Design and analysis of high-gain CMOS low-noise amplifiers for 5G communications

適用於5G行動通訊之CMOS高增益低雜訊放大器設計與分析

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Introduction

To meet the growing demands of high-speed 5G applications such as AR, IoT, and autonomous driving, the 28 GHz mm-wave band has been widely adopted. In this work, we design and simulate CMOS LNAs at 28 GHz using TSMC 90nm RF PDK. Two-stage and three-stage common-source and cascode topologies are explored and evaluated in terms of gain, bandwidth, NF, and linearity for mm-wave receiver applications.

CS + CS

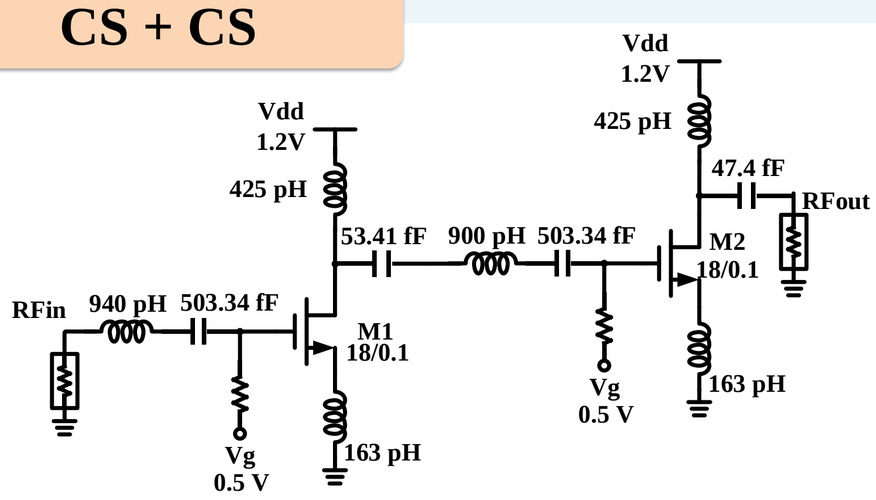
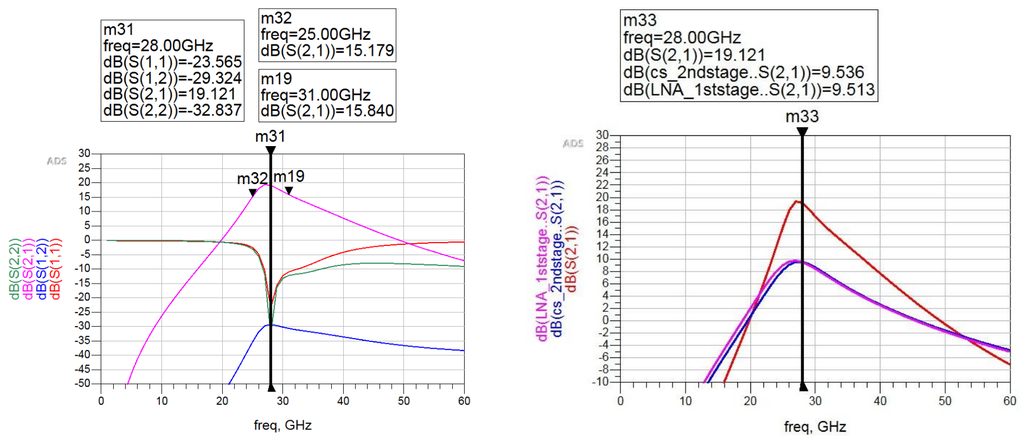


Fig. 1 the proposed 28-GHz two-stage CS + CS LNA schematic



(a)　　(b)

Fig. 2 (a) simulated S-parameters of the proposed LNA. (b) simulated S of each stage

