ELCA
Mekelweg 4,
2628 CD Delft
The Netherlands

M.Sc. Thesis

Highly Linear LNA Design for Base Station Applications

Bo Wu B.Sc.

Supervisors:
Associate Prof. Dr. ing. Leo C. N. de Vreede, TU Delft
Ir. Paul Mattheijssen, NXP Semiconductors
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Bo Wu B.Sc.
born in Anhui, P.R.China

This work was performed in:

ELCA Group
Department of Microelectronics
Faculty of Electrical Engineering, Mathematics and Computer Science
Delft University of Technology

Delft University of Technology

Delft University of Technology
Department of
Microelectronics

The undersigned hereby certify that they have read and recommend to the Faculty of Electrical Engineering, Mathematics and Computer Science for acceptance a thesis entitled **"Highly Linear LNA Design for Base Station Applications"** by **Bo Wu B.Sc.** in partial fulfillment of the requirements for the degree of **Master of Science**.

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Chairman:

Prof. Dr. John R. Long

Advisors:

Dr. Leo C. N. de Vreede

Ir. Paul Mattheijssen

Committee Members:

Dr. Rene van Swaaij

Prof. Domine Leenarts

Dr. Mark van der Heijden

Abstract

As the first stage of the amplifier chain aiming for the base station applications, a highly linear low noise amplifier (LNA) dictates very high performance for optimum coverage with a best signal quality. In today's commercial market, the GaAs enhancement-mode pHEMT based LNA is dominant. However, a SiGe-based LNA, due to its high integration, is still attracting the interest from industry. In this thesis, the highly linear SiGe-based LNA design procedure is presented.

For the fully-differential LNA design, the base tuning and emitter tuning, which both belong to the out-of-band matching technique used to increase linearity, are analyzed in details. Although the base tuning suffers more from mismatches in comparison with the emitter tuning, it is proved that proper choice of the harmonic trap capacitor is able to mitigate this effect, which can trigger a higher linearity.

For the single-ended LNA design, the out-of-band matching is still feasible for narrow band applications. A compact topology of highly linear low noise amplifier which is composed of an emitter inductive degeneration and out-of-band matching core is proposed. Moreover, a modified neutralization function block based on on-chip transformer and bondwire inductor is also proposed. For this configuration, simultaneous noise/input matching, linearity improvement and a good reverse isolation is able to be achieved. It proved effective and convenient for a packaged monolithic RF chip.

However, most input-referred linearity optimization techniques focused on the harmonic termination design at the input part, which leads to a narrower bandwidth and a higher noise figure due to extra losses in practice. To avoid these issues, an innovative linearity improvement method based on optimizing the output load is proposed. A novel two-stage highly linear LNA is designed to validate this theory. It achieved a power gain of 29dB and noise figure of 0.7dB at 1.7GHz, while only consumed 41mA from 3.3V supply. The OIP_3 can be better than 38dBm from 1.2GHz to 2GHz. The input-referred 1dB compression point is -5dBm. The simulated result is the state-of-the-art among the current existing SiGe-based LNAs for base station applications. The design, as a part of a highly linear monolithic RF receiver, has been carried out using NXP QUBiC4x BiCMOS technology.