37-39 GHz GaN Low Noise Amplifier

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Abstract

To address the utilization of the 5G millimeter-wave frequency band, this low noise amplifier (LNA) is designed using the WIN 0.12 μm gate GaN on SiC process. It adopts a 2-stage common-source architecture, operating in the 37-39 GHz frequency range. The LNA achieves a noise figure of 3.8-3.9 dB, a gain of 12-13.5 dB, input/output return losses of <-11 dB / <-25 dB, an OP1dB of 13.6 dBm, an OIP3 of 24.8 dBm, and a compact chip size of 1x1 mm².

Implementation

To address the development of 5G millimeter-wave applications, this project designed a 37-39 GHz low noise amplifier (LNA) suitable for the 5G NR (FR2) n260 frequency band (covering 37-40 GHz).

This design utilizes the WIN 0.12 μm depletion mode GaN/SiC HEMT (NP12-01) process, with an fT of 35 GHz and an fmax of 132.5 GHz. Additionally, the GaN HEMT offers higher power handling capabilities.

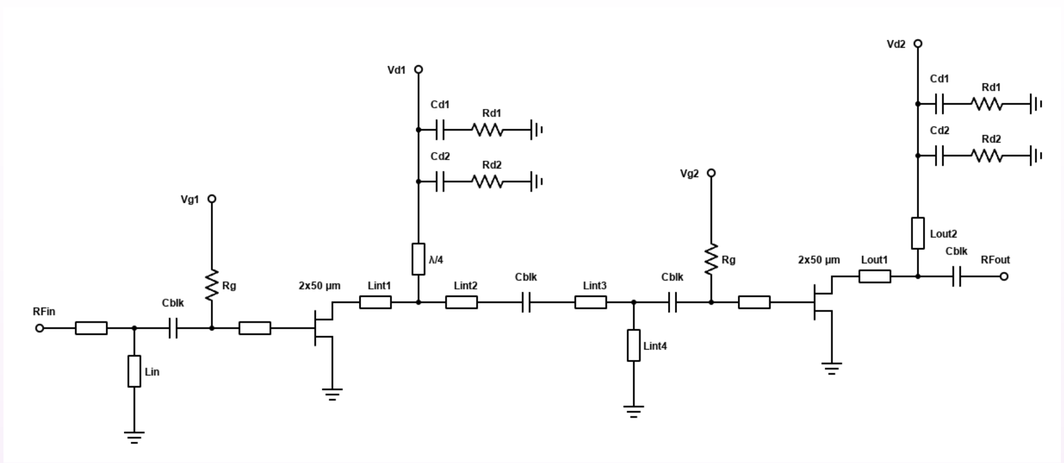
Circuit design

This LNA adopts a 2-stage common-source architecture. The bias is set to minimize the noise figure (NF) in the first stage and maximize the transconductance (gm) in the second stage, with Vd set to 10V, Id1 to 10mA, Id2 to 20mA, and a total power consumption of 0.3W.

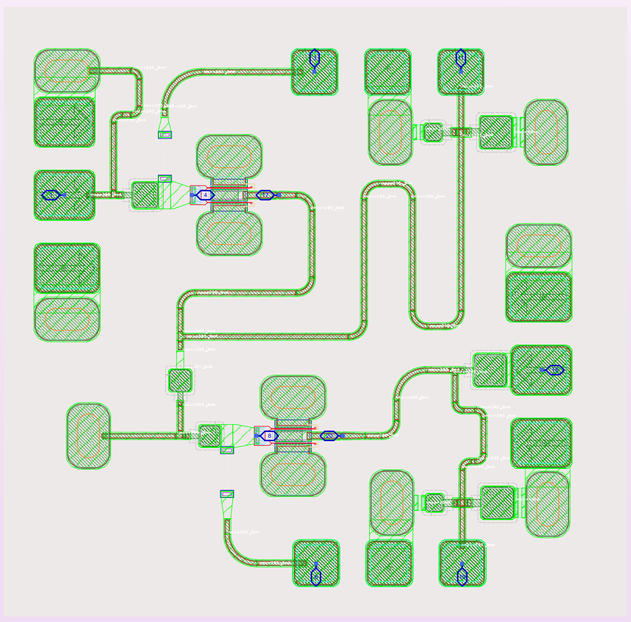
The transmission line width is 10 μm. The gate resistor is sufficiently large (in the kΩ range) to enhance robustness. A bypass capacitor is added to absorb noise and improve stability, ensuring the circuit remains unconditionally stable.