CS + Cascode

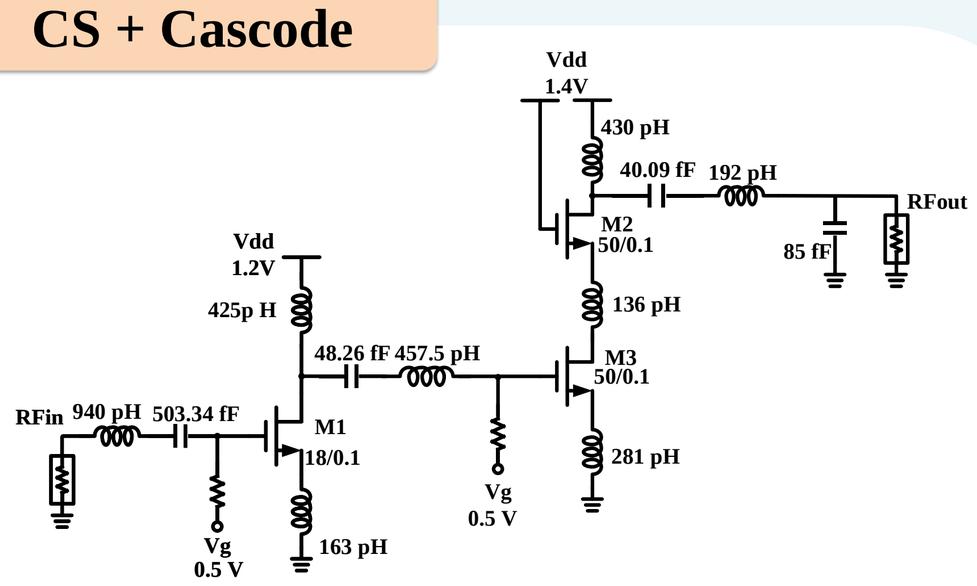
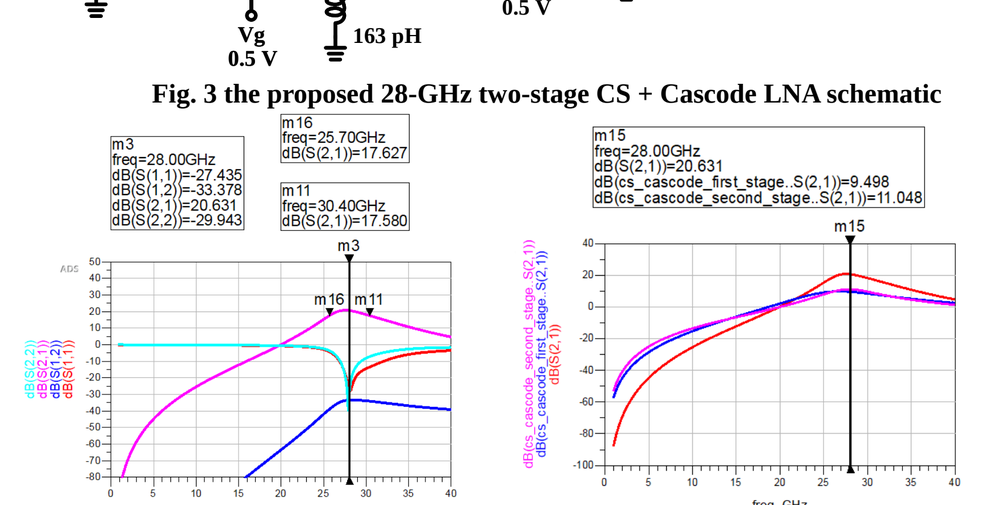


Fig. 3 the proposed 28-GHz two-stage CS + Cascode LNA schematic



(a)　　(b)

Fig. 4 (a) simulated S-parameters of the proposed LNA. (b) simulated S of each stage

