ISSN 2395-1621

2.4GHz G_m-boosted LNA with current reuse technique

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ABSTRACT

A low noise amplifier is an essential block of receiver. To increase the strength of weak electric signal is necessary for amplification of signal further. Hence LNA plays vital role in communication system. With increasing the strength, it is also important to remove the noise present in the signal. If LNA is able to remove the noise present in the signal, then overall system noise will also be low. LNA design meets different requirements like high gain, low noise, low power consumption, good input matching circuit and high stability. For increasing G_m-boosting and current reuse techniques can be useful for better noise figure, increasing bandwidth & gain, and low power consumption. As scattering parameters can be express in terms of power and are suitable for high frequencies, we use them at RF.

Keywords— CMOS, CG-LNA, CS-LNA, current reuse, g_m-boosting, UWB.

ARTICLE INFO

Article History

Received : 16th July 2015

Received in revised form : 18th July 2015

Accepted : 23rd July 2015

Published online : 28th July 2015

I. Introduction

The demand for low power applications is increasing as technology scales down and more and more applications become battery operated. The reduction of power consumption is therefore an important aspect of winning marked shares. As technology moves towards finer geometries, the power consumptions are going down. In Radio Frequency circuits this reduction in power consumption has not taken place in the same manner. In other words, there should be some potential to reduce the power consumption in RF-circuits. As LNA is first block of receiver, it plays vital role in communication system. The overall performance of receiver depends on the LNA noise figure, gain, impedance matching, power consumption. LNA design is such that it should provide minimum noise while providing gain with sufficient linearity. For increasing gain g_m-boosting is benificial while for less power consumption current-reuse is good one. Different topologies of LNA like common gate, common source, common drain have different pros and cons. Common gate provides better noise performance while common source has high gain.

Super-heterodyne receiver-

As LNA is front end receiver block, it must capture and amplify very low-power, low-voltage signal. LNA also helps in reducing the noise of the received signal. Output of this LNA is feed to the mixer where this signal is down convert to lower frequency. Another input to the mixer is from local oscillator (LO) whose frequency is set near to the RF input. The low output of mixer is filter by IF filter. High gain IF amplifier raises the power of signal and thus baseband information is recovered back without distortion.Fig.2 shows the basic blocks of LNA where termination impedance is 50Ω.When two port network is transistor, its performance is optimized by inserting matching network at each port.

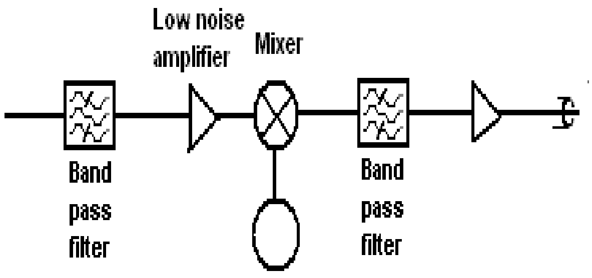

Fig 1: Super-heterodyne receiver

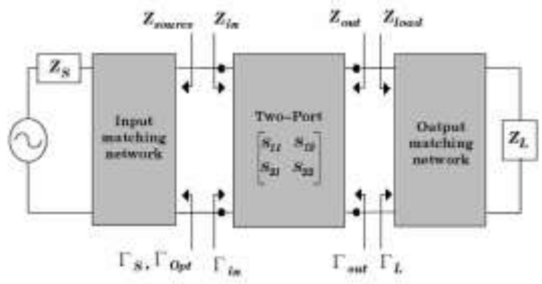

Fig 2: Blocks of LNA

Overview of UWB

In 2002 the Federal Communications Commission (FCC) approved the ultra-wideband unlicensed spectrum usages of 1.99-10.6 GHz, 3.1-10.6 GHz and 22-29 GHz for commercial applications [2]. This announcement attracted the interest of both industry and academic leading to a flurry of research in this relatively new domain.

The definition of UWB according to the FCC is either (a) a fractional bandwidth greater than 0.2 or (b) a bandwidth greater than 500 MHz. The fractional bandwidth is calculated as $2(f_H - f_L)/(f_H + f_L)$/(UWB systems are capable of transmitting over a large frequency bands and can do so with very low power and high data rates . Other advantages are coexistence with other radio services, resistance to jamming and multipath fading, excellent signal penetration properties and simple transceiver architecture.

