IDEC Chip Design Contest

Ka-Band Two-Way Power-Combining Power Amplifier using Merged Inter-stage Transformers

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Introduction

- Ka-band has recently attracted significant attention due to its potential for high-capacity wireless communication and radar applications.
- For such applications, high-output-power power amplifiers (PAs) are essential to ensure sufficient transmission range and signal integrity.
- This work demonstrates a two-way power combining technique using merged inter-stage transformers to enhance output power.

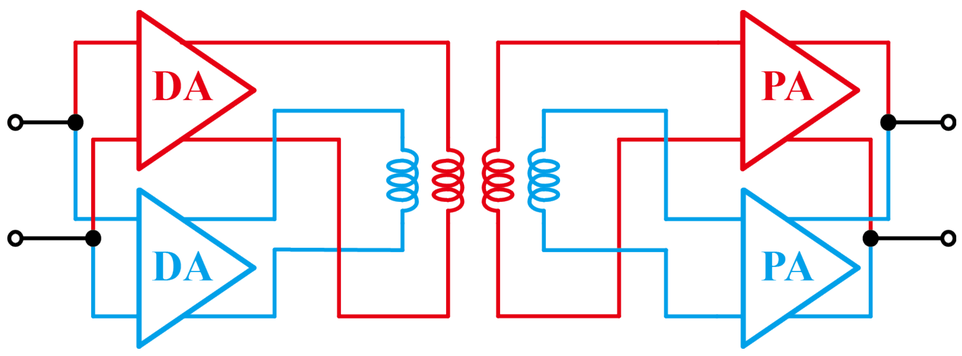

Fig. 1, Block diagram of two-way power combining using a merged inter-stage transformers

Circuit Design

- Frequency : 27–31 GHz
- Topology : 2-stage Diff.-to-Diff.
- Applied Technique :
  - ✓ Merged inter-stage transformers were used to achieve high output power while enabling compact two-way power combining.
  - ✓ A cascode structure was employed in the power stage to achieve both high gain and high output power.
  - ✓ Neutralization capacitors were applied to both the driver and power stages to enhance gain and ensure stability.

