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Design of Inductively Degenerated 2.5 GHz LNA Using 0.13µm Technology

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Abstract

Low Noise Amplifier (LNA) is an electronic amplifier used to amplify very weak signals. Low noise amplifiers are the main component in the receiving end of the communication systems .In a communication system the wanted input signal is weak and the main function of LNA is to amplify the signal without adding noise to it. LNA is often located very close to the antenna, so that losses in the feed line become less critical.

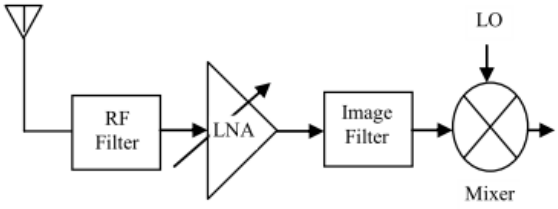
In this paper, the design of a Single-Ended LNA operating at 2.5GHz using 0.13µm technology is explained. The tools used for design the single-ended design is Advanced Design System (ADS 20011.10) for simulation.

This design and implementation is based on inductively degenerator cascode type. The results show a gain of 24.521 dB, noise figure of 2.787dB and a stability factor of 9.24

Keywords: LNA.

Introduction

Wireless communication systems use electromagnetic signals which are having frequencies in the range of hundreds of kilo hertz to giga hertz. Those frequencies we usually call as radio frequency(RF).In communication systems, the information that is usually sent is modulated and put onto a radio frequency carrier and amplified before transmission .A RF receiver front end comprises of antenna, band pass filter, a voltage controlled oscillator and a mixer. The signal coming out of band pass filter is to be amplified by LNA from a wide range of frequencies. The function of the mixer following LNA is to convert the amplified signal to lower frequencies.



Receiver Topology Of Basic RF

Specifications Of LNA

The specifications of single ended LNA are listed in the table given below. These parameters are very useful in designing of single ended LNA.

Table 1: Specifications of LNA

SI No	Parameters	Specifications	Units
1	Frequency	2.5	GHz
2	Noise Figure	<3	dB
3	Gain	<15	dB
4	Power Consumption	<30	mW
5	Source & Load Impedance	50	Ω

Design of LNA

A) Low Noise Amplifier Topology

To match the input impedance techniques such as common gate and common source are used .Resistor common source topology is not used because the various the noise associated with the resistor. Also the common gate is used so that the input conductance is equal to transconductance of the CMOS transistor. Another method which is inductive source degeneration is used .The advantage of this method is that a good noise performance is achieved but the main problem in this technique is sensitivity to gate induced current noise which can be improved by quality factor of the circuit. So in this design we use cascade inductor source degeneration topology. By selecting the values of gm,Ls and Cgs,the input resistance can be equated to 50 ohms source resistance and the input reactance can be resonated

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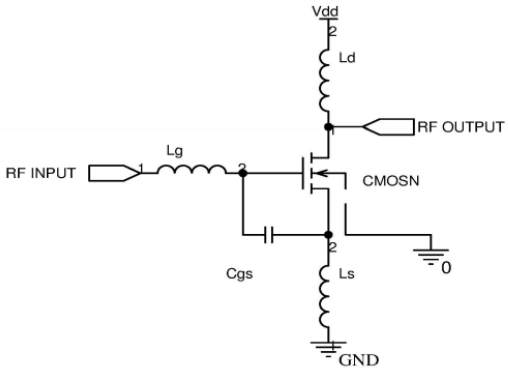
out by series inductor(Ls).Inductor degeneration also improves the linearity by forming a negative series feedback.



Common Source Inductive Degeneration

B) Design of Single-Ended Low Noise Amplifier

The input impedance Zin of a LNA is given by the equation

Zin= s(Lg+Ls)+ 1/s(cgs+cd)+gmLs/(cgs+cd)

And the value of the ώt is

ώt = gm/(cgs+cd)

The value of the gate inductor Lg is

Lg = ((Ql * Rs/ω) - Ls)

From the above 3 equations we find the various values as below

1. Value of Ls is 0.5nH.
2. Cut-off frequency ωt is 1*10^11 rad/sec.
3. Optimal Quality factor of inductor Ql is 3
4. Value of Lg is 18nH and Ld=27nH
5. Width W is 90.5u.
6. Transconductance Gm is 0.02124A/V.
7. Effective voltage Veff is 2.3V.
8. Bias current Id is 837µA
9. Value of c is 0.1pf

Where

Lg is the inductor connected to the gate,

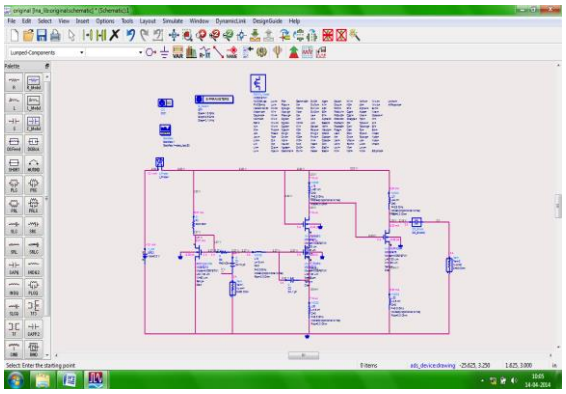
Ls is the source inductor,

Cgs gate source capacitance ,

Gm transcondutance of input device

Lmin is the minimum length of the transistor specified as 0.130µm and

Cox is the oxide capacitance of transistor



Schematic Single Ended LNA Design

Based on the BSIM3 0.13 m model, when the operating frequency is 2.5 GHz and the voltage is2.3V, the ADS software is used to simulate the CMOS LNA.

S-parameter is usually used to measure the performance of the LNA.

*S*11 means input matching, the value of it below ¡10 dB is reasonable.

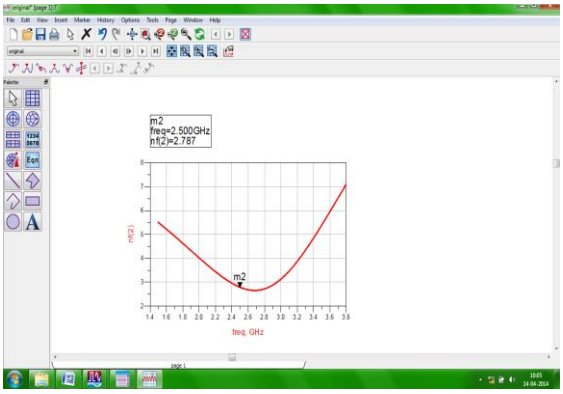
*S*21 is the gain.

NF is the noise figure.

*S*12 is the reverse isolation. To reach good performance that LNA noise below 3 dB and gain beyond 10 dB are needed.

Simulation Results

A) Noise figure analysis: The value of the noise figure obtained after simulation is shown in the graph below