The output is matched to 50Ω, while the interstage uses conjugate matching. For input matching and source degeneration, a trade-off is made to achieve an optimal balance between noise figure and gain.

Schematic



Layout



Chip size: 1x1 mm²

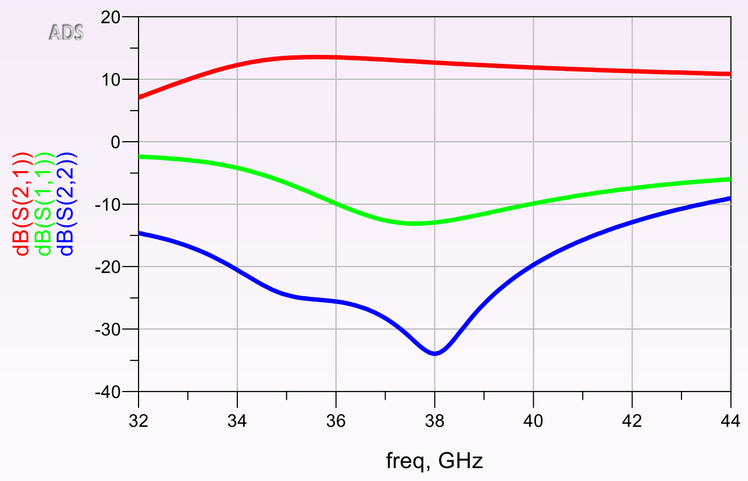
Transistor type: 2x50

- 2 stages
- Common Source

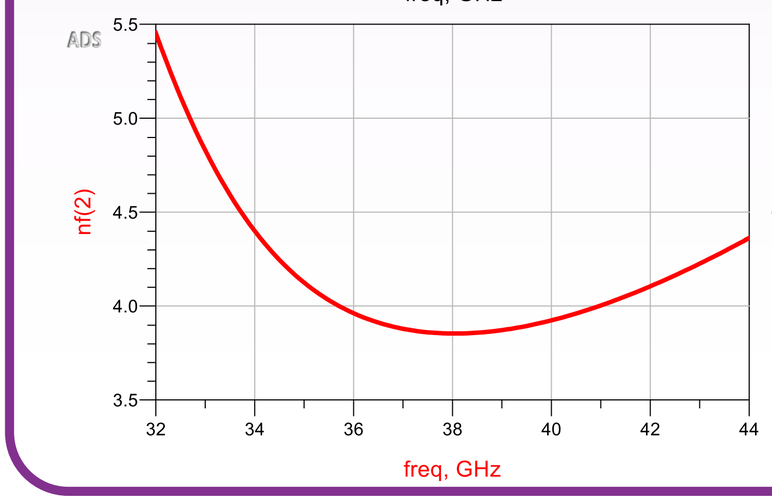
Results

Through electromagnetic simulation, the frequency range is 37-39 GHz:

- The S21, or gain, is 12-13.5 dB.
- The S11/S22, or input/output return loss, is <-11/-25 dB.
- The NF(2), or noise figure, is 3.8-3.9 dB.
- The OP1dB is 13.6 dBm, and the OIP3 is 24.8 dBm.



← S parameter



← Noise Figure

Comparison Table

Ref.	Technology	Freq. [GHz]	NF [dB]	Gain [dB]	I/O RL [dB]	OP1dB [dBm]	OIP3 [dBm]	DC [W]	Chip size [mm2]
[1]	0.15um GaN/SiC	25-35	>3	>20	>10	-	-	0.36	3.5x1
[2]	0.15um GaN/Si	35-37	3.7	19.7	>8/14	21.6	-	3	4.34x1.2
[3]	0.15um GaN/SiC	27-31	3.7-3.9	14-20	>10/5	-	-	0.64	3.4x1.2
This Work	0.12um GaN/SiC	37-39	3.8-3.9	12-13.5	>11/25	13.6	24.8	0.3	1x1

Conclusion

Through the design and optimization of the topology, biasing, transmission line width, input/interstage/output matching, gate resistor, bypass capacitor, and source degeneration, this LNA was successfully developed and is suitable for 5G millimeter-wave communication.

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