II. CURRENT REUSE TECHNIQUE

In literature, several narrowband and broadband current-reuse architectures have been proposed and majority of them are based on a cascade of CS stages (CS-CS) sharing the bias current[1]–[2]. A single inductor is used, to isolate the cascading stages adequately. Then for better isolation, in [3], LC T-network is used to provide third order isolation. A narrowband gm-boosted CG LNA with current reuse technique is introduced which uses a CS amplifier as the cascaded stage (CG-CS) to boost the gain, in [5]. By using the transformer coils connected across the source and the gate terminals of the input device the gm -boosting gain is provided.

Despite the transformer being a passive device consuming no electrical power, it is not suitable for adoption in UWB applications due to process nonlinearities and the presence of low parasitic resistance that can cause pronounced noise at the output of the amplifier. A gm-boosted CG UWB LNA is designed in [5], that utilizes an active pMOS CS device to provide the inverting gm-boosting gain. This design does not utilize the current-reuse technique and the bias currents through the CG amplifying stage and the CS gm –boosting stage are not shared. It also utilizes another CS stage in cascade which is separately biased as well and because of that more power dissipation is there[8]. The UWB LNA circuit, proposed in this paper, takes advantage of the current-reuse technique. Thus the new approach proposed here, is to reduce the power dissipation. Current-reuse with G_m-boosting share the bias current.

III. GM-BOOSTING TECHNIQUE

The gm-boosting stage made with a common source amplifier in [7]. In order to cancel the noise of CG transistor, instead of using feed-forward path, to cancel the noise of the input matching transistor we utilize gm-boosting stage. A way to reduce the noise factor of the common gate LNA is to increase the transconductance.

The noise factor can be traded against input matching by increasing the transconductance i.e. increasing the current lowers the input impedance and the noise factor. Fig.3 shows general scheme of Gm-boosted common gate LNA. It ismore clever way to do this is by inserting an inverting gain between the source and the gate node of the common gate LNA. G_m-boosting technique is employed which can effectively restrain the power, enhance the gain and reduce the noise simultaneously.

$$\mathbf{Fmin_{CG} = 1 + \gamma/\alpha \,.\, 1/(1+A)2\, gm.Rs = 1 + \gamma/\alpha \,.\, 1/1+A}$$

This equation suggests that an inverting gain between the source node and the gate node clearly reduces the noise figure. It is the best way of increasing gain without increasing noise figure and reducing power consumption. To achieve these requirements CG LNA needs to increase the transconductance(g_m).

