Design of Folded-Cascode Low Noise Amplifier with Low Power and High Gain for UWB Application

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ABSTRACT:
This paper presents the low noise amplifier for ultra-wide-band applications.the UWB LNA is design in 0.18μm CMOS technique to achieve low noise figure, low power consumption and high gain. To attain the low power dissipation and low supply voltage,foldedcascode with current reused technique is utilized in first stage. Negative feedback is adopted to extend the bandwidth. using the proposed technique, a maximum gain of 12.7 dB and minimum noise figure of 2dB is achieved. The total power consumption is37 mW. S11 and S22 are less than -10 dB.

KEYWORDS: UWB, LNA, folded-cascode, gain.Noise figure.

1. INTRODUCTION

In recent years, ultra-wideband technology using have attracted interest due to high data rate (up to 480Mb/s) and low power consumption (limit to -41.3 dBm/Mhz). in IEEE 802.15.3a standard, Federal Communications Commission (FCC) approved the use of frequency band from 3.1 to 10.6 GHz [1].

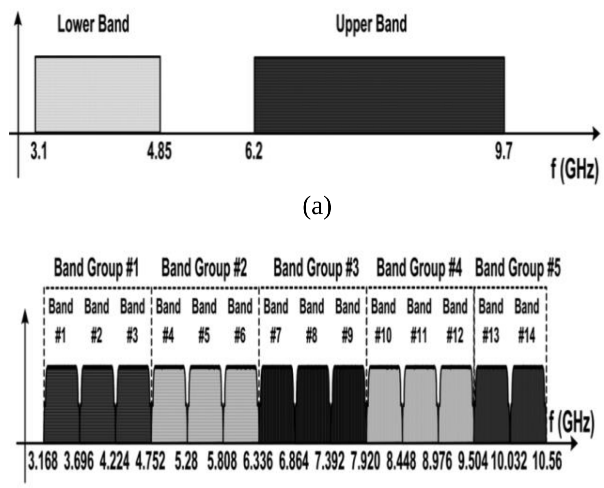
Among possible applications, uwb technology performs for imaging systems, high-speed indoor networking, Radio-frequency identification (RFID), wireless local area network (WLAN), ground and vehicular penetrating radars.

Two approaches have been proposed for uwb systems [2].

1) B-OFDM modulation divides the whole band into 14 sub-bands with a band-width of 528 MHz each as shown in Fig.1.

2) DS-UWB divides the whole band into two discontinuous.

Several LNAs have been reported for uwb receiver systems with different techniques: RLC matching, resistive shunt feedback, current reused, shuntpeaking, distributed amplifier, stagger tuning [2-7].



(b)

Fig.1. Spectrom UWB LNA [2]

Filter synthesis technique is useful for input matching network.current reuse technique is attractive for uwblna design due to its high gain and low power consumption.theshematic of the folded Cascode LNA is illustrated in Fig.2. the folded cascade confiquration is one of the suggestion topologies to provide a low noise fiqureuwblna.

In comparison with other low voltage lna topologies the folded cascade one possess exclusive advantage in terms low power consumption, noise figure, linearity and bias point stability [4-6].

The low noise amplifier (LNA), as the first block in uwb transceiver has significant impact on the sensitivity and dynamic range of the whole receiver system.

The wide-band LNA must several stringent requirements such as low cost,low power consumption,high security and high data rate, low and flat NF, high power gain and wide- band input matching[10-12].

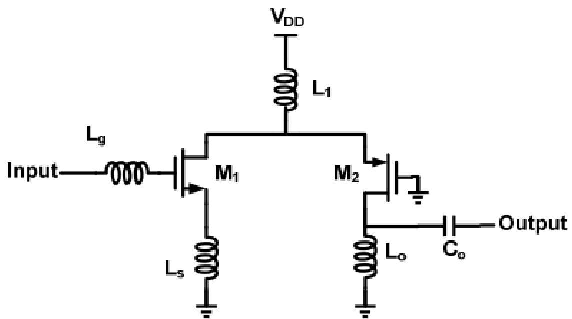


Fig.2. Shematic of folded cascode LNA

2. CIRCUIT DESIGN

The proposed wide-band LNA is shown in Fig.3.

It consists of a input matching network,main amplifier and output buffer. A source degenerated inductor coupled with high-pass filter is adopted in first stage to obtion the input matching network.

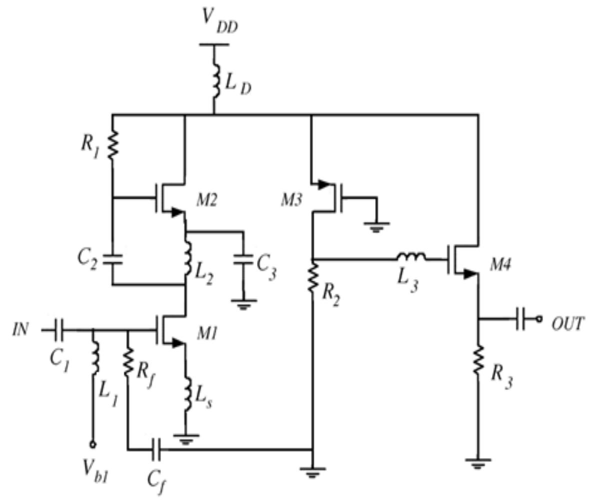


Fig.3. Shematic of the proposed UWB LNA

Fig. 4 shows the simplified small signal model of common source amplifier for input matching.

L_s is the source degeneration inductance which is used for impedance matching at the input and it contributes to linearity improvement of system.

The input impedence of the LNA are expressed as:

$$Z_{D1} = \left[\left(\frac{1}{SC_{GS2}} + \frac{1}{SC_2}\right) \parallel S_{L2}\right]$$

$$Z_{D2} = \left[\frac{1}{SC_{ds1}} \parallel r_{o1}\right] + Z_{D1}$$

$$Z_S = SL_S \parallel \frac{1}{1 + gm_1 r_{o1}}$$

$$Z_{in} = \frac{1}{SC_1} + \left[SL_1 \parallel R_f \parallel \left(\frac{1}{SC_{gs1}} + Z_S\right)\right]$$

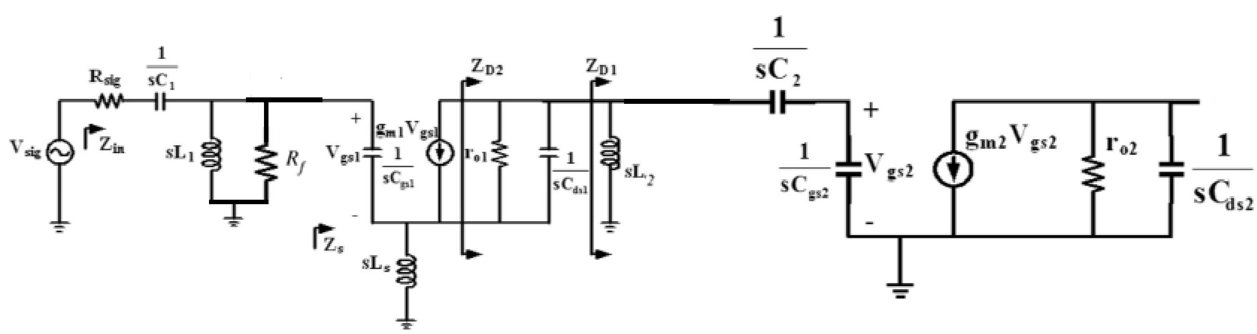


Fig.4. Simplified small signal equivalent circuit.

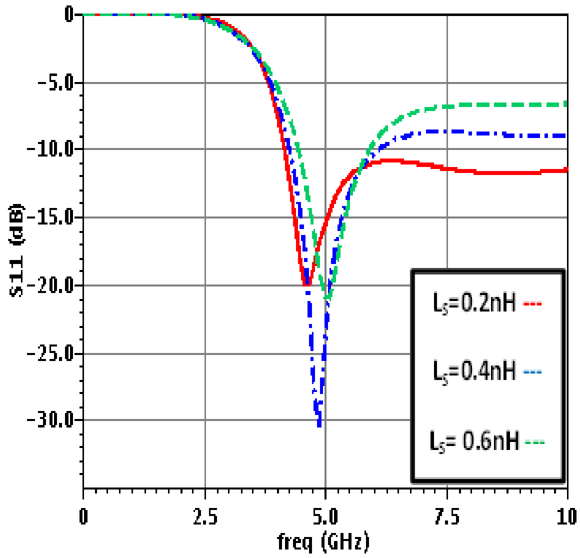


Fig.5. Effect LS on the S11

Fig.2 shows the circuit shematic of the proposed LNA. The folded-cascod topology is adopted in the input stage to satisfy a good trade-off between low noise, sufficient, gain and low power consumption. we adopted current reuse structure to reduce power consumption. The folded cascade LNA is formed by transistors M1 and M2 and inductors(LS,L2).

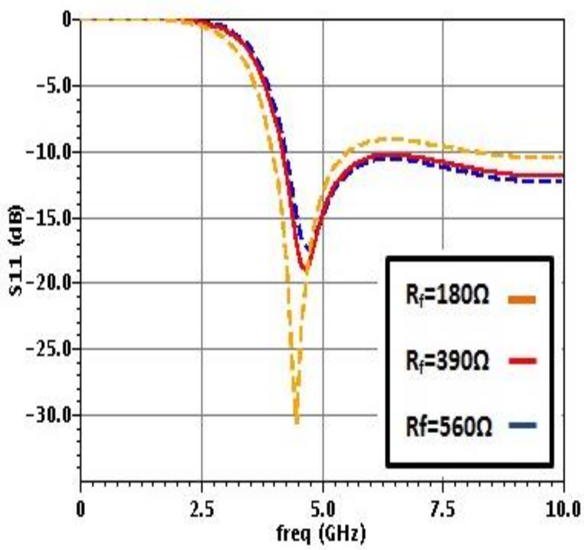


Fig.6. Effect Rf on the S11

3. RLC NEGTIVE FEEDBACK:

The shematic of the UWB LNA is composed of a two-stage topology with negative feedback.we use shunt-shunt feedback technique to improve the input and output matching of the wideband amplifier negative feedback can extended the band-width and reduce sensitivity and gain.Fig.6 shows effect Rf on the S11.

Inductor L_d resonates with the parasitic capacitors at the frequencies of interest and provides bias current for M1 and M2.

4. NOISE FIGURE ANALYSIS

Noise factor can be expressed by the following equations :

$$F = 1 + \frac{\gamma}{\alpha}\left(1 - 2|C|\sqrt{\frac{\alpha^2\sigma}{5\gamma}}\right) + \frac{\alpha^2\sigma}{5\gamma}\frac{1+Q^2}{Q^2}\frac{\omega_0}{\omega_T} \quad (5)$$

$$\mathbf{Q} = \frac{1}{\omega_0 R_S C_{gs}} = \frac{\omega_0(L_S)}{R_s} \quad (6)$$

$$\omega_T = \frac{g_m}{C_{gs}} \quad (7)$$

Where by choosing width value of L_S and transistor M_1 performance noise figure LNA is obtained. Fig.5 shows effect L_S on the NF.

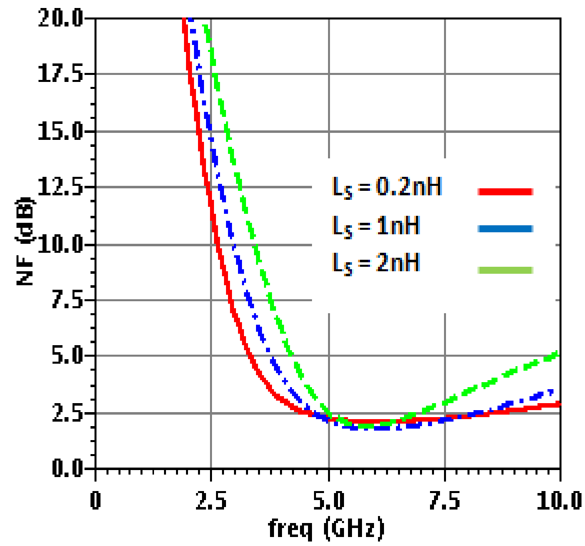


Fig.7. Effect Ls on the UWB LNA

5. SIMULATION RESULT

The UWB LNA were simulated in TSMC 0.18µm CMOS process. simulations have been performed using Spectre simulator of cadence.

