A Low Noise Amplifier for 5G Applications in 0.13-µm SiGe HBT technology

Armagan Dascurcu, *Student Member, IEEE*, and Yasar Gurbuz, *Member, IEEE*

***Abstract*—This paper presents a K-Ka band low-noise amplifier(LNA) using 0.13-µm SiGe HBT technology. Inductive degenerated common source topology is designed as first stage to realize the noise figure(NF) and cascaded with cascode stage to improve isolation. Wideband output matching is obtained with equalization based matching network. The simulation results of proposed 2-stage LNA shows that 2.2 dB NF at 28 GHz, 16 dB maximum gain and 18-40 GHz 3-dB bandwidth. Total dissipated power is 28.8 mW and LNA occupies 0.79 µm^2.**

***Index Terms*—5G, LNA, SiGe HBT, K Band, Ka band, wideband**

I. INTRODUCTION

As a matured technological system, 4G almost reached its ultimate limits, there is only left small room for improvement in terms of technology and frequency spectrum. Today, number of device, desired data rates and expected communication quality are increasing exponentially. In near future, current technology will not provide desired quality and data rate, fifth generation(5G) technology is proposed to serve this purpose. Researches on required block designs and improvement of existing topologies for previous generation techniques have already started in the world. Despite the fact there is a remarkable time for transition to 5G, there is not enough work for purpose of new generation yet [1].

Recent improvements in heterojunction bipolar transistors(HBTs) enable SiGe BiCMOS technology to reach performance of III-V technology. Higher integration capability and lower cost property of Silicon based devices compare to III-V counterparts lead them to be used widely in RF circuits [2].

In this paper, a two-stage wideband LNA with 0.13 µm SiGe BiCMOS technology is proposed. Low noise performance is achieved with inductive degeneration at first stage and wide output matching is established equalization based matching network.

II. CIRCUIT DESIGN AND RESULTS

Equalization based matching network limits gain of circuit by introducing loss for this reason a two-stage amplifier is designed as common source cascaded by a cascode stage, illustrated in Fig. 1.

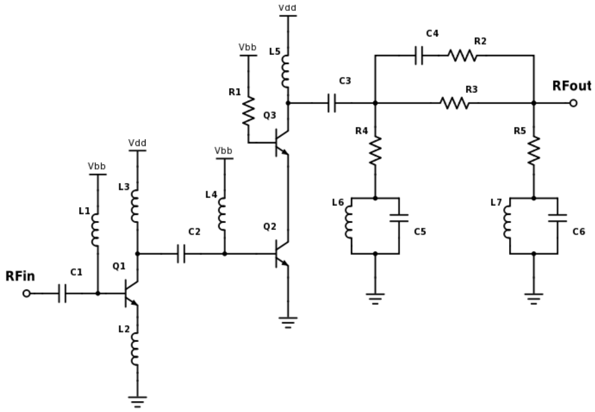

Fig. 1. Schematic of the 2 stage LNA

Common source is chosen as first stage because of its low noise performance. Degenerative inductor is designed to achieve simultaneous noise and input matching at 28 GHz. Cascode stage provides high isolation between input and output by eliminating Miller effect on base to collector parasitic capacitance(C_μ). Besides the acquisition of blocking direct coupling, it provides higher bandwidth. Wideband output matching network is based on equalization of gain values for different frequencies by introducing loss that is inversely proportional with frequency in a way that compensates gain reduction towards frequency increase. Introduced loss is adjusted to achieve its minimum at highest frequency in desired band and has positive slope that is identical with absolute value of gain slope. Despite the fact proposed technique for output matching limits achievable gain, it provides maximum bandwidth for gain linearity.

Fig. 2 provides the layout of proposed LNA which is designed with IHP Microelectronics 0.13-µm SiGe HBT technology. Total die size is 0.935x0.84 mm^2. The schematic and layout is designed with Cadence virtuoso and electromagnetic simulations are completed in Advance Design System(ADS) momentum.

A. Dascurcu, was with Sabanci University, Istanbul, 34956 TURKEY. She is now with the Department of Electrical Engineering, Columbia University, New York, NY 10027 USA (e-mail: ad3428@columbia.edu).

Y. Gurbuz is with the Faculty of Engineering and Natural Sciences, Electronics Engineering, Sabanci University, Istanbul, 34956 TURKEY (e-mail: yasar@sbanciuniv.edu).

