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2-8GHz, 1.6dB Integrated CMOS LNA Using Image network technique for 4G LTE application

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***Abstract* - The paper proposed 2-8GHz wide bandwidth CMOS low noise amplifier using image network technique for 4G LTE application. The proposed circuit are made by cascade stage of CMOS common gate-common source (CG-CS), input and output matching network. The novel image network technique in the proposed circuit investigates inverse impedance at the output and provides higher wideband and low noise figure. These two most important observed parameters overcome the problem of high speed data rate in the 4G LTE application. The proposed circuit is implemented and analyzed using RF simulator ADS. Chip fabrication and measurement is done by using TSMC 45nm commercial design Kit. The results achieved minimum noise figure of 1.6dB with highest gain of 18dB. Experimental and simulated results are made good agreement with each other.**

***Index Terms*—CMOS (Complementary metal oxide semiconductor), Low noise amplifier (LNA), Noise figure, transceiver).**

INTRODUCTION

Recently, researches and developments have been The explosive growth in the domain of wireless communication due to rapid evolution of a series standard generations from the traditional Global System for Mobile Communication (GSM) to 4G Long Term Evolution (LTE) standard and still growing. Consequently, for multiple support standards, wireless radio systems needed to be promoted. However miniaturized integrated circuit development in mobile communication are combined with continuous improvement in semiconductor technology fields. Low noise amplifier (LNA) is one of the most critical components of any wireless communication systems. It is usually placed after the bandpass filter or often directly connected to the antenna at the receiver front end side of radio base station transceivers [1-4]. Among all the challenges in the design of integrated active antenna with low noise amplifier, the most crucial aspects are high gain, low signal attenuation, minimum noise figure and wide bandwidth.

In [5], considered popular familiar topologies of CMOS LNA with mathematical approach and provides a forward gain of 22dB with a noise figure (NF) of 3.5dB. The CMOS LNA using reconfigurable input matching network achieved gain of 10-14dB with NF of 3.2-3.7dB within the band range

of 1.9-2.4GHz [6]. A wideband CMOS LNA with varactor tuned input matching for WLAN/WiMAX applications covering 2.3-2.7GHz band where a gain of 26.2dB is obtained [7]. In the analysis of LNA with antenna co-design for UWB system achieved 13dB maximum gain for band range of 3.1-5.1GHz [8]. In the design of LNAs using parallel to series resonant matching network in between common gate and common source stage where dual band operation is achieved that offers the maximum operating frequencies in the ranges of 3.1-10.3GHz and 4.3-29.3GHz with the respective gains of 9.6-12.71dB and 8.25-1.65dB while noise figures are 2.5-3.9dB and 4.3-5.8dB [9].

In this paper, wideband CMOS LNA using image network technique for 4G LTE application is proposed. The proposed circuit achieves minimum almost flat noise figure of 1.6dB with highest gain of 18dB. The organization of paper is follows as: section II describes design and its consideration in detail while results and discussion is given in section III. Finally, conclusion is followed in section IV.

II. DESIGN AND CONSIDERATION

This subsection includes cascade CG-CS LNA design whose schematic is shown in fig1. The schematic LNA design consists of CG stage as a first stage, T-network as intermediate stage and CS as last stage.

The input impedance of T-network with CG topology is calculated as (47.5+j2.9) Ω. While using smith chart analysis output impedance of T-network is now calculated as (46+j4.52) Ω and which is closely matched to input impedance of CS topology and which is shown in fig1. The input impedance is observed

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using smith chart plot and i.e. (46.5+j3.9) Ω at 4GHz when Z_o is calculated as 50Ω. The same approach is applied in the CS topology where image network is superimposed for achieving the performance parameters of LNA such as broad bandwidth, higher gain, lower noise figure etc. It is possible to achieve those parameters with follow some design procedure steps given below:

Step (1): Device size selection of CG and CS i.e. essential which provides matching impedance between both topology. Addition factor is to reduce noise by selecting higher trans conductance of M1 and M2 such that $\frac{1}{G_m}$ is goes smaller than 50Ω therefore M2 and M2' are able to provide inverse impedance. Moreover, impedance contributed by second stage will improve the matching.

Step (2): Choose appropriate inductor values L_s and L_s' or L_{s1} and L_{s1}'which resonates with the gate-source capacitance of MOSFETs (M1 and M1' or M2 and M2') at the center of the band.

Step (3): Adjust T-network position with matched impedance between CG and CS topology where RF signal in the form of power will make appropriate path from input to output topology.

Step (4): Select output impedance which should be suitable for matching between output of CS topology and RF port.

Step (5): Calculate impedance at each node with the smith chart analysis such that matching between each topology could be easier.

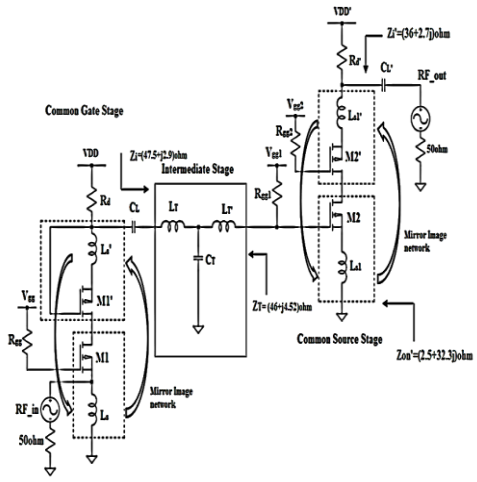

Fig. 1 Proposed schematic of cascade CG-CS topology

RESULTS AND DISCUSSION

With follow steps from section2, it is observed that inverse impedance of CG-CS LNA design is (36+j2.7) Ω at 4GHz when Z_o is calculated as 42Ω. The impedance Z_o is calculated from return loss which is in fractional term $\left(\frac{68.0}{1.62}\right)$. This impedance made close agreement with the output impedance i.e. (38.3+j0) Ω at 4GHz of RF port and provides wide bandwidth as per the desired frequency of operation. Fig. 2 shows microchip photograph for CG-CS LNA design which is fabricated using 0.65µm RF mixed signal TSMC process including all testing pads and its calculated chip area is 0.4*0.2µm^2. The RF MOSFET as BSIM (Berkeley Short-channel IGFET Model) is used for implementation and fabrication of LNA design. The performance is investigating with s-parameter analysis with measured and simulated results which are shown in fig3. From this figure, it is clear seen that resonating 4GHz band with fractional bandwidth of 120% is achieved ranging from 2GHz to 8GHz. The highest gain about 18dB is obtained at the resonant frequency which fulfill the requirement of 4G spectrum at high speed data rate.

Fig. 2 Microchip photograph of proposed schematic

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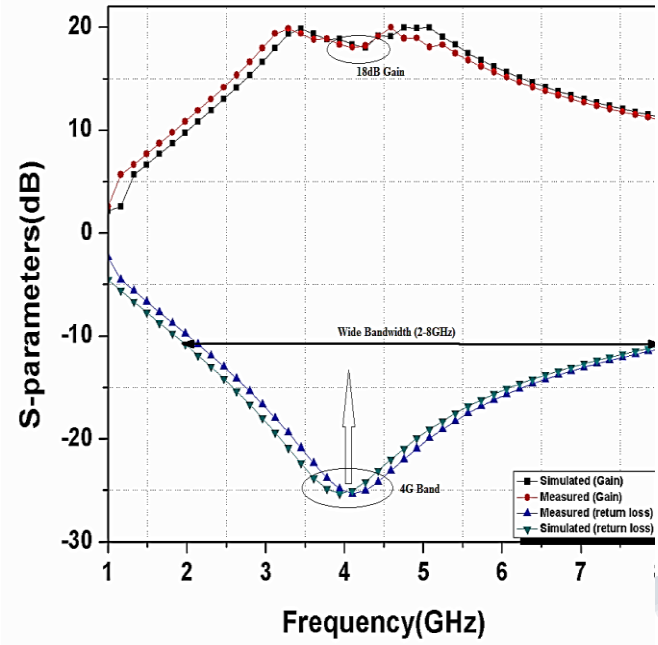

Fig. 3 Variation of return loss and gain with respect to frequency

IV.CONCLUSION

In this paper, wide bandwidth CMOS LNA using image network for 4G LTE application is proposed. The proposed circuit achieved wide bandwidth of 2-8GHz using image network technique. Additionally, achieved minimum noise figure of 1.6dB is the outstanding achievement for this application.

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