Fig. 8 and Fig.9shows the input return loss and output return loss of the first UWB LNA. The simulated input and output return loss is below -10dB. Fig.10 show that maximum S_{21} is12.7 dB.The simulation NF of the UWB LNA is illustrated in Fig.12. The minimum NF is 2dB.The parameters of the UWB LNA design are listed in Table 1. in general, the fiqure of merit(FOM) is applied to evaluate performance of LNAs and is defined as:

$$FOM = \frac{Gain_{max}(dB) \times BW(GHz)}{[F-1] \times P_d(mw)}$$

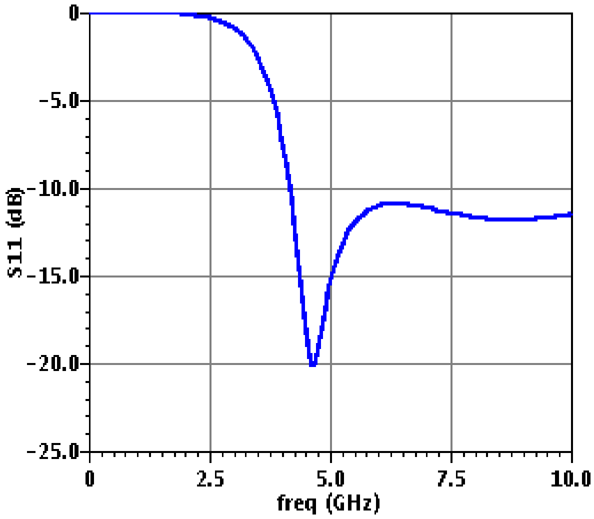


Fig.8. Input return loss of UWB LNA

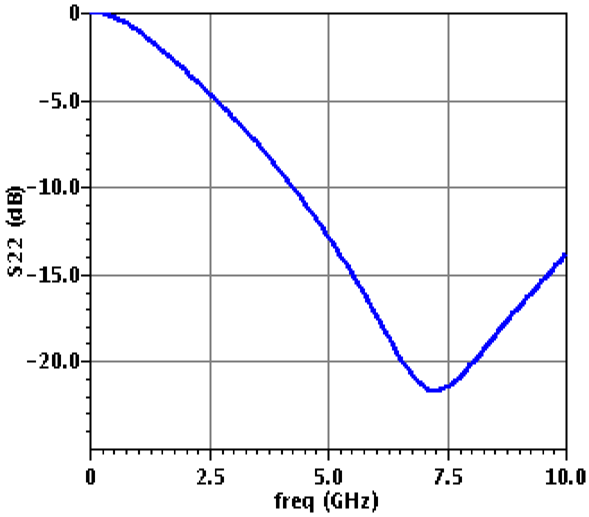


Fig.9. Output return loss of UWB LNA

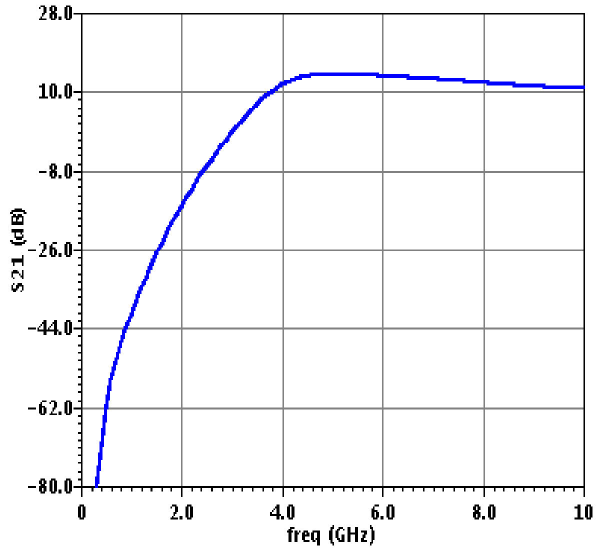


Fig.10. Gain of UWB LNA

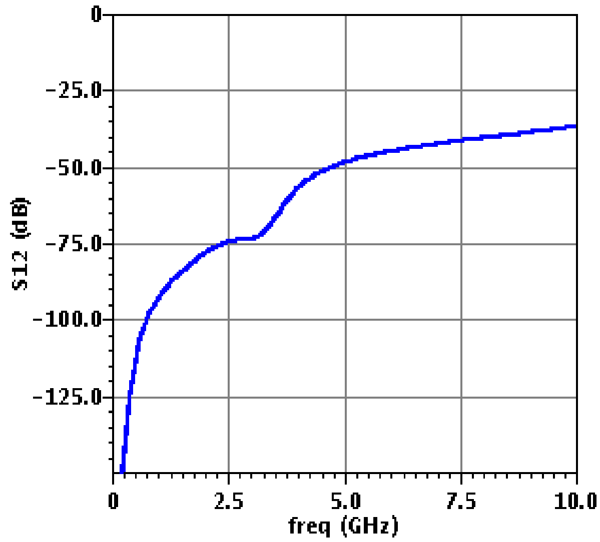


Fig.11. Simulated S_{12} of the UWB LNA

