ISSN: 2395 - 2180

Available online at http:// www.ijemmr.co.in

International Journal of Engineering, Management & Medical Research (IJEMMR)

Vol- 2 , Issue- 2 , FEBRUARY -2016

Research Paper

ANALYSIS OF LOW NOISE AMPLIFIER USING CMOS IN 3GHZ TO 10GHZ RANGE

ADITYA DUBEY [1] , ANAND KHARE [2], UTTAM MISHRA [3]

1. **M.TECH, SCHOLAR, DEPARTMENT OF ELECTRONICS & COMMUNCIATION, OJASWINI INSTITUTE OF MANAGEMENT & TECHNOLOGY, DAMOH, (M.P.)**
2. **HOD, DEPARTMENT OF ELECTRONICS & COMMUNCIATION, OJASWINI INSTITUTE OF MANAGEMENT & TECHNOLOGY, DAMOH, (M.P.)**
3. **ASST. PROF., DEPARTMENT OF ELECTRONICS & COMMUNCIATION, OJASWINI INSTITUTE OF MANAGEMENT & TECHNOLOGY, DAMOH, (M.P.)**

ABSTRACT

A 3.1 to 10 GHz Low Noise Amplifier (LNA) with gain enhanced and band-pass property for Ultra Wide Band (UWB) applications using 0.18 µm CMOS technology is designed.

Therefore, we proposed a wideband input network with band-pass capability UWB LNA using LC network. It uses a CMOS amplifier with 0.18 µm technology. We have achieved A power gain of 49mW and minimum noise figure of 0.9 dB for the core LNA.

KEYWORDS

Index Terms—CMOS -Complementary metal–oxide semiconductor, low-noise amplifier (LNA), band-pass, ultra wideband (UWB).

ISSN: 2395 - 2180
Available online at http:// www.ijemmr.co.in
International Journal of Engineering, Management & Medical Research (IJEMMR)
Vol- 2 , Issue- 2 , FEBRUARY -2016

INTRODUCTION

ULTRA-WIDEBAND (UWB) systems realize high data rate in the short-range wireless transmission, which are suitable for integration in various electronics products for consumers such as PCs, cellular phones, digital cameras etc.

A tone is measured in a smart phone at 1.87 GHz currently on the market, and the power level is 35 dB higher than the UWB signal [2]. , As shown in Fig.1 all of these interferers, have a harmful effect on the received UWB signal. A larger attenuation can also relax the baseband filter achieving an implementation with the smaller group-delay variations and lower dc power consumption [5].At present, a design of multiple-stop band filters is presented for the suppression of interfering signals just like as global system for mobile communications (GSM), WLAN, and worldwide interoperability for microwave access (WIMAX) in UWB applications [3]. The coupled resonator stop band filter sections with bent resonators were adopted in order to more effectively suppress harmonics and the maximum rejection is about 25 dB at 1.8 GHz. However, this prototype of the filter, which was fabricated on the basis of the standard printed circuit board (PCB) process, will increase the entire UWB system area. Moreover, the multiple receivers with equal-gain combining were employed to eliminate the narrowband interferers received in the two paths and combined out-of-phase to cancel each other by selecting the optimal local oscillator (LO) phase [4]. A maximum 28-dB attenuation of the interferers was measured, but it is unavoidable to increase the system's complexity. On the other hand, the topologies utilized for wideband amplifiers generally include the distributed configuration [8], [9], resistive shunt-feedback structure [10]–[12], common-gate termination [15] and LC input network [17]. The distributed amplifiers are attractive for their ultra-wide bandwidth. However, the major drawbacks are the large area and high dc power consumption, which make them unsuitable for many applications. The resistive shunt-feedback and common-gate amplifiers can provide good impedance matching and moderate gain while dissipating small amounts of dc power, but without the band-pass capability. Recently, a new topology of the broad band amplifier for out-bands rejection, which adopted a notch filter circuit with negative-resistance cell embedded has reported in [18] and [19]. Inevitably, the extra notch filter circuit made of inductors and cross-coupled transistors will occupy additional chip area and dc power simultaneously.

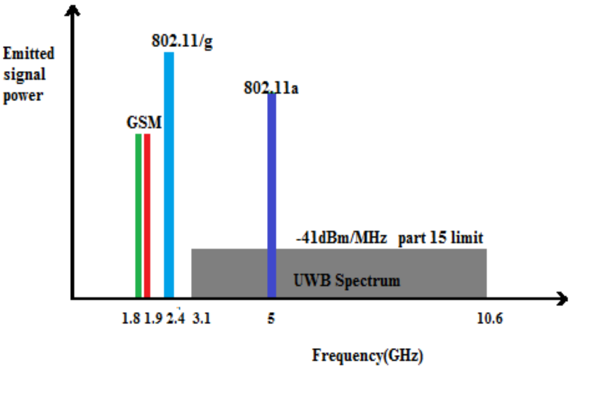

Fig. 1. UWB Spectrum and interferences

ISSN: 2395 - 2180

Available online at http:// www.ijemmr.co.in

International Journal of Engineering, Management & Medical Research (IJEMMR)

Vol- 2 , Issue- 2 , FEBRUARY -2016

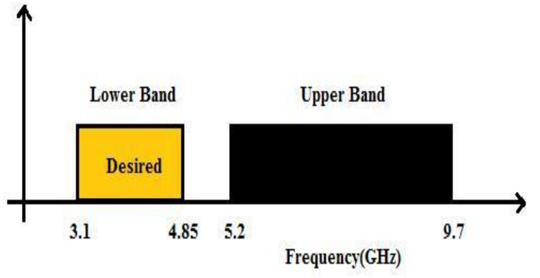

Fig. 2. Dual Band (DB) UWB Spectrum

LNA Design Approach

The 3.1 to 10 GHz CMOS UWB LNA proposed here adopts a source-degenerated configuration, as shown in Fig. 3. An LC input network for wideband operation is utilized with two new capacitors and to increasing the higher and lower limit for band-passs, respectively. The load inductor in series with the resistor helps to enhance the gain flatness. The buffer transistor with a purely resistive load is employed for testing purposes. An additional inductor is inserted between the Cascode stages to enhance the overall gain.

A. Power Gain

The overall gain of the LNA without an additional inductor Lc is given by [22] (Lc considered to be shorted)

$$S_{21} = \frac{(1+S_{11})v_{out}}{v_{in}}$$

$$= (1+S_{11})\frac{v'_{out}}{v_{in}}\, g_{m3(R_o||Z_o)} \quad (1)$$

Where

$$\frac{v'_{out}}{v_{in}} = \frac{g_{m1}(1-\omega^2 L_g C_{RH})}{\square(\omega)}\left[(R_L + j\omega L_L)||\frac{1}{j\omega C_L}\right] \quad (2)$$

With

$$(\omega) = \omega^4 L_g L_s C_T C_{RH} - j\omega^3 L_g L_s g_{m1} C_{RH} - \omega^2(L_g C_t + L_g C_{RH} + L_s C_t) + j\omega g_{m1} L_s + 1 \quad (3)$$

Z_o is the 50-Ω source resistance, Ct = Cgs1 +Ca and CL is the total capacitance between the drain of the transistor M2 and ground. S11 is the reflection coefficient at the input port. From (1), it is seen that extra transmission zeros (i.e.,S21 = 0) can be created when the following conditions are satisfied:

$$S_{11} = -1 \; or \; \frac{v'_{out}}{v_{in}} \quad (4)$$

In which means that the input impedance of the LNA is short circuit, and it occurs as the impedance ZR, i.e., the impedance of the L1C1tank in series with the capacitor CRL is equal to zero, where

$$Z_R(\omega) = \frac{[1-\omega^2 L_1(C_{RL}+C_1)]}{j\omega C_{RL}(1-\omega^2 L_1 C_1)} \quad (5)$$

By using (2), (4), and (5), the locations of transmission zeros can be predicted as

$$\omega_{RH} = \frac{1}{\sqrt{L_g C_{RH}}} \quad \omega_{RL} = \frac{1}{\sqrt{L_1(C_{RL}+C_1)}} \quad (6)$$

The overall gain of the circuit is increased by inserting an additional inductor in between the

ISSN: 2395 - 2180
Available online at http:// www.ijemmr.co.in
International Journal of Engineering, Management & Medical Research (IJEMMR)
Vol- 2 , Issue- 2 , FEBRUARY -2016

stages as shown in the fig 3. Complete schematic of proposed LNA.

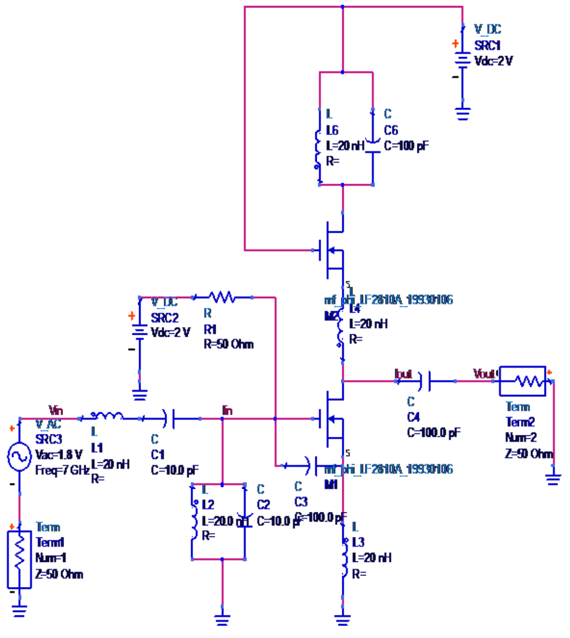

Fig. 3. Complete circuit diagram of proposed UWB LNA.

The above ratiocination reveals that the additional capacitors and will bring about two transmission zeros to ameliorate the out-band performance. However, the band-pass characteristics are restricted by the series resistance of the on-chip inductor. As seen from (6), the higher and lower out-band transmission zeros are associated with the inductors and L and L1 , respectively. These component values influence not only the zeros' frequencies, but also the out-band suppression levels,. The higher frequency out-band elimination efficiency is mainly determined by the impedance of the LgCRH tank at the resonant frequency (i.e., the larger impedance, the superior out-band suppression). Therefore, the first step is to assign a larger to arrive at larger resonant

g

impedance [20, Ch. 14]. In addition, a preferable power gain in the target frequency range can be procured contemporaneously by using a larger value of Lg. The impedance of input LC circuit produces one series and one parallel resonance from which the lower transmission zero can be created. It is expectable that a smaller impedance at the series resonant frequency will accomplish the superior out-band elimination efficiency.

From the above discussion, it should be taken into account punctiliously by choosing appropriate values of and to achieve the tradeoff between the input match and band-pass performances. It is interesting to see the influence of the input network on the LNA's NF. After astraightforward derivation following the procedure in [21],Obviously, the proposed UWB LNA will produce double-peak maxima in noise factor at the two transmission zeros. Consequently, it must be cautious to prevent from worsening the noise property in the given frequency range when designing the locations of the zeros. Fig. 5 shows the simulation result of the NF the total circuit. In this LNA the dominant noise contributor is the active gain stage. The band-pass input network has a minor influence on the total NF as long as the designed transmission zeros are not too close to the in-band. To reduce the noise from the active gain stage, the width of the transistor will be chosen for optimum noise property. The additional inductor between the Cascode stages is chosen to optimize the total noise figure.

ISSN: 2395 - 2180
Available online at http:// www.ijemmr.co.in
International Journal of Engineering, Management & Medical Research (IJEMMR)
Vol- 2 , Issue- 2 , FEBRUARY -2016

Implementation and simulation

The proposed band-pass UWB LNA is designed and simulated using Agilent Advanced Design System with 0.18 µm CMOS technology.

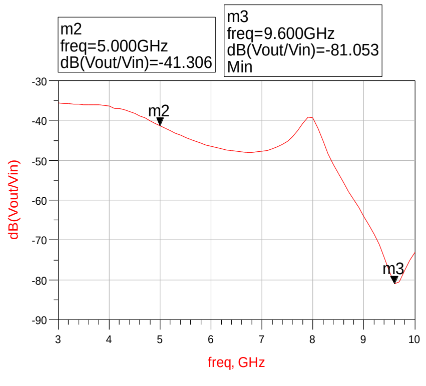

Fig.4. Voltage Gain of LNA

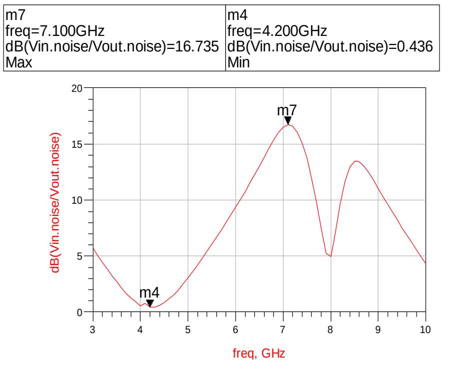

Fig. 5. Noise Figure of LNA

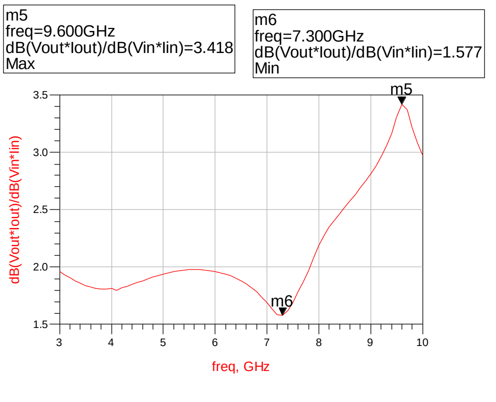

Fig. 6. Power gain

this study, the component values of the input network are L1 =20 nH, L6 =20.0 nH,C1 = 10 pF, C3 = 100pF,C2 = 10 pF, Ca =100.0 pF and additional inductor Lc = 20 nH. The load consists of an inductor LL in series with RL to achieve flat gain over the whole band width.

Results

Power gain	1.5W	3-10 GHz
Voltage gain	9.0mV	3-10GHz
Noise Figure	1.1	3-10GHz

Conclusion

In this paper, we proposed a UWB LNA configuration with band-pass ability and demonstrated the simulated results using the 0.18 µm CMOS process. Extra transmission zeros are created by the use of an LC input network with additional capacitors and for improving the higher and lower out-band performances. Finally we have achieved gain enhancement and low power dissipation with an additional inductor .

References

[1] *R.S.Sai Ram ,Dr.T Madhu , P.Lakshmi Sarojini ,* " Analysis and Design of CMOS Cascode LNA for UWB Application with Gain Enhancement and Out- Band Rejection Capability." (IJERT) Vol. 1 Issue 5, July - 2012 ISSN: 2278-0181

[2] S. Lo, I. Sever, S.-P. Ma, P. Jang, A. Zou, C. Arnott, K. Ghatak, A. Schwartz, L. Huynh, V. T. Phan, and T. Nguyen, "A dual-antenna phased-array UWB transceiver in 0.18-µm CMOS," *IEEE J. Solid- State Circuits*, vol. 41, no. 12, pp. 2776–2786, Dec. 2006.

[3] T. W. Fischer, B. Kelleci, K. Shi, A. I. Karsilayan, and
E. Serpedin "An analog approach to

suppressing in-band narrow-band interference in UWB receivers,"
IEEE Trans. Circuits Syst. I, Reg. Papers, vol. 54, no. 5, pp. 941–950, May 2007.

[4] K. Rambabu, M. Y.-W. Chia, K. M. Chan, and J.
Bornemann, "Design of multiple-stopband filters for interference suppression in UWB applications," *IEEE Trans. Microw. Theory Tech.*, vol. 54, no. 8, pp 3333– 3338, Aug. 2006.

[5] I. Sever, S. Lo, S.-P. Ma, P. Jang, A. Zou, C. Arnott, K. Ghatak, A. Schwartz, L. Huynh, and T. Nguyen, "A dual-antenna phase-array ultra-wideband CMOS transceiver," *IEEE Commun. Mag.*, vol. 44, no. 8, pp. 102–110, Aug. 2006.

[6] A. Valdes-Garcia, C. Mishra, F. Bahmani, J. Silva-Martinez, and E. Sánchez-Sinencio, "An 11-band 3– 10 GHz receiver in SiGe BiCMOS for multiband
OFDM UWB communication," *IEEE J. Solid-State Circuits*, vol. 42, no. 4, pp. 935–948, Apr. 2007.

[7] A. Bevilacqua, A. Maniero, A. Gerosa, and A.
Neviani, "An integrated solution for suppressing WLAN signals in UWB receivers," *IEEE Trans. Circuits Syst. I, Reg. Papers*, vol. 54, no. 8, pp. 1617– 1625,Aug. 2007.

[8] A. Vallese, A. Bevilacqua, C. Sandner, M. Tiebout, A.
Gerosa, and A. Neviani, "Analysis and design of an integrated notch filter for the rejection of interference in UWB systems," *IEEE J. Solid-State Circuits*, vol. 44, no. 2, pp. 331–343, Feb. 2009.

[8] X. Guan and C. Nguyen, "Low-power-consumption and high-gain CMOS distributed amplifiers using cascade of inductively coupled common-source gain cells for UWB systems," *IEEE Trans. Microw. Theory Tech.*, vol. 54, no. 8, pp. 3278–3283, Aug. 2006.

[9] P. Heydari, "Design and analysis of a performance-optimized CMOS UWB distributed LNA," *IEEE J. Solid-State Circuits*, vol. 42, no. 9, pp. 1892–1905, Sep. 2007.

[10] Y. Park, C.-H. Lee, J. D. Cressler, and J. Laskar, "The analysis ofUWB SiGe HBT LNA for its noise, linearity, and minimum group delay variation," *IEEE Trans. Microw. Theory Tech.*, vol. 54, no. 4, pp. 1687– 1697, Apr. 2006.

[11] P. Z. Rao, Y. C. Cheng, C. P. Liang, and S. J. Chung,
"Cascode feedback amplifier combined with resonant matching for UWB system," in *Proc. Progr. Electromagn. Res. Symp.*, Mar. 2007, pp. 1040–1043.

[12]J. Lee and J. D. Cressler, "Analysis and design of an ultra-wideband low-noise amplifier using resistive feedback in SiGe HBT technology," *IEEE Trans. Microw. Theory Tech.*, vol. 54, no. 3, pp. 1262–1268, Mar. 2006.

[13] G. Cusmai, M. Brandolini, P. Rossi, and F. Svelto, "A
0.18-μm CMOS selective receiver front-end for UWB applications," *IEEE J. Solid-State Circuits*, vol. 41, no. 8, pp. 1764–1771, Aug. 2006.

[14] Y. Lu, K. S. Yeo, A. Cabuk, J. Ma, M. A. Do, and Z. Lu, "A novel CMOS low-noise amplifier design for 3.1- to 10.6-GHz ultra-wideband wireless receivers,"
IEEE Trans. Circuits Syst. I, Reg. Papers, vol. 53, no. 8, pp. 1683–1692, Aug. 2006.

[15] X. Li, S. Shekhar, and D. J. Allstot, "G_m-boosted common-gate LNA and differential Colpitts VCO/QVCO in 0.18- m CMOS," *IEEE J.Solid-State Circuits*, vol. 40, no. 12, pp. 2609–2619, Dec. 2005.

[16] A. Bevilacqua and A. M. Niknejad, "An ultrawideband CMOS lownoise amplifier for 3.1– 10.6-GHz wireless receivers," *IEEE J. Solid- State Circuits*, vol. 39, no. 12, pp. 2259–2268, Dec. 2004.

[17]A. Ismail and A. A. Abidi, "A 3–10-GHz low-noise
amplifier with wideband *LC*-ladder matching network," *IEEE J. Solid-State Circuits*, vol. 39, no. 12,
pp. 2269–2277, Dec. 2004.

[18] Y. Gao, Y. J. Zheng, and B. L. Ooi, "0.18-μm CMOS dual-band UWB LNA with interference rejection," *Electron. Lett.* vol. 43, no. 20, pp. 1096–1098, Sep. 2007.

[22] Ching-Piao Liang, Pei-Zong Rao, Tian-Jian Huang, and Shyh-Jong Chung," Analysis and Design of Two Low-Power Ultra-Wideband CMOS Low-Noise Amplifiers With Band-

pass", *IEEE transactions on microwave theory and techniques*, vol. 58, no. 2, february 2010.pp.277-286

[23] C.-P. Chang and H.-R. Chuang, "0.18-µm 3–6 GHz CMOS broad-band LNA for UWB radio," *Electron. Lett.*, vol. 41, no. 12, pp. 696–698, Jun. 2005.

[24] F. Zhang and P. R. Kinget, "Low-power programmable gain CMOS distributed LNA," *IEEE J. Solid-State Circuits*, vol. 41, no. 6, pp 1333–1343, Jun. 2006.

[25] Y.-J. E. Chen and Y.-I. Huan, "Development of integrated broad-band CMOS low noise amplifiers,"
IEEE Trans. Circuits Syst. I, Reg. Papers, vol. 54, no. 10, pp. 2120–2127, Oct. 2007.

[26] M. l. Jeong, J. N. Lee, and C. S. Lee, "Design of UWB switched gain controlled LNA using 0.18-µm CMOS," *Electron. Lett.*, vol. 44, no. 7, pp. 477–478, Mar. 2008.

[27] S.-K. Tang, K.-P. Pun, C.-S. Choy, C.-F. Chan, and K.
N. Leung, "A fully differential band-selective low-noise amplifier for MB-OFDM UWB receivers," *IEEE Trans. Circuits Syst. II, Exp. Briefs*, vol. 55,no. 7, pp. 653–657, Jul. 2008.