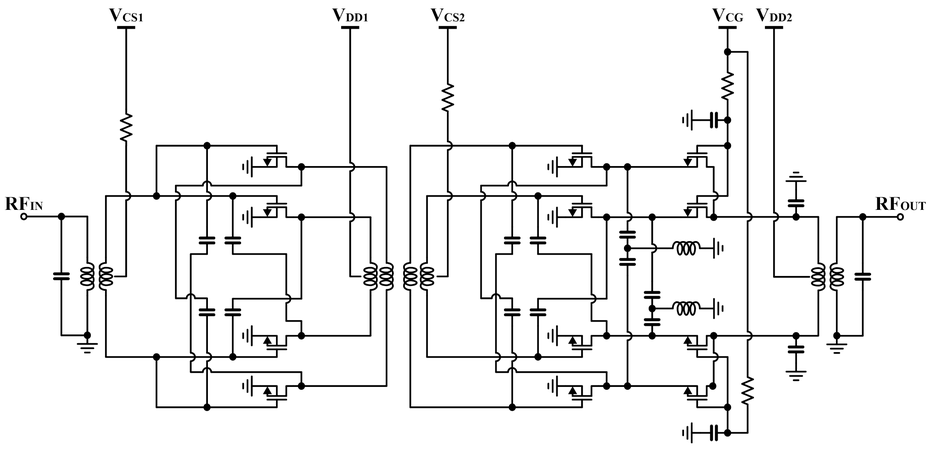

Fig. 2, Full schematic of the two-way PA using merged inter-stage transformers

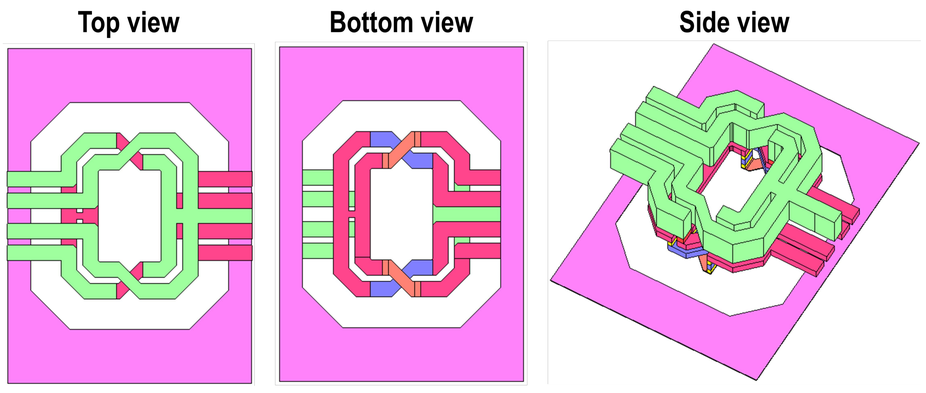

Fig. 3, Layout of the merged inter-stage transformers

Simulation Results

- Simulation results
  - ✓ Gain (dB) : 21.8–24.3
  - ✓ P_{SAT} (dBm) : 21.5–21.8
  - ✓ OP1dB (dBm) : 19.6–20.1
  - ✓ Peak-PAE (%) : 34.0–37.7

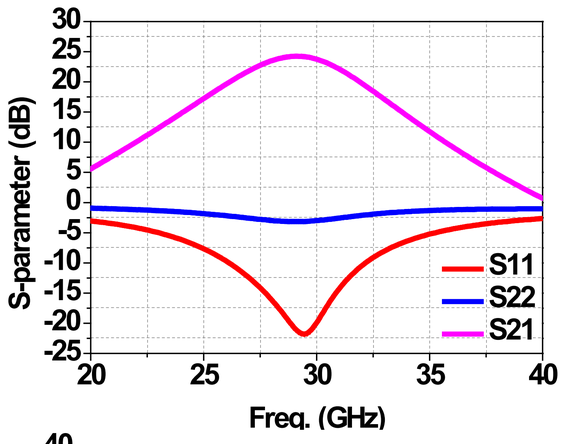

Fig. 4, Simulation results

Conclusion

Ref.	This work (Sim.)	[1]	[2]	[3]
Tech.	28nm	65nm	28nm	65nm
Architecture	2–way	2–way	1–way	1–way
Freq. (GHz)	27–31	12.3–15.6	28	28
Gain (dB)	21.8–24.3	26–27.3	20.5	18
P_{SAT} (dBm)	21.5–21.8	23–23.4	18.1	18.5
OP1dB (dBm)	19.6–20.1	22.7–22.9	16.8	N/A
Peak-PAE (%)	34.0–37.7	22.7–22.9	41.5	27.3
Core Area (mm^2)	0.195	0.23	0.28	0.14

- The two-way power combining power amplifier with high output power was designed using merged inter-stage transformers, achieving a compact chip size.
- The fabricated chip has been received and is currently being prepared for on-chip probing measurements.

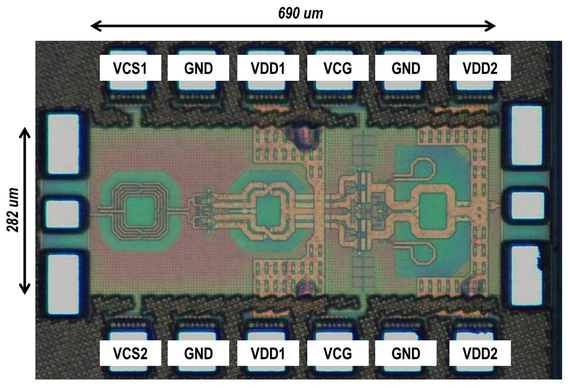

Fig. 5, Microphotograph of the two-way PA

Reference

[1] J. -H. Kim et al., "An Efficient Ku-Band Two-Way Vertical-like Power-Combining Power Amplifier using Merged Inter-stage Transformers Achieving 23-23.4 dBm Psat and 45.2-46.6% Peak PAE in 65nm CMOS," 2024 IEEE Radio Frequency Integrated Circuits Symposium (RFIC)
[2] