Design of Single to Differential Amplifier using 180 nm CMOS Process

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Abstract

An Active balun for 500 MHz is presented in this paper. An active balun converts single-ended input signals to differential signals. The design is implemented using 180 nm CMOS process and it operates from 400MHz to 1 GHz. The study elaborates the design technique to improve the mixer performance. The main aim is to increase the voltage swing. Four metal layers are available to design.

Keywords: Balun, voltage swing, CMOS

1. Introduction

Design of the modern Radio Frequency Integrated Circuits (RFIC) receivers becoming more and more challenging. The simplest receiver is consists of Low Noise Amplifier (LNA) to amplify signal and mixer to convert high frequency signal to lower frequencies. The signal that comes from antenna to LNA is single-ended. It should split input signal into two signals opposite in phase and equal in amplitude. This type of circuit is called as phase splitters or BALUNs (BALanced to UNbalanced converter).To save the power, balun can be integrated with LNA. LNA has to fulfill a lot of requirements. Beside its basic parameters, like noise figure, gain, impedance matching and current consumption, it also has to provide small phase and gain imbalance. It is not easy to design a circuit that thatl meet all these requirements. And if one will succeed then power consumption of such balun and LNA will very often exceed power consumption of both circuits separately. This paper is focused on balun as a separate block.

Baluns can be divided into two groups: passive and active. Passive circuits are not a popular choice in ICs. The passive elements have capacitors and especially inductors, which consumes a lot of chip area. It will increase the cost. The main disadvantage is passive circuits are lossy. It is especially importat when the receiver ha to detect weak signals. The major disadvantage of passive circuits is that they operate in narrowband.

A block diagram of the proposed system is presented in Fig. 1. Single-ended signal from LNA is converted to a differential by balun and then differential signal process for mixinf by the mixer.

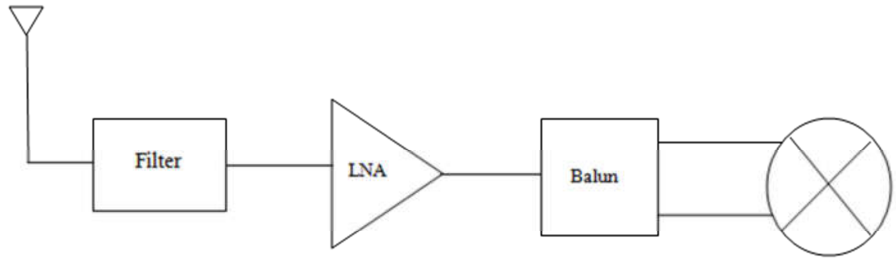

Fig.1 Block diagram of the front end of receiver

The aim of this work is to design a balun in CMOS process is to design balun with low power consumption and without using integrated inductors (to save chip area).The paper is organized in the following way: Section II discusses the balun circuits presented in literature. Simulated architecture, simulation results and the comparison with baluns described in other papers are presented in Section III. Finally, conclusions is presented in Section IV.

2. Balun Architecture

The simplest architecture is presented in Fig. 2 as one transistor balun. Due to the parasitics it is impossible to achieve good gain and phase imbalance in wide frequency range, so this circuit is not used in ICs.

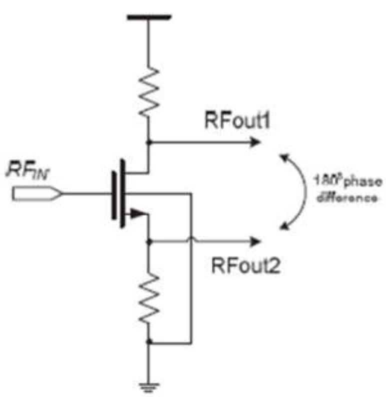

Fig. 2 one transistor configuration

The second architecture is a combination of common gate and common source amplifiers. RF signal is fed into input of both amplifiers. The first stage will not change phase of the input signal but the phase will change in the second stag by 180°. This circuit is also not used often in ICs.