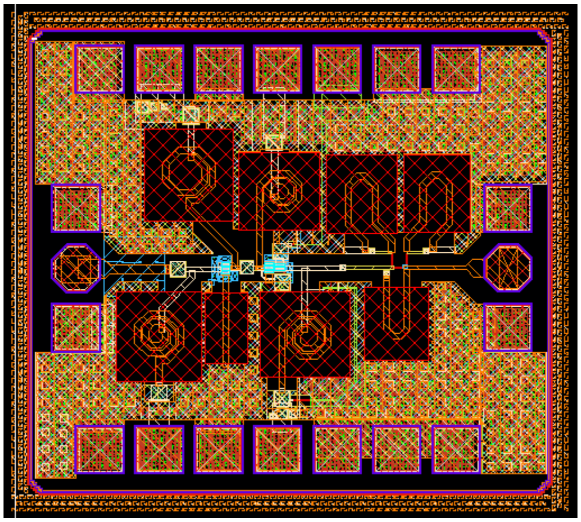

Fig. 2. Layout of the 2 stage LNA

Fig. 3 and 4 are simulated S-parameters of designed amplifier. Proposed amplifier achieves small signal gain of 15.5±1.5 dB gain for all K and Ka band (18 - 40 GHz). Simulated input and output return loss are below -10 dB which is acceptable. Relatively better output matching is seen around 40 GHz because of the adjustment of output matching circuit to provide lowest loss at that frequency. Simulated noise figure performance can be seen in Fig. 5. LNA provides 2.2 dB NF at 28 GHz and acceptable NF up to 40 GHz. NF performance can be improved for high frequencies by having noise match for above 28 GHz frequency with a tradeoff degradation of NF at low frequencies.

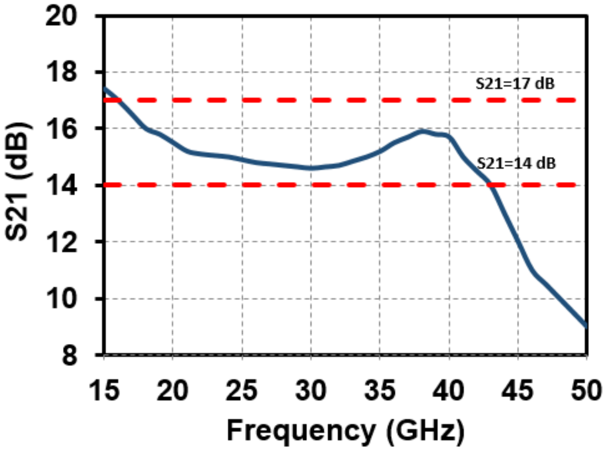

Fig. 3. Simulated small signal gain of the 2 stage LNA

Total power consumption of LNA is 28.8 mW for supply voltage values of 1.5V and 2.5V for common source and cascode stages respectively.

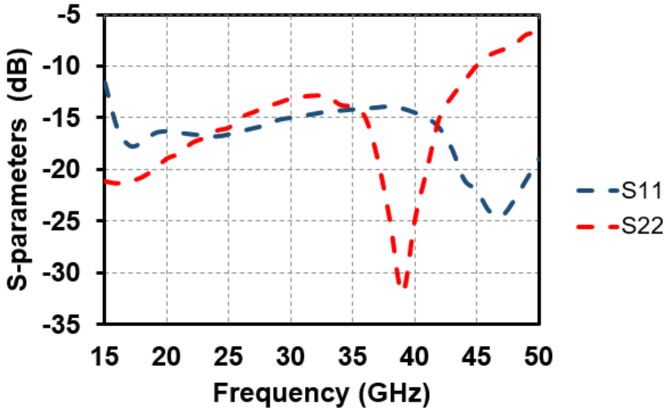

Fig. 4. Simulated input and output return loss of the 2 stage LNA

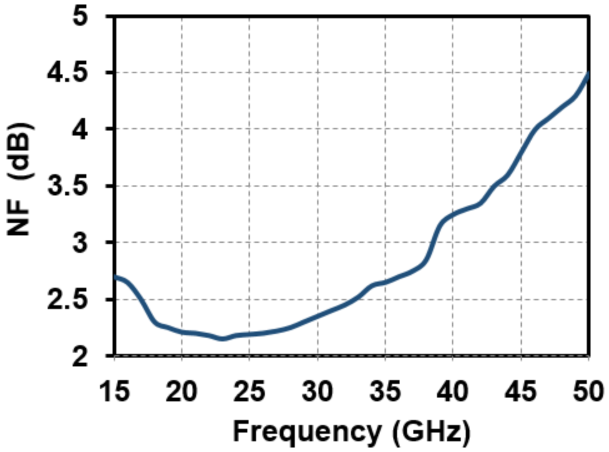

Fig. 5. Simulated noise figure of the 2 stage LNA

III. CONCLUSION

A K-Ka band wideband low noise amplifier with IHP Microelectronics 0.13 µm SiGe HBT technology is presented. Using equalization based output matching network, proposed LNA provide 3dB gain linearity over all band, 2.2dB NF and 16 dB gain at 28 GHz.

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