A 2 – 10 GHz Common Gate UWB Low Noise Amplifier in 90nm CMOS

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***Abstract*—Low power and noise are constantly becoming popular and this has led to enormous demand of low noise devices. Among these, one of the key devices is Low Noise Amplifier. A UWB LNA designing using cascaded common gate common source, and common drain stages has been presented in this paper. The input common gate stage gives good input match with the antenna, i.e. S11 below -20dB and the common drain provides the output match, i.e. S22 below -10dB. The common Source provides the gain of 8.7299dB. The reverse isolation is below -90dB and the noise figure ranges from 5 to 10 dB through the required frequency range. The LNA's 1 dB compression point is -27dBm and input third intercept point (IIP3) of 4.30 dBm at 7.747GHz. The supply voltage is 1V.**

***Keywords*—Low Noise Amplifier (LNA), Common Gate, Common Drain, Common Source, UWB**

I. INTRODUCTION

As the want of data with higher and higher speed is increasing, there comes the need for receiver with high sensitivity and very large bandwidth for high speed wireless communication systems. The difficulty in maintaining a decent trade-off between noise, gain, bandwidth, linearity, stability and power consumption with a decreased size for wideband topology can be improved by the performance of an LNA. To improve these trade-off, different researchers have studied and published various topologies and designs for wideband LNA's. An LNA (or low noise amplifier) is an electronic amplifier, which is found in RF transmitter or receiver and its job is to amplify a very low power signal and not degrading its signal-to-noise ratio significantly. LNA's are used to amplify weak signals that are just above the noise floor.

$$Freciever = Flna + \frac{Frest-1}{Glna} \tag{1}$$

By using LNA so close to the signal source, the effect of the noise from the subsequent stages of the receiver chain in the circuit is reduced by the signal gain created by an LNA. The design of the LNA is important for the various reasons given below:

i) NF of the receiver system is mostly dominated by the NF of the LNA,

ii) Gain of the LNA helps in reducing the NF contributed by the rest of the subsequent components

iii) Linearity of the LNA can control how much the receiver sensitivity is compromised.

This can be proved by the Friis's noise formula [12] given in equation (1). A good LNA has low Noise Figure, good Gain and a large enough intermodulation and compression point (IIP3 and P1dB) and impedance matching.

Some examples of distributed amplifiers are shown in [2]-[4] for their wide input matching characteristics. But these cases suffer from high power consumption, low gain and large chip size. In [5] a UWB LNA is designed, whose input network in embedded in 3 section Chebychev filter, which had helped achieve good gain, linearity, low noise with good wideband performance but increased chip area. In [9] there is cascade of two different topologies.

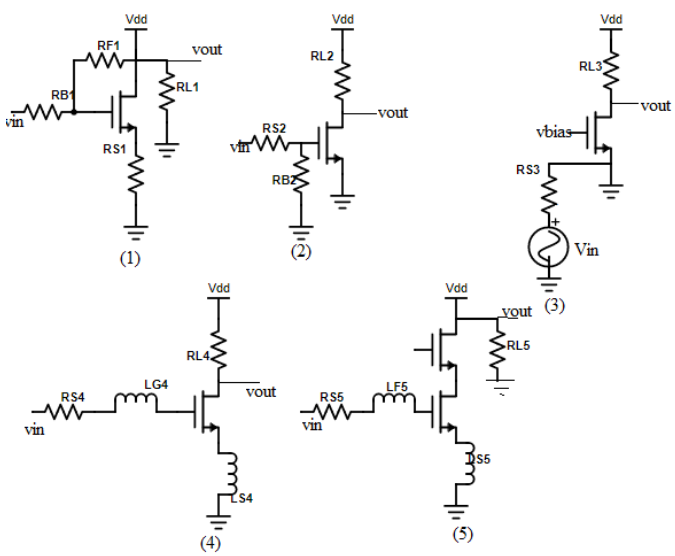

Fig 1. Fundamental Topologies of LNA:(1) Shunt Series Feedback Common Source (2) Resistive Termination Common Source (3) Common Gate (4) Inductive Degeneration Common Source (5) Cascode Inductor Source Degeneration

The most common core topologies that has been used wideband applications for LNA design are 1) Inductive degenerated Common source topology (IDCS) and 2) Common gate (CG) topology. Some literatures that have used IDCS as core topologies are [6],[8] and some literatures that have used common gate are [7]. The CG has much better noise performance at higher frequencies, when compared to the IDCS topology. But at lower frequencies, the minimum achievable noise figure of IDCS topology is a little better. One more advantage of IDCS topology over CG topology is that it mostly has higher gain due to the amplification by the input matching network. IDCS uses a series resonance to match with the source impedance while CG uses a parallel one. The quality factor for a series resonance is generally greater than one at the resonance frequency therefore increasing the input transistor's transconductance. And also, the quality factor of a parallel resonance is equal to one at the resonance frequency. Yet, having a high quality factor input matching network makes IDCS more sensitive to process variation and parasitic. Most of the parasitic at the input of the CG topology can be absorbed into its structure, thereby reducing their effect on the circuit performance. This comparison is summarized in Table-I.

This paper is organized as follows. Section I gives the working idea of an LNA and introductory gist of the reference literatures which have been studied and reviewed here. Section-II presents the proposed LNA design. Section-III gives the simulation data of the LNA. Section-IV gives the comparison of this work and the conclusion of this study.

II. DESIGN OF PROPOSED LNA

The proposed LNA is shown in figure II. It consists of 3 stages. The first stage is the common Gate stage, that provides the input matching for the wide frequency band. The 2nd stage is the common source stage, that provides good gain. The 3rd stage is the common drain stage or the source follower stage that basically acts as a buffer and gives output matching i.e, S22. To achieve maximum flow, an input matching filter consisting of C1, Ls1 and R1, and a output matching circuit which is a series LC filter consisting of C2 and L0.

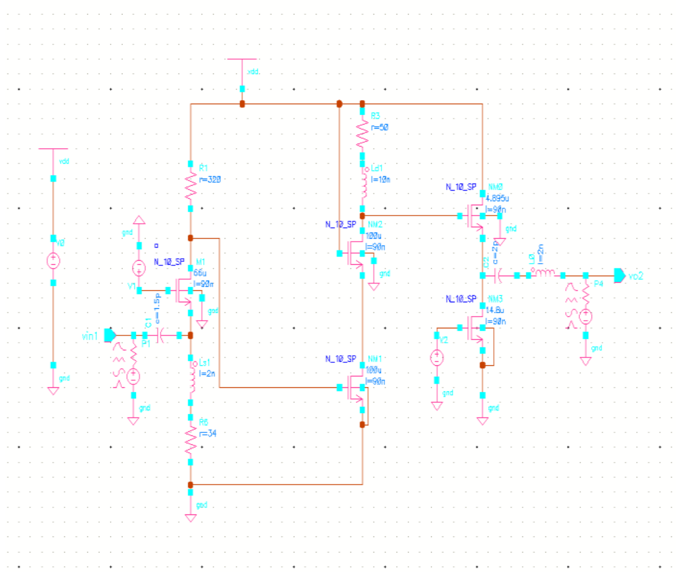

Fig. 2 Schematic diagram of the proposed LNA

The CG amplifier is used as the first stage instead of CS amplifier because CG has lower quality factor than CS amplifier and thus can achieve wideband input matching. CG stage requires less number of passive elements when compared with the CS stage to achieve same bandwidth. CG amplifier finds difficulty in achieving high gain which is essentially required to increase the incoming signal strength. So, here, CS stage is used as the 2nd stage to increase the overall gain of the proposed LNA.

III. RESULTS AND DISCUSSION

The S11, input reflection coefficient of the proposed LNA has shown in the figure III. S11 is below -10dB for the required frequency range 2-10GHz. It shows a minimum value of -25.45dB at 7.78461GHz.

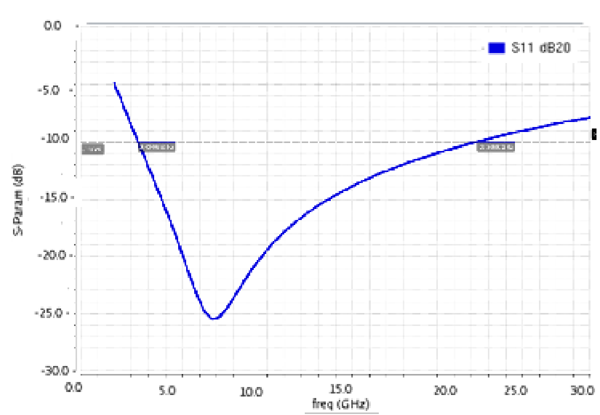

Fig.3. S11 vs frequency

The output reflection coefficient vs frequency is shown in the figure 4. It remains below -10dB from 2 GHz to 9.16GHz.

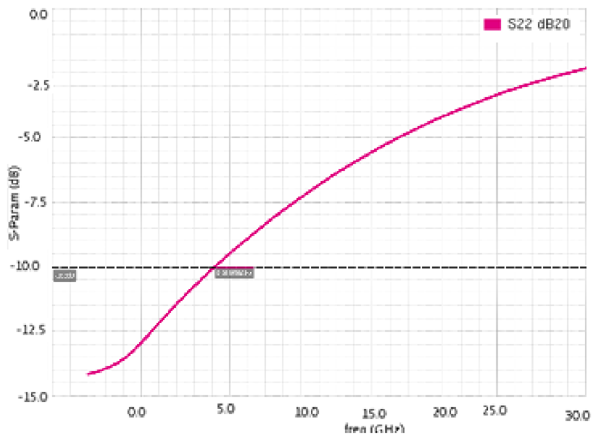

Fig.4. S22 vs frequency

The figure 5 gives the gain performance of the proposed LNA. It's give good gain in the range 2-9.65 GHz with a maximum of 8.73 dB at 4.5 GHz.

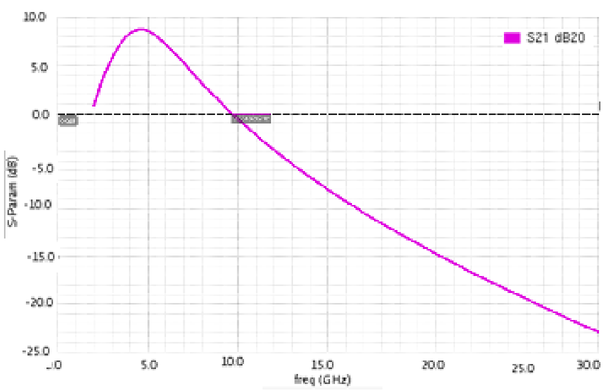

Fig.5 S21(gain) vs Frequency (GHz)

The figure 6 gives the reverse isolation(S12) The value of S12 stays below -85dB for the whole frequency range.

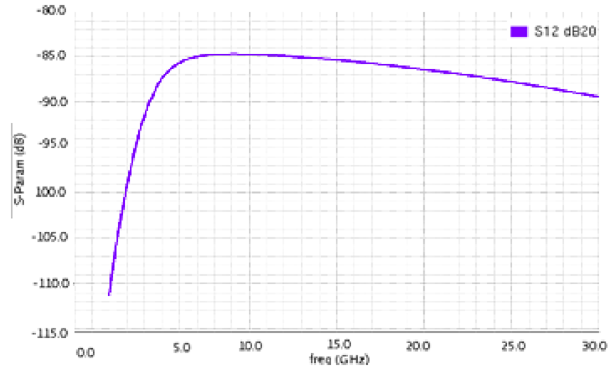

Fig. 6 S12(reverse isolation) vs Frequency (GHz)

The noise figure (N.F) versus the frequency plot is shown in the figure 7, with a minimum value of 5.89 dB at 6.96 GHz. The N.F ranges from 5 to 10 dB in the frequency range 2-10 GHz.

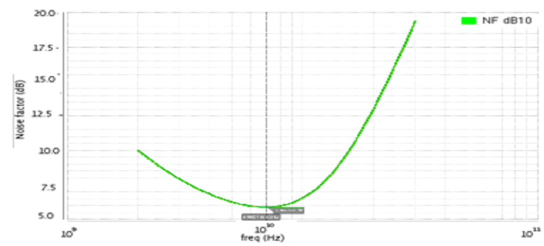

Fig. 7 Noise Figure (NF) vs Frequency (GHz)

The figure 8 and 9 show the stability factors, Kf and B1f versus frequency respectively. Kf>1 for the whole frequency band and B1f<1 from 4.3GHz to 10 GHz.

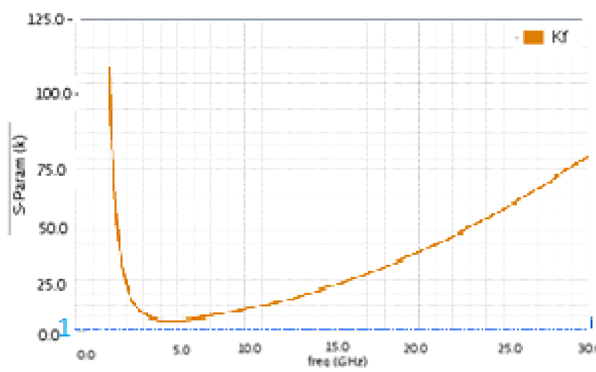

Fig. 8 Stability factor(kf) vs frequency (GHz)

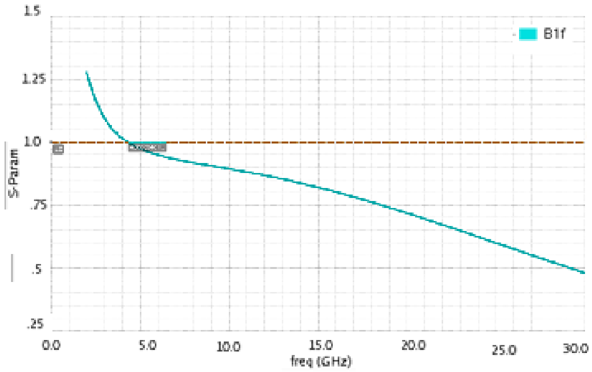

Fig. 9 Stability factor(B1f) vs frequency (GHz)

The figure 10 and figure 11 shows the linearity characteristics of the proposed LNA. The P1dB is at -27 dBm. The IIP3 is at 4.30 dBm, by keeping the difference between the 1st order and 3rd order frequency 10MHz.

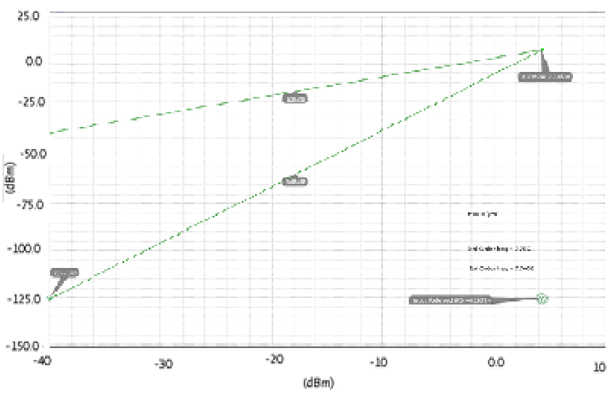

Fig. 11 Input third intercept point (IIP3) vs input power(dBm)

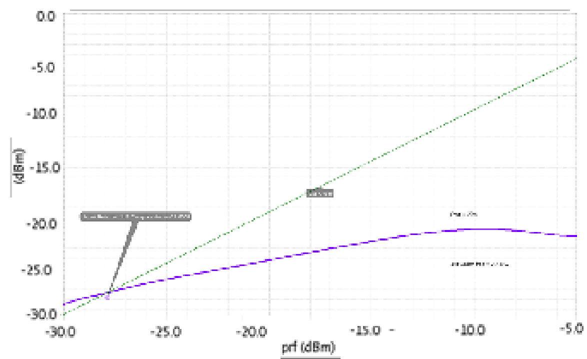

Fig. 10 1 dB compression point (P1 dB) vs input power(dBm)

IV. CONCLUSION

In this paper a UWB band LNA has been proposed. The LNA has been designed used common gate, common source and common drain cascaded one after the other, each stage fulfilling its characteristic properties. The input common gate stage gives good input match with the antenna, i.e. S11 below -20dB and the common drain provides the output match, i.e, S22 below -10dB. The common Source provides the gain of 8.7299dB. The reverse isolation is below -90dB and the noise figure ranges from 5 to 10 dB through the required frequency range. The LNA's 1 dB compression point is -27dBm and input third intercept point (IIP3) of 4.30 dBm at 7.747GHz. The technology used to realize this design is Cadence UMC CMOS 90nm.

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Parameter	**[1]**	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**	**[7]**	**This Work**
CMOS Technology	0.18µm	0.18 µm	65nm	90nm	0.18µm	0.18µm	0.18µm	**90nm**
LNA Topology used	CG+CS	CG+CS	CG+CS	CG+CS	CG+CS	CG+CS+CD	CG+CS	**CG+CS +CD**
Power Supply(V)	1	1.8	1	1	1.8	1.5	1.5	**1**
Bandwidth(GHz)	8.5-20	1-5	7.6-29	3.1-10.6	0.4-10	3.1-10.6	3.1-10.3	**2-30**
Gain(dB)	11.13	21-25	10.7	17.25±1.25	11.2-12.4	Avg.9.7	9.6-12.71	**Max.8.723**
N.F(dB)	2.1-3.2	2.6-3	4.5-5.6	4.1-9.4	4.4-6.5	5.27-7	2.5-3.9	**19.3-5.6**
S11(dB)	< -9.44	<-7		<-12	<-10	<-13.5	<-9	**<-15**
S12(dB)	<-60	-	-	-	-	<-43	<-45	**<-95**
Area(mm^2)	0.116	-	0.3	0.13	0.42	1.0296	0.68	**UC**
IIP3(dBm)	0.96	-	-	-	-6	-2.23	-3 to 1	**4.30**
1-dB compression point(dBm)	-	-	-	-	-	-10	-12.5	**-27.85**
Power Consumption(mW)	5.4	14.5	12.1	8.5	12	4.5	13.4	**UC**
FOM	15.1-28.4	2.759	4.159	2.255	1.91	2.63	1.873	-

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