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Analysis of Low Noise Amplifier

Shivpraksh Palhewar[1], A.K. Singh[2], Amit Jain[3]

M.Tech Scholar, OIMT Damoh (M.P.)
[2]Head, Dept. Of Electronics & Communication Engineering, OIMT Damoh (M.P.),
[3]Asst.Prof. Dept. Of Electronics & Communication Engineering, OIMT Damoh (M.P.)

Abstract

An ultra-wideband (UWB) low-noise amplifier (LNA) has been proposed in this paper. The effective bandwidth of noise canceling is extended. The 0.18μm CMOS technology is used in the fabrication of this amplifier. The noise figure is calculated over 3.1–10.6-GHz along with good gain and noise figure, good linearity is also required for the LNA to operate properly. The l-dB compression point and IIP3 point are the characteristics measuring the linearity of the RF components.

Keywords— CMOS , LNA , UWB , GHz , OFDM , Bandwidth .

I. INTRODUCTION

From the last five years the demand for high-speed wireless communication systems is growing . With a frequency spectrum allocated from 3.1 to 10.6-GHz ,ultra-wideband (UWB) is emerging as a very attractive solution for short-distance and high data rate wireless communications. Two possible approaches have been proposed to implement an UWB system. One uses the multi-band OFDM modulation, while the other transmits short pulses with position or polarity modulation. Although the standard has not been completed, a front-end wideband low noise amplifier is indispensable regardless of the receiver architecture. The amplifier must meet several stringent requirements. Those include broadband input matching to minimize return loss, sufficient gain to suppress the noise of a mixer, low noise figure (NF) to enhance receiver sensitivity, low power consumption to increase battery life, and small die area to reduce the cost. There are several existing solutions for high frequency wideband amplifiers in CMOS technology. Distributed amplifiers can bring the gain-bandwidth-product (GBW) to a value close to device fT, but consume large power and area [1]. Amplifiers employing shunt-shunt feedback are well-known for their wideband matching capability, but require high power consumption to obtain reasonable noise figure [2]. A multi-section LC ladder matching network has been proposed to achieve wideband matching, low noise figure, and low power consumption simultaneously [3].However, the rapid growth of noise figure at high frequencies decreases the receiver sensitivity when operating at upper bands. Besides, the loss of inductors in the matching network contributes substantial noise, and this makes it difficult to realize them in a small area. In this work, the concept of noise canceling is re-exploited [4]. By using inductive series and shunt peaking techniques and the design methodology described in this paper, broadband noise canceling effectively lowers the noise figure over the target band under reasonable power consumption and small die area.

II. CIRCUIT DISCRIPTION

The proposed schematic is shown in Figure 1. A Chebyshev filter is used to achieve resonance in the reactive part of the input impedance over the whole frequency range of 3 to 10 GHz. Typically the Chebyshev filter consists of two capacitors and two inductors. The Chebyshev filter works as a passband filter if the sizes of L1, C1, L2 and C2 are selected correctly.

The proposed solution expands the basic inductively degenerated common source amplifier by inserting an input multi section reactive network, so that the overall reactance can be resonated over a wider bandwidth. This input matching network is shown in the Figure 1. by a dotted square. An inductor (L5) is placed in series with a capacitor (C3) to add flexibility to the design. Different values of L5 and C3 would give different matching conditions. The cascade connection of M1 and M2 improves the input output reverse isolation and the frequency response of the amplifiers.

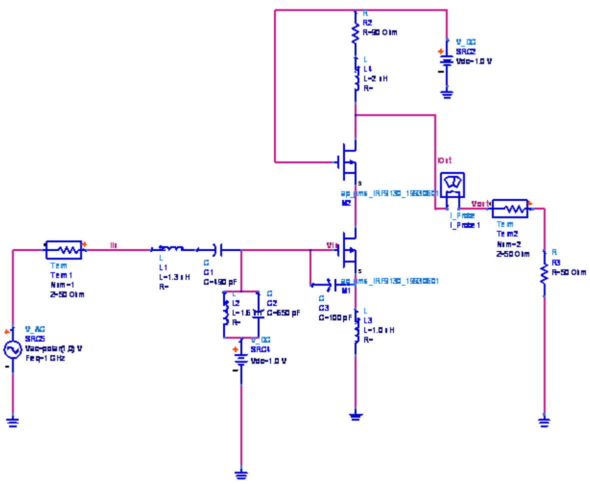

Figure 1: Proposed circuit diagram.