CS + CS + CS

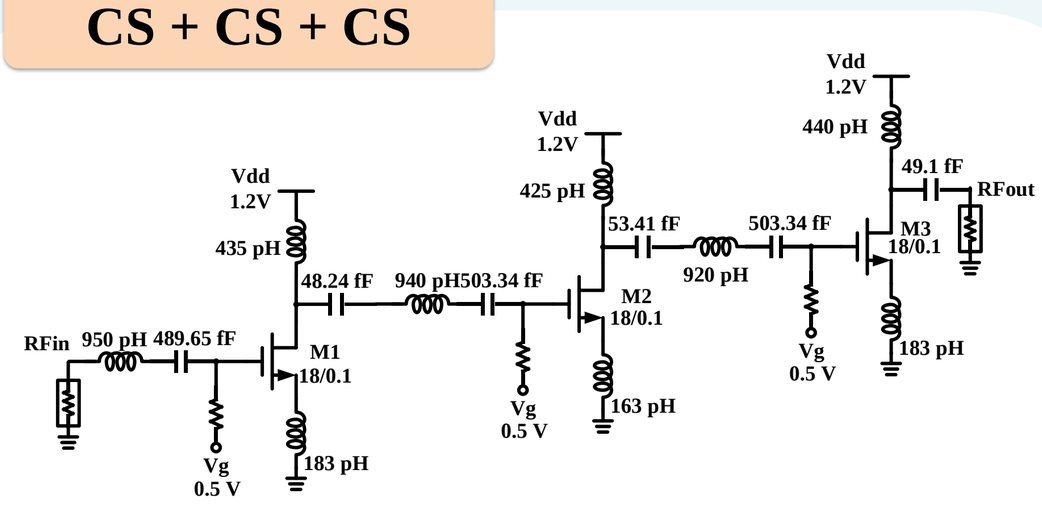
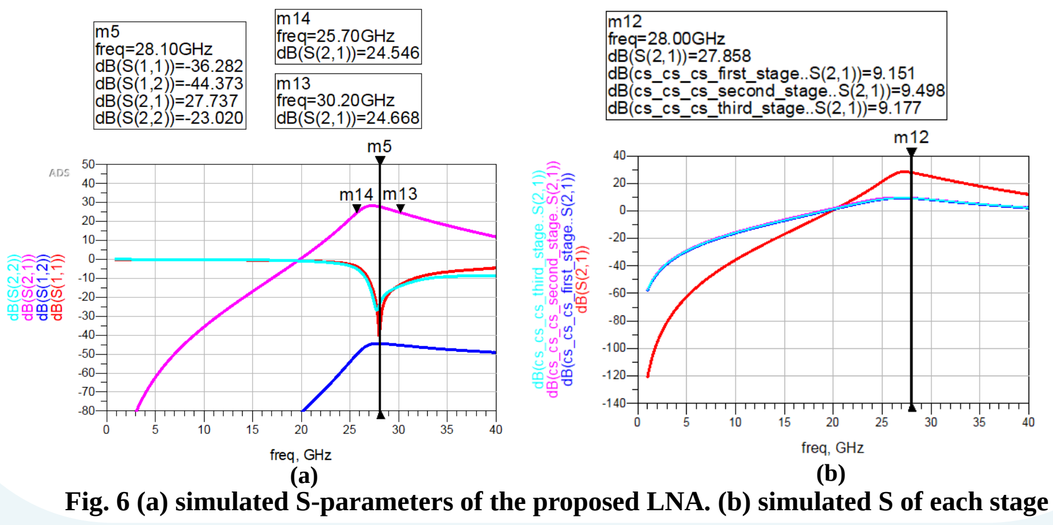


Fig. 5 the proposed 28-GHz two-stage CS + CS LNA schematic



(a)　　(b)

Fig. 6 (a) simulated S-parameters of the proposed LNA. (b) simulated S of each stage

