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Ain Shams University
Faculty of Engineering
Electronics and Communications Engineering Department

Low-Noise Amplifier Design in SiGe BiCMOS Technology

A Thesis

Submitted in Partial Fulfillment for the Requirements of the degree of
Master of Science in Electrical Engineering

Submitted By

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The work included in the thesis was carried out by the author in the Department of Electronics and Communication Engineering, Ain Shams University.

No part of this thesis has been submitted for a degree or a qualification at any other University or institute.

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Abstract

Hany Yousef El Hak, "Low-Noise Amplifier Design in SiGe BiCMOS Technology", Master of Science dissertation, Ain Shams University, 2003.

Low-Noise Amplifiers (LNA's) for wireless applications are examined in detail demonstrating their role in a wireless receiver. LNA performance parameters namely gain; noise figure; return loss; reverse isolation; linearity; and stability are explained illustrating their impact on the system performance. A survey on recent LNA publications is carried out. Different LNA topologies are presented and LNA implementations in silicon bipolar and SiGe HBT BiCMOS technologies are compared.

Design and optimization techniques of inductively degenerated, tuned, cascode LNA are presented, showing the impact of bonding pads, bond wires, layout and package parasitics on LNA performance. These techniques are applied to the design of a single-ended and a differential LNA that target GSM specifications. The two LNA's are implemented in 0.8μm SiGe BiCMOS technology. Simulation results of the single-ended LNA show 2 dB noise figure, 13 dB forward gain, -16 dBm iP_{-1dB} and iIP_3 of -5.4 dBm, together with good input/output matching and 30 dB reverse isolation, while those of the differential LNA show 2 dB noise figure, 15 dB forward gain, -14.7 dBm iP_{-1dB} and iIP_3 of -4.7 dBm, with good input/output matching and 70 dB reverse isolation. Both single-ended and differential LNA's are stable and consume 13 mW and 35 mW respectively from a 3V supply.

A new compact approach for the design of a dual-band LNA is devised. The proposed topology features a minimum number of devices, reducing the physical layout to its limit, thus improving cost and form factor. Band selection is controlled by three switches that guarantee good input/output matching, adequate forward gain and low noise figure. The LNA circuit is designed and simulated in a 0.8 μm SiGe BiCMOS technology. Simulation results for the GSM 900 MHz and DCS 1800 MHz bands indicate that the achieved noise figure is below 2 dB, forward gain is higher than 18 dB and iIP_3 is above -7 dBm, while consuming 13 mW from a 2.7V supply for both bands.

The differential GSM LNA has been prototyped at Austriamicrosystems and housed in an SSOP package. The measured LNA gain and noise figure are 14.8 dB and 2.2 dB respectively at 850 MHz, and 13.3 dB and 2.5 dB respectively at 900 MHz. Measurements match simulation results except for a 40 MHz shift in frequency which is accounted for by the 20% error in the modeling of on-chip spirals. Measured LNA input and output return loss are 14 dB and 9.5 dB respectively at mid-band, while reverse isolation is 47 dB. Measured iIP_3 and P_{-1dB} are -4.2 dBm and –11.2 dBm respectively. Power consumption is 36 mW from a 3V supply.

Key Words: LNA, GSM, noise, dual-band, wireless applications.