

A Review on Low Noise Amplifier

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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.

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 beneficial 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.

II. 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.

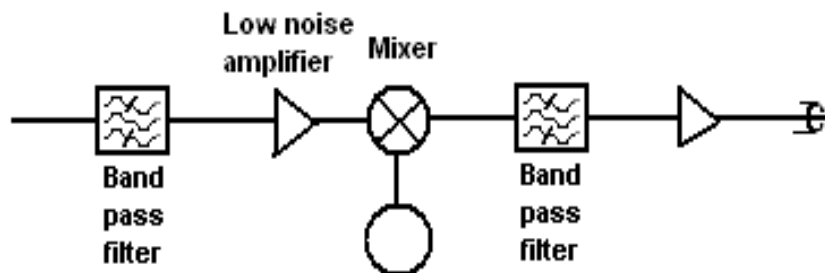


Fig 1: Super-heterodyne receiver

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III. BASIC BLOCKS OF LNA

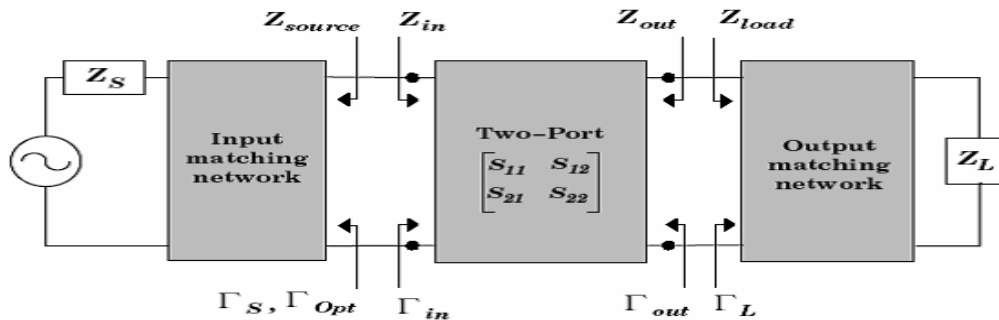


Fig 2: Blocks of LNA

It has input matching network, output matching network and in between them two port network is there. When two port network is transistor, its performance is optimized by inserting matching network at each port.

IV. TOPOLOGY WITH COMPARISON

In terms of gain & noise figure CS or cascade is widely used topology. But at lower operating current, near weak inversion CG provides better noise performance. CG provides a broader and less sensitive input matching network than the CS does while the gain of CG is lower than that of CS. As CG has better noise performance, it is used in the ultra-low power domain, the CG topology is applicable for noise limited design.

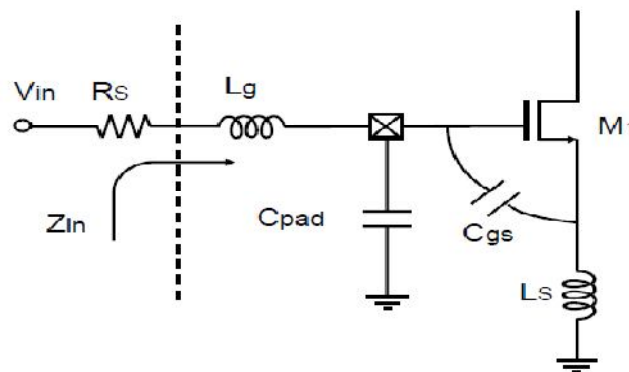


Fig 3: Common source topology

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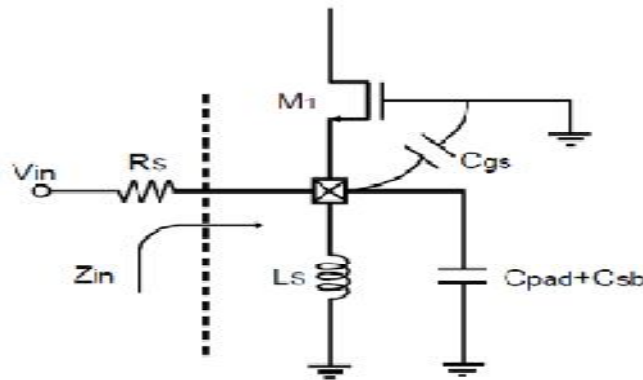


Fig 4: Common gate topology

V. 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 in the operating band along with improved noise performance. A narrowband g_m -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 g_m -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 g_m -boosted CG UWB LNA is designed in [5], that utilizes an active pMOS CS device to provide the inverting g_m -boosting gain. This design does not utilize the current-reuse technique and the bias currents through the CG amplifying stage and the CS g_m -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 associated with the g_m -boosting, by implementing the “current-reused g_m -boosting”, where the bias current is shared between the amplifier stage.

VI. G_m -BOOSTING TECHNIQUE

The g_m -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 g_m -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. A more 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 will be employed which can effectively restrain the power, enhance the gain and reduce the noise simultaneously.

