90nm CMOS design of an Ultra Wide Band active balun

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***Abstract*— This report describes the design and implementation of an ultra-wide band active balun operating in 2GHz-10GHz frequency range. The balun is put at the front end of a receiving balanced antenna in order to transform the differential input signal into a single-ended output. The fact that the balun operates on a broad spectrum makes it convenient to use for many applications. With this active balun a low power supply of 1.2V is used in order to target a low power consumption product, 90nm CMOS technology can meet these specifications. The active characteristic of the balun provides a positive gain which compensates the loss due to impedance mismatch or due to the presence of non-ideal elements in the design.**

***Index Terms*—balun, balanced, wide-band, CMOS**

I. Introduction

A balun is a system used to connect balanced lines to unbalanced lines. It is designed to properly interface unbalanced circuits to balanced circuits. Balun is derived from "**bal**anced to **un**balanced" but this does not restrict baluns to only balanced input/unbalanced output configuration as there also exist unbalanced input/balanced output baluns. An unbalanced line consists of two conductors one of which is the ground and the other one is the signal. The problem with this kind of lines is that any noise picked up along the way will appear at the end of the line and this could completely alter the signal if the noise is important. A balanced line though consists of three conductors: the signal, an out of phase copy of the signal and finally the ground. This kind of lines has the advantage of being extremely resistant to noise because any noise picked up on the signal will be picked up as well on the signal copy and thus a simple subtraction of the two signals cancels the noise.

Nowadays, baluns are widely used in a variety of applications such as transmitters, radars, satellites and telephone networks. They are present at inputs and outputs of balanced amplifiers feeding balanced antenna systems. The majority of modern commercial transceivers contain a balanced amplifier at the output stage which is connected to the unbalanced output by the means of a wide band balun.

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There are two types of baluns which are classified mainly by their conversion nature (balanced-to-unbalanced or unbalanced-to-balanced). The implementation of a balun can be done using different topologies, this report discusses a topology of a balanced-to-unbalanced balun using single stage amplifiers.

II. Balun Design

A. System description

The idea of the design is to use two single stage amplifiers on the two input pins (differential input). The two amplifiers should provide the same gain for a wide bandwidth (2 – 10 GHz). The first amplifier should flip the Vin- pin with a certain gain; a common source amplifier is used to achieve that goal. The second amplifier should be in phase with the Vin+ pin and provide the same gain, a common gate amplifier is used for that. The figure below (Fig.1) is the functional block of the design:

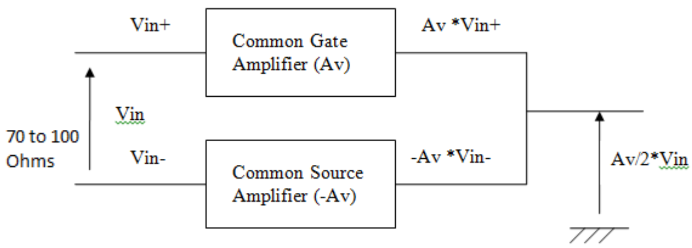


Fig.1 – Functional block of the balun

First, simple single stage amplifiers are designed with the appropriate biasing networks and are simulated separately before assembling the final balun. This paper presents the final optimized balun and the results of the S-Parameter simulations done in ADS from Agilent.

B. Balun configuration

Fig.2 presents the circuit used for the balun

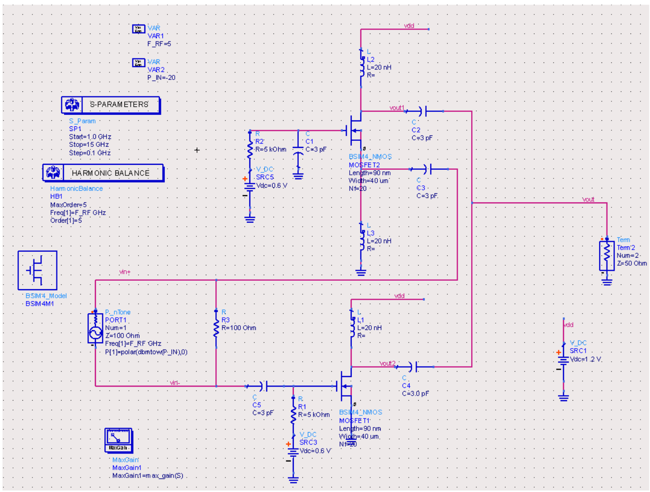
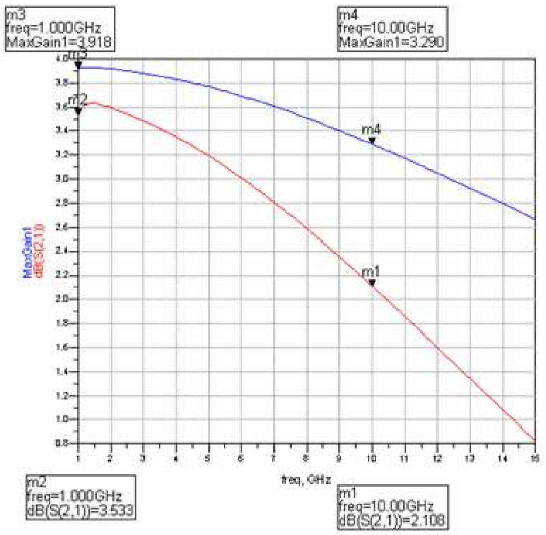
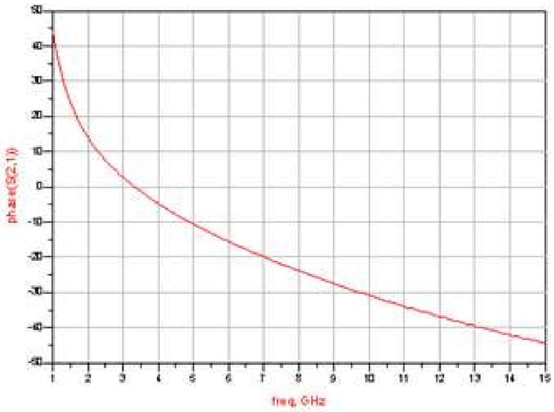


Fig.2 – Balun Schematic

In the figure above, the top block represents the common gate amplifier while the bottom block represents the common source amplifier. The signal is issued from a differential harmonic tone and is amplified through both stages before getting combined at the output. The 100Ω resistor at the input stage is used for input matching. Fig.3 presents the simulation results of the balun.





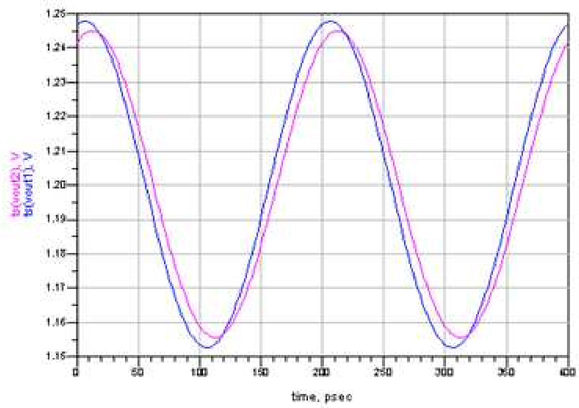


Fig.3 – Simulation results of the balun

We can see from the figures that broadband matching is performed from 1GHz to 10GHz. The gain is ranging from 3.5dB down to 2.1dB for the same frequency band. The output wave forms of the two stages are approximately identical with a very small phase that can be corrected by adjusting the DC bias and/or the transistor sizes.

III. Conclusion

A balun is an electrical system that can convert a balanced signal (differential signal) into an unbalanced signal (single-ended signal). It is used in a wide range of applications such as transmitters, radars, satellites and telephone networks. Baluns are classified based on the type of the conversion they perform: either a balanced-to-unbalanced-conversion or an unbalanced-to balanced conversion. Another criterion of classification is based on whether they are active or passive.

In this project we presented a new idea of implementing a 90nm CMOS UWB active balanced-to-unbalanced balun for 2GHz-10GHz frequency band. We showed how we can simply associate two single stage amplifiers in order to couple the two waves issued from the differential input signal. Simulations of the balun in ADS showed that we can combine signals from the two amplifying stages to transform a differential input signal to a single-ended output signal.

These simulations were later done in Cadence using a real transistor model from TSMC, the results are quite similar to the results obtained using ADS. We are at the present time at the fabrication stage of the chip.

IV. Next Career Plans

I am doing a PhD program with the same advisor John Papapolymerou. MTT-S scholarship motivated me to continue my career in the research field and helped shade the light on my work by allowing the publication of this paper in the MTT-S education website. It also supported me in covering part of the expenses for my travel to MTT-S IMS conference 2012 in Montreal. That was an opportunity for me to see the most prestigious RF conference in the world and to meet with many professionals in this field, I was also given the award certificate during that week.