CS + CS + Cascode

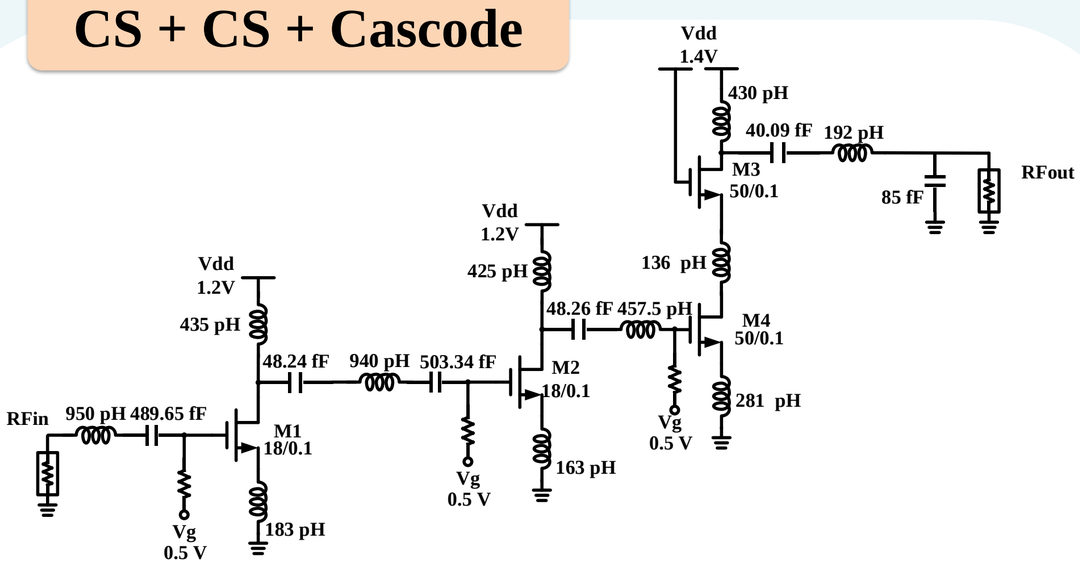


Fig. 7 the proposed 28-GHz two-stage CS + CS + Cascode LNA schematic

(a)　　(b)

Fig. 8 (a) simulated S-parameters of the proposed LNA. (b) simulated S of each stage

Conclusion

The results show that the overall gain increases proportionally with the number of stages, while the NF is dominated by the first stage. The CS topology provides design simplicity, broader bandwidth, and lower power consumption, whereas the cascode configuration enhances gain at the cost of design complexity and bandwidth reduction.

Table 1
Performance Summary and Comparison

	CMOS Process	Freq. (GHz)	Gain (dB)	NF (dB)	BW (GHz)	OP_{1dB} (dBm)	OIP3 (dBm)	IP_{1dB} (dBm)	IIP3 (dBm)	P_{DC} (mW)	Topology
Spec	90 nm	28	>15	<4.5	3	--	--	-40	-30	10~15	--
This work			19.224	3.588	5.24	5.61	11.5	-18.4	-7.822	6.36	cs+cs
			20.631	3.594	4.7	-2.18	5.89	-25.4	-15.338	12.77	cs+cascode
			27.858	3.627	4.3	-0.29	11.15	-26.3	-17.195	11.14	cs+cs+cs
			29.191	3.63	3.7	-2.28	6.16	-35.0	-25.705	15.46	cs+cs+cascode

References

[1] Y. Yu, H. Liu, Y. Wu, and K. Kang, "A 54.4–90 GHz low-noise amplifier in 65-nm CMOS," *IEEE Trans. Microw. Theory Techn.*, vol. 68, no. 2, Feb. 2020.
[2] S. Jamil, M. Usman, H. Atiq, and R. Ramzan, "28–32 GHz wideband LNA for 5G applications," in *Proc. IEEE Int. Conf. Emerging Technologies (ICET)*, 2018
[3] B. Razavi, *RF Microelectronics*, 2nd ed. Upper Saddle River, NJ, USA: Prentice Hall, 2012.