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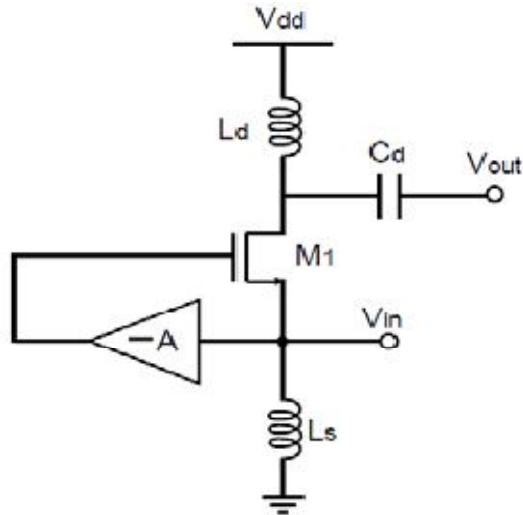


Fig 5: General scheme of g_m -boosted common gate LNA

VII. DIFFERENT TYPES OF LNA

As per the literature survey, the types of LNA are shown here. Each one has different feature.

Cascode LNA-Fig.6 shows cascode LNA which has external capacitor connected to it C_{ex} that has value equal to C_{gs} . The addition of C_{ex} helps in reduction of power consumption without affecting noise performance & linearity.

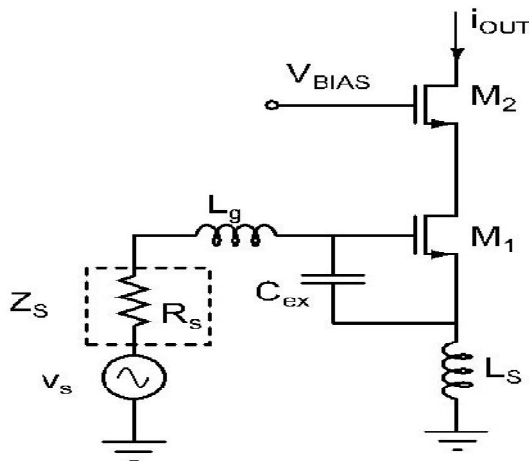


Fig 6:Cascode LNA with external capacitor

Single ended LNA-

Fig. 7 shows the schematic of designed single ended LNA.

Transistor M_1 is the main transistor and the M_2 is the cascode transistor. It uses two more additional transistors than in the basic LNA. They are used to improve the linearity through feed forward technique. Single ended are simple to implement but more importantly they do not have crossover distortion which is when the signal changes from positive to negative and for very small signals this can be pretty bad. That having said it does have second harmonic distortions but these are correctable. A disadvantage is that single ended are not as power efficient either.

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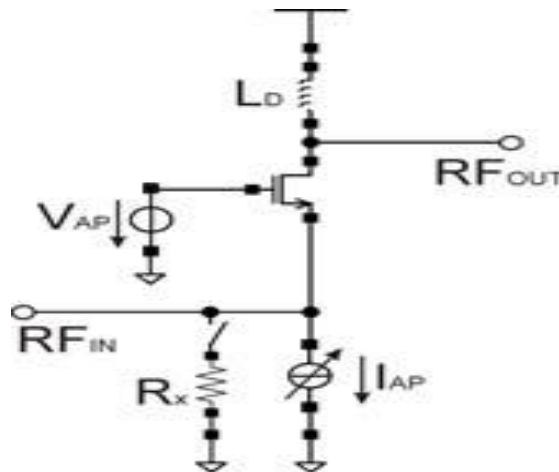


Fig 7 : Single ended LNA

Differential LNA-

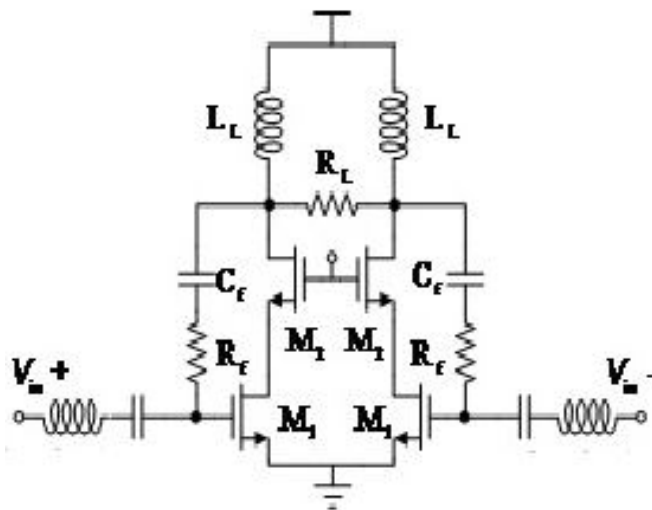


Fig 8: Differential LNA

There are so many merits to use differential architecture, such as abiding the noise. Millimeter wave signal can be easily leaked, and differential signal can be used to eliminate the negative effect of leaking signal. Meanwhile differential LNA can restrain common mode interference, so the noise of source voltage and underlay voltage can also be restrained. Differential amplifiers have some advantages over single ended amplifiers. They usually have higher power supply noise rejection and package parasitic does not influence the operation in the same extent as in single

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ended amplifiers. The applications they are meant for are not equal, but there is one important common feature for this thesis, that is they all share a relatively high branch current which leads to higher power consumption compared to a single ended LNA.

VIII.CONCLUSION

Different types of LNA & topologies like common gate & common source are explained here. CG topology provides better noise performance while CS has high gain. But by using G_m -boosting technique, it is possible to enhance the gain and reduce the noise as well. Current reuse helps in reducing power consumption & thus increases the performance of LNA.

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