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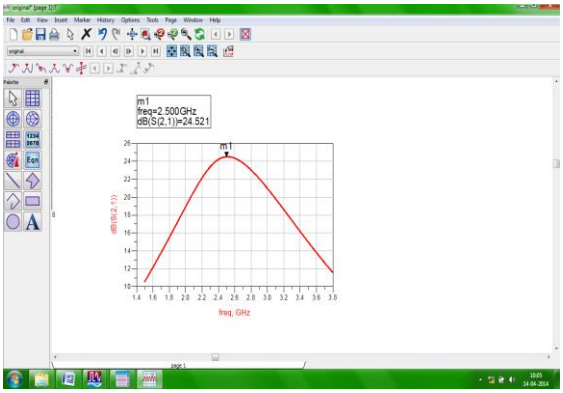
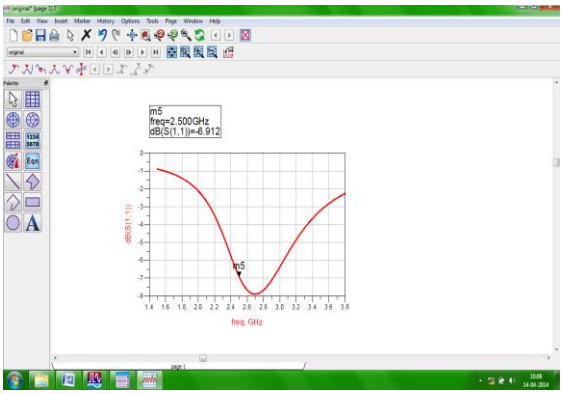
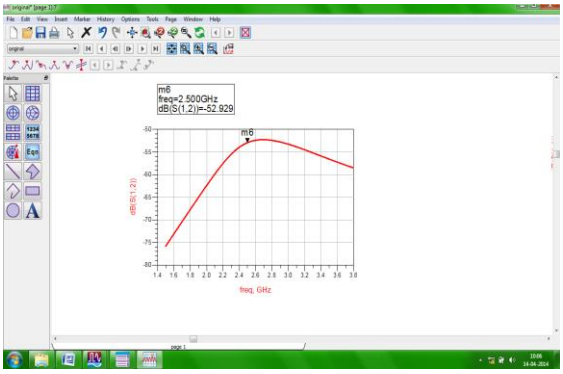
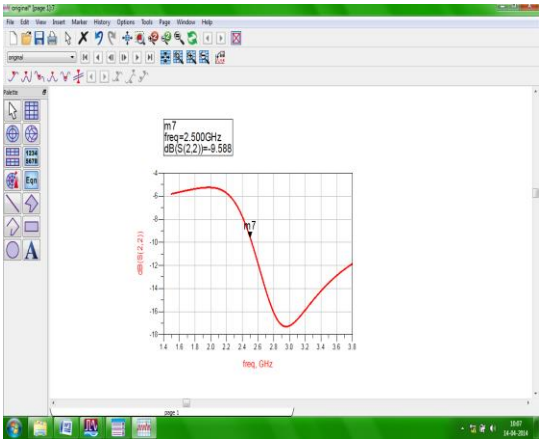
B) Gain: The value of the gain S (2, 1) obtained after simulation is shown below



C) S-Parameter analysis: The various values of s-parameters is shown below in the graph



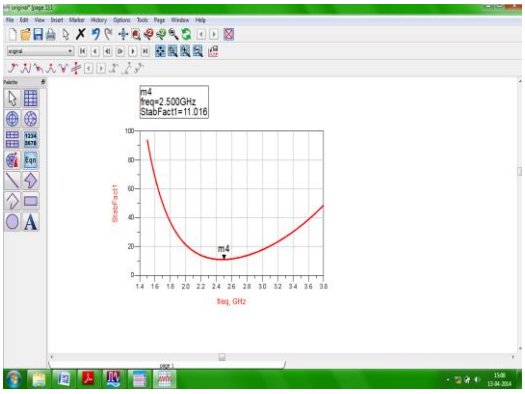




D) Stability Factor K: The value of the stability factor K can be calculated as

$$K = \frac{1 - |S_{22}|^2 - |S_{11}|^2 + |\Delta_S|^2}{2|S_{12}S_{21}|} > 1$$

$$\Delta_S = S_{11}S_{22} - S_{12}S_{21}$$



Comparison of Single Ended Lna Design

The table given below compares the reference LNA with the proposed LNA which is being used for Bluetooth transformation.

SINO	PARAMETERS	LNA(III)	PROPOSED LNA	UNITS
1	Frequency	2.5	2.5	Ghz
2	Noise Figure	3	2.787	dB
3	Gain	15	24.521	dB
4	Power Consumption	30	27.83	mW
5	Source & Load Impedance	50	50	Ω

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Conclusion

The single ended LNA has been designed and simulated using ADS (2011.10) tool .The various values of the noise figure ,gain ,power consumption has been analysed for 0.13µm and later on comparison has been made in the table.

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