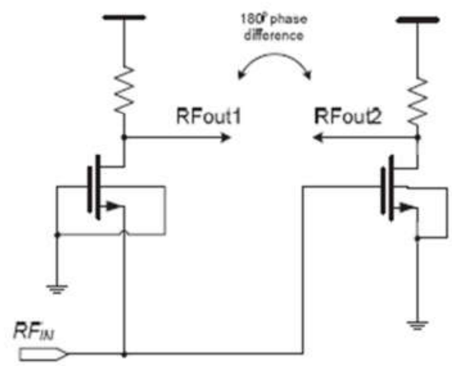

Fig. 3 Common Gate with common source configuration

Fig.4 presents two common source amplifier configuration. Each of them shifts phase by 180°. The first stage provides gain and the second one the desirable phase difference.

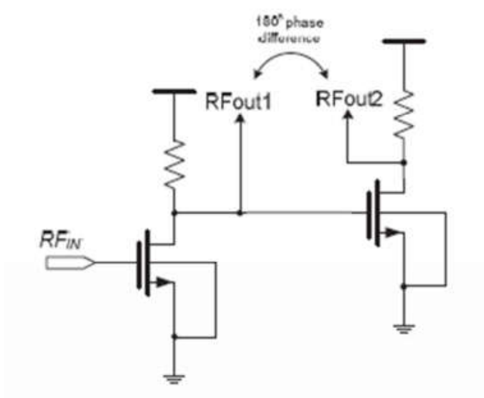

Fig. 4 Two stages of common source configuration

A single-ended signal is measured with respect to fixed potential and usually it is ground. A differential signal is measured between two nodes which are probably equal and opposite around a fixed potential. The center potential in differential signal is called as common-mode signal.

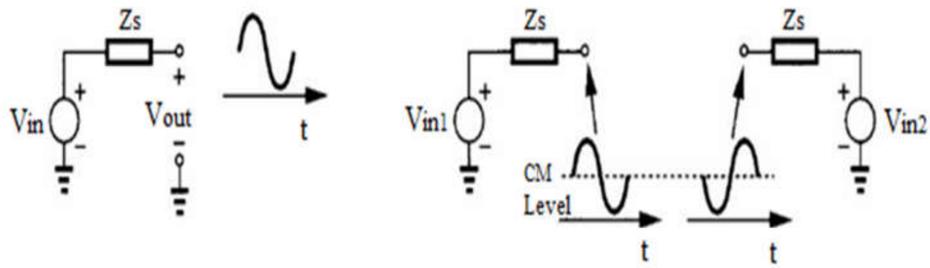

Fig. 5 (a) Single-ended and (b) differential signals

The differential operation has higher noise immunity compare to single-ended signal. The common mode level of two phases are distributed but differential output is not corrupted it rejects the common mode noise.

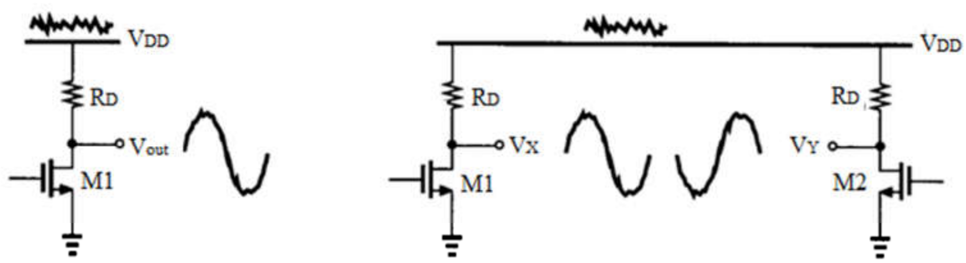

Fig. 6 Effect of Supply noise on (a) a single-ended circuit (b) a differential circuit

Basic Differential Amplifier

The major advantages of differential signalling is high rejection of supply noise and high output swings. As the input common mode level changes the bias currents of M1 and M2 changes and transconductances of the devices changes thus output common mode level changes.

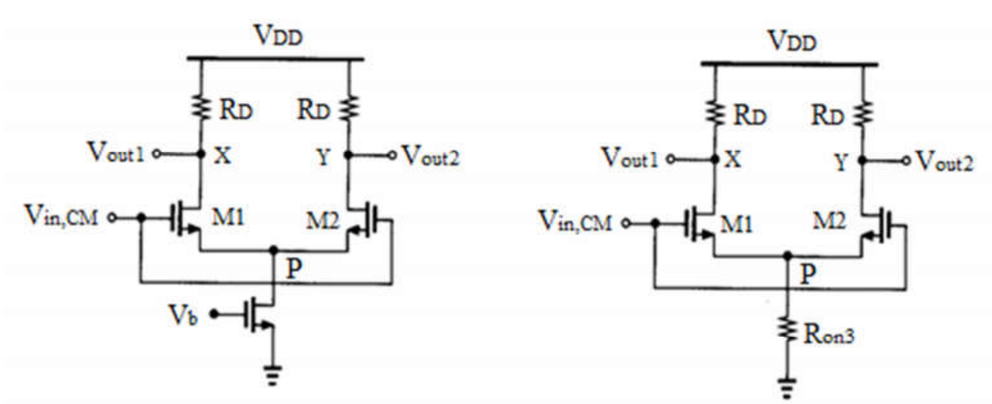

Fig. 7 Differential Amplifier[5]

3. Design and Simulated Results

Design of Balun at 500 MHz

The circuit is designed for 500MHz which will used in next stage(mixer).Here Voltage source is 500MHz which in single-ended input. As a result we want differential signal in

same amplitude and 180 ° phase shift. All the nmos are in saturation region. At source side capacitor is used for DC blocking and another capacitor is used for changing amplitude. At the terminals where outputs are taken has 50 ohms resistors for matching. As a result IF+ and IF- are out of phase and get 0.4 to 1.8V voltage swing.

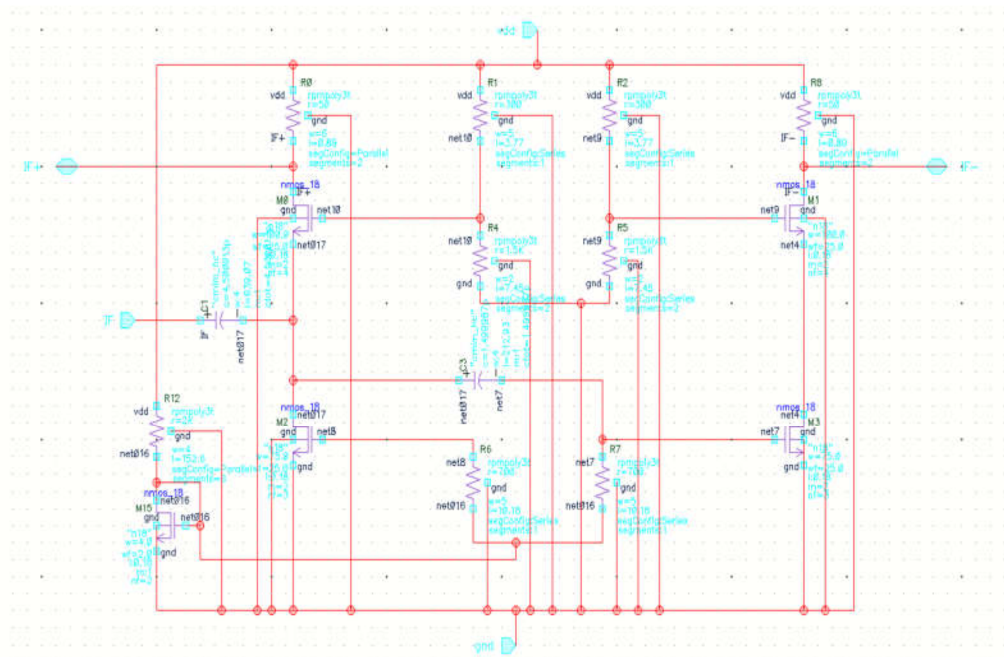

Fig. 8 Balun Schematic

Balun Transient Response

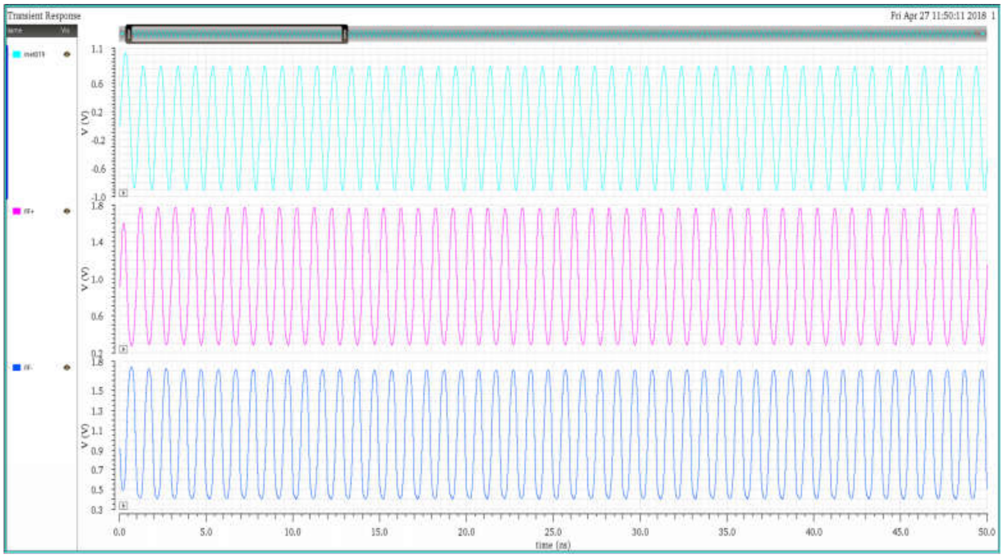

Fig.8 Balun Schematic

Balun Layout

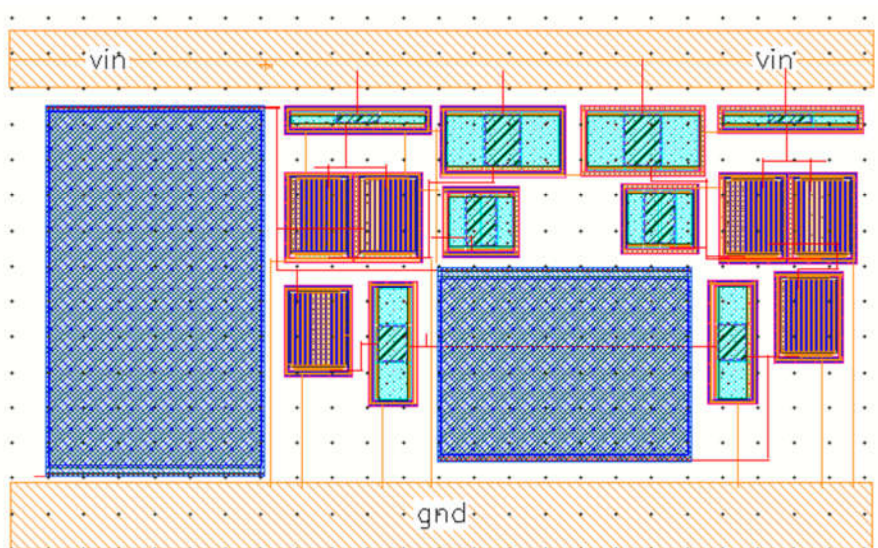

Fig.9 Balun Layout

4. Conclusion

The proposed active balun has been designed using 180 nm CMOS technology. The active balun is designed for single ended to differential signals. Inductor is not used in balun so chip size should be compact. The proposed design can achieve.

References

[1] Yiming Huo, Xiaodai Dong, Ping Lu , "A TRPC-UWB Transmitter Front-end Based on Wideband IQ Modulator in 0.13-μm CMOS", 12th IEEE International Conference on Solid-State and Integrated Circuit Technology(ICSICT), 2014

[2] Hossein Kassiri , M. Jamal Deen, "Low Power Highly Linear Inductorless UWB CMOS mixer with Active Wideband Input Balun", International Wireless Symposium,IEEE,2013

[3] De-Mao Chen, Zhi- Ming Lin, "A Fully Integrated 3 to 5 GHz CMOS Mixer with Active Balun For UWB Receiver", Asia Pacific Conference on Circuits and Systems (APCCAS), IEEE,2006

[4] Senghg-Feng Lu, Jyh-ChyurnGuo, "5.5 GHz Low Voltage and High Linearity RF CMOS Mixer Design", European Microwave Integrated Circuit Conference, IEEE, 2008

[5] Behzad Razavi, "Design of Analog CMOS Integrated Circuits"