III. CIRCUIT ANALYSIS

A. Gain Analysis

The input network impedance is equal to Rs/W(s) where W(s) is the Chebyshev filter transfer function given by:

$$W(s)= wL1 + (1/wCi) + wL2 \quad (1)$$

Note that W(s) is approximately unity in the in-band and tends to zero at out-of-band. The impedance looking into the amplifier is therefore equal to Rs in the in-band, and it is very high out-of-band. At high frequency the MOS transistor acts as a current amplifier because of the channel length modulation effect. The current gain is given by n(s) = gm/(sCt) . The current flowing into M1 is [Vi W(s)]/R, and therefore the output current is $V_I W(s)/(sCtR,)$. The load of the LNA is a shunt peaking transistor used as a resistor.

The overall gain is:

$$Vout = \{GmW(s)\}\{R_L(1+sL/R_L)\}$$

$$\frac{Vout}{Vin} = \frac{\{GmW(s)\}\{R_L(1+sL/R_L)\}}{\{SCtRs\}\{1+SR_L C_{OUT} + sLC_{OUT}\}} \quad (2)$$

where, RL is the load resistance, L is the load inductance, and Cout is the total capacitance between the drain of M2 and ground. That means Cout = $C_{db1}+C_{gd2}$, where Cdb2 is the drain and bulk capacitance and Cgd3 is the gate and drain capacitance of transistor M2. Equation (2) shows that the voltage gain roll is compensated by L because it is directly connected to the drain of transistor M2. Moreover, it shows that Cout introduces a spurious resonance with L, which must be kept out of the band.

IV. SIMULATION AND RESULTS

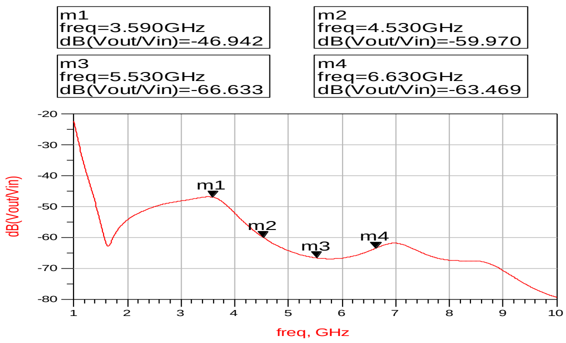

Figure 2: Voltage gain in dB

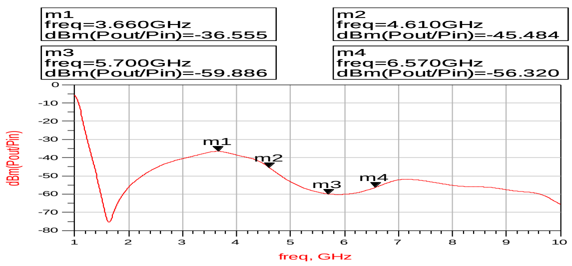

Figure 3: : Power Gain

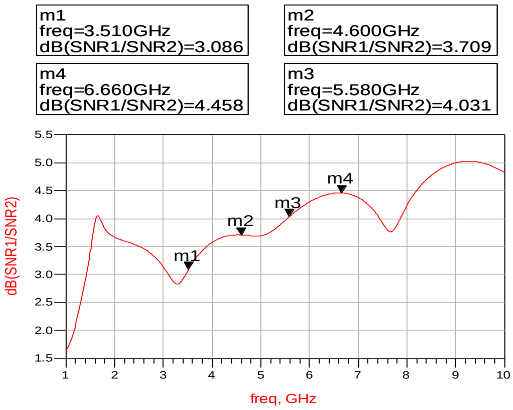

Figure 4 : Noise factor

V. CONCLUSIONS

Wireless high rate communications leverage the ultra-wide unlicensed spectrum around 60 GHz. The combination of wide bandwidths and high frequency carriers makes the design of a transceiver CMOS IC challenging. Conventional narrowband RF implementations circumvent the problem of delivering high gain at low power levels by extensive use of tuned *LC* circuits. This work introduces that is we use a Chebyshev filter at input stage than we can reduce the noise considerable amount .

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