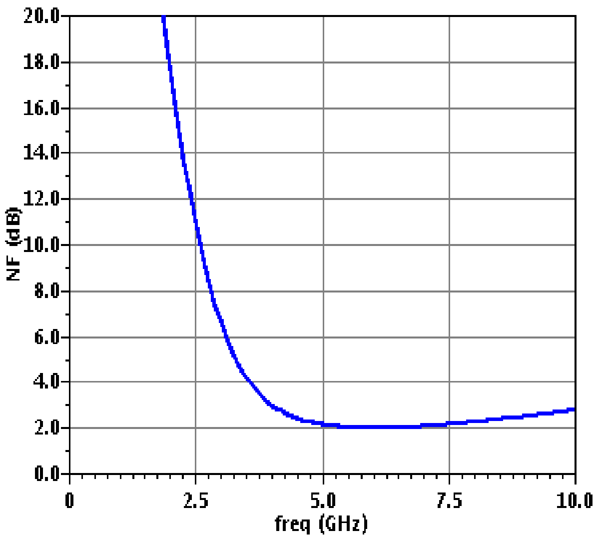


Fig.12. NF of UWB LNA

Table 1. Circuit Parameters of the UWB LNA

Transistor size	Resistor value	Inductor value
$(W/L)_1$=180/0.1 m	R_1=1KΩ	L_1=1.1nH
$(W/L)_2$=96/0.18 µm	R_2=350Ω	L_2=3nH
$(W/L)_3$=70/0.18 µm	R_3=100Ω	L_3=3.6nH
$(W/L)_4$=40/0.18 µm	R_f=390Ω	L_S=0.2nH
		L_D=0.8nH

Table 2. Circuit Parameters of the UWB LNA

Parametrs	[3]	[4]	[8]	[11]	[12]	This work
Technology	65nm	0.18µm	65nm	0.18µm	0.18µm	0.18µm
BW(GHz)	0.4 – 10.6	3.1 – 10.6	1-10	3.1 – 10.6	3.1 – 10.6	3.1-10.6
S_{11}(dB)	< −11	< −10	<-10	< −8.6	< −9.6	<-10
S_{22}(dB)	< −10	< −10.5	<-10	< −8	< −9.5	<-10
S_{21}(dB)	10.4	10.5	15.6	9.5	11.7	12.7
NF_{min}(dB)	3.5	2.7	2.8	5	5.8	2
P_{dc}(mW)	12	13.7	14.1	9.4	33.66	37
FOM	7	2.05	9.16	3.5	0.93	4.4

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