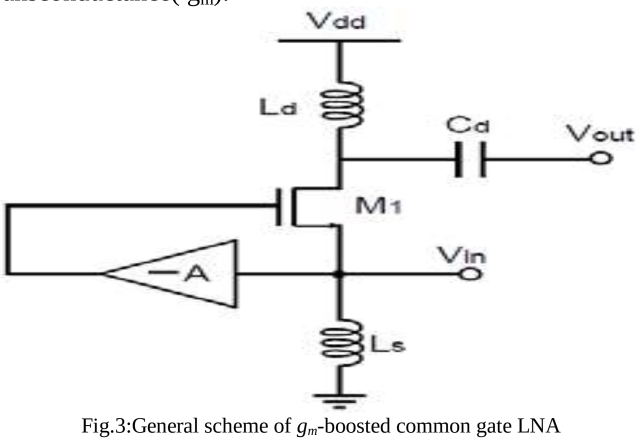

Fig.3:General scheme of g_m-boosted common gate LNA

Proposed CG LNA with current reuse & gm-boosting technique

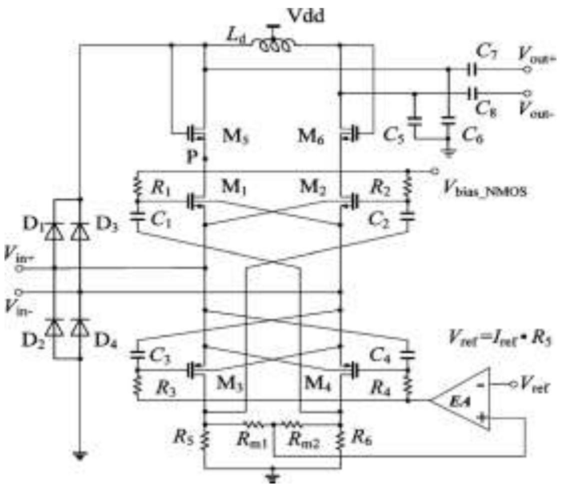

Fig.4:Proposed Common gate LNA

Fig. shows commong gate low noise amplifier where M1, M2 makes the NMOS input CG stage and M3, M4 constitute PMOS input CG stage. C3,C4 and R3, R4 constitute the capacitor cross coupling(CCC) topology. The M3, M4 with R5,R6 constitute an amplifier to provide amplified signal to the gate of M1, M2. Rm1, Rm2 & error amplifier costitute the common mode feedback circuit to stabilize the current

IV.RSULT AND DISCUSSION

Gain obtain at 2.4GHz is 10.3dB. After simulation noise figure we get is 3.2dB. which is reduced with the help of G_m-boosting technique. Input return loss (S_{11}) is -9.41d B. Output return loss(S_{22}) is -2.47dB. If we further increase the transconductance it will help in reduction of noise. For this CG-LNA power dissipation is about 0.58mW. As we used current reuse technique here it helps in reduction of power dissiption.

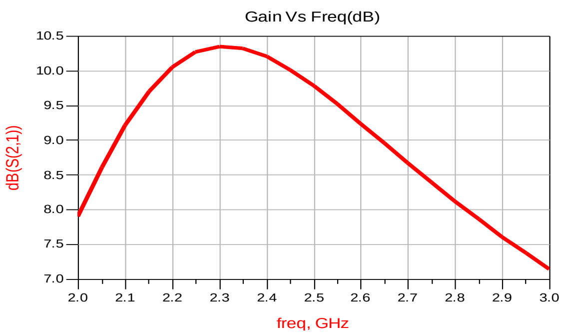

Fig.5 :Graph of gain Vs frequency

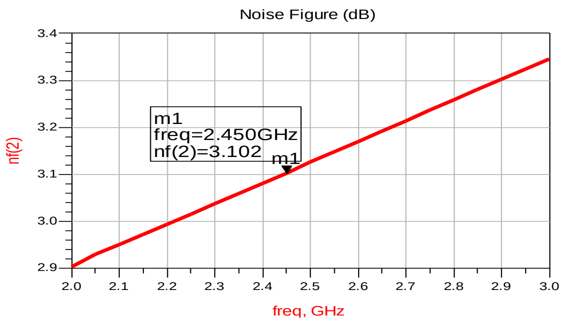

Fig.6: Graph of noise figure

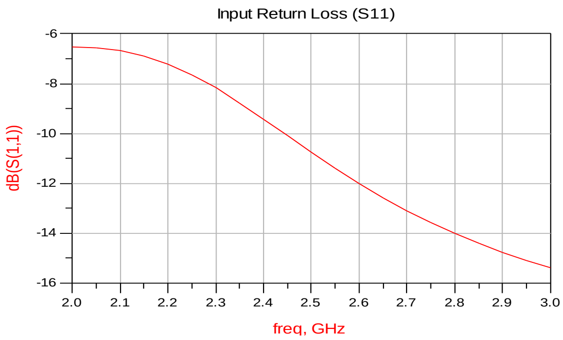

Fig.7 : Graph of Input return loss

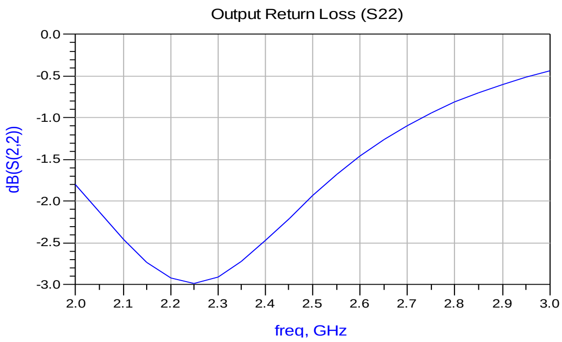

Fig.8: Graph of output return loss

V. CONCLUSION

In this article 2.4GHz CG-LNA with G_m-boosting technique & current reuse technique have seen. As we work on 2.4GHz frequency range, we can have application of this low noise amplifier in Bluetooth,zigbee etc. Introduced g_m-boosting current reuse topology exhibits lower noise figure & also consumes less power than conventional CG-LNA

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