing impedance with increasing frequency, by introducing a zero in the transfer function. This helps offset the decreasing impedance introduced by the capacitance, leaving the net impedance more or less steady throughout a wider frequency range.

However, because of noise figure degradation, smaller RF is an undesirable approach. Therefore, high Av allows for not only wider bandwidth, but also lower noise figure. However, in CMOS technology, because of poor transconductance, higher Av requires a large DC current. We want a non-impedance stable load for the compensation of gain loss because of the capacitive parasitics. In a modern process with low supply voltage, a pure inductive load would be an alternative to the combined resistive and inductive load shown in Figure (2). The lower Q factor of on chip inductors is actually an advantage and reduces the need for series resistor. Many bandwidth enhancers make use of both series peaking and shunt peaking techniques [11]. Shunt peaking bandwidth extension technique is added into shunt resistive feedback LNA topology and is analyzed using EDA tools.

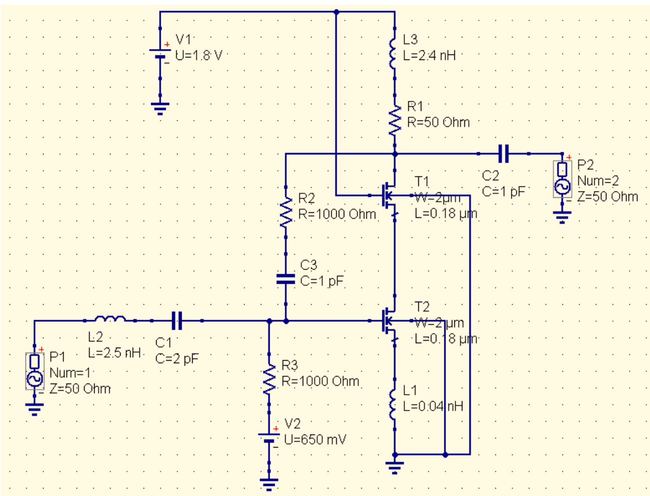

Figure (2): Schematic of shunt resistance feedback with shunt inductive peaking LNA

The LNA with shunt resistive feedback and shunt peaking technique can be chosen as a better design with noise figure reduction for UWB receiver, compared to LNA with only shunt resistive feedback [11].

IV. DESIGN IMPLEMENTATION AND RESULTS

A. *Simulation of Shunt Resistive Feedback LNA*

Shunt Feedback LNA circuit is simulated. The S-parameter analysis is done and the noise figure is obtained. The basic resistive shunt feedback LNA gives a comparatively good gain, poor noise figure and the circuit is stable. But the bandwidth is very less which can be treated as a limitation of such type of LNAs.

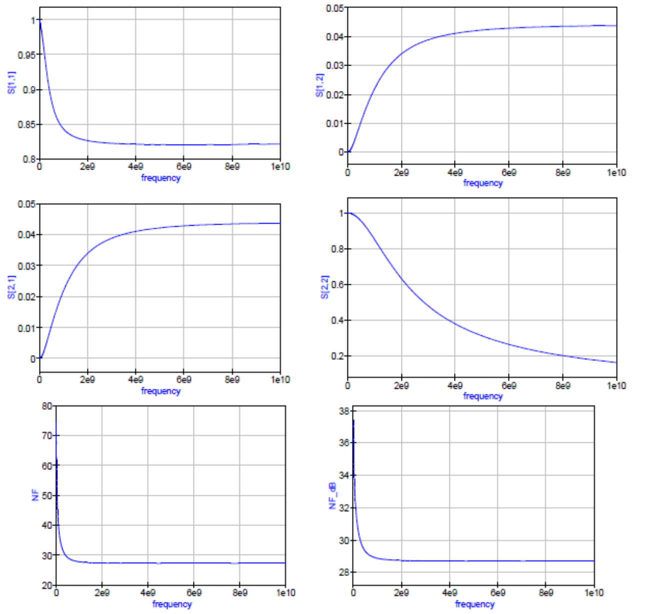

Figure (3): Simulation results of LNA without shunt inductive peaking (S11, S12, S21, S22, NF, NFmin)

B. *Simulation Of Shunt Resistive Feedback LNA with Shunt Peaking Technique*

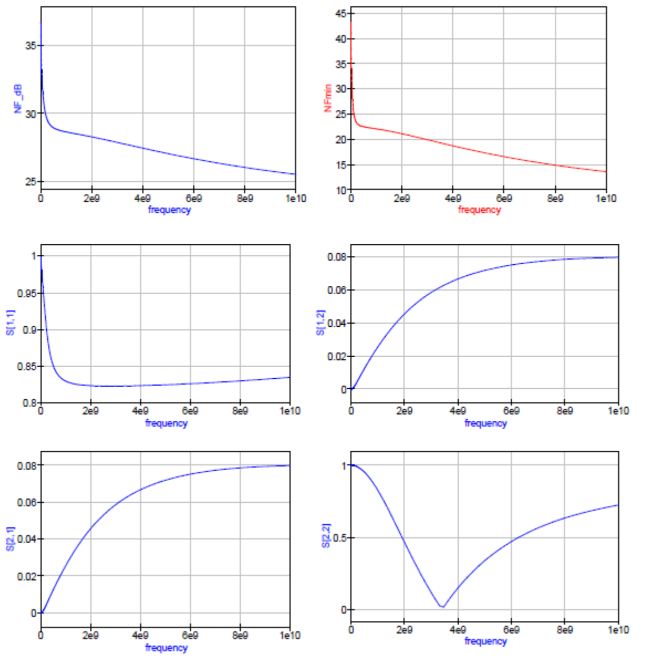

Figure (4): Simulation results of LNA with shunt inductive peaking (NF, NFmin, S11, S12, S21, S22)

V. Comparison Of Simulated Results

LNA topology	*NFmin dB(At 5GHz)*	*S11 dB*	*S12 dB*	*S21 dB*	*S22 dB*
Resistive shunt Feedback LNA *LNA-1*	*22.4*	*-1.72*	*-27.5*	*-27.5*	*-10.17*
Shunt Peaking LNA with Resistive feedback LNA-2	*17.5*	*-1.68*	*-22.9*	*-22.9*	*-9.37*

VI. Conclusion

UWB LNAs with resistive feedback and shunt inductive peaking techniques that can be applied to the lower band (3.1-5GHz) UWB system are presented. LNA of resistive shunt feedback topology which has a reduction in NF compared to basic LNA topology using cascode inductive degeneration which is initially designed. A new technique using shunt inductive peaking has been incorporated into the resistive feedback LNA topology. In LNA topology with shunt resistance feedback, the wideband characteristics are obtained by utilizing the feedback resistor as a component to reduce the Q-factor of the narrowband amplifier input impedance. The proposed topologies are applied for 3.1-5 GHz UWB amplifier implementation in 180nm CMOS technology. The shunt resistive feedback LNA has the minimum NF 22.4dB. The designed LNA with shunt inductive peaking achieves the minimum NF 17.5dB at 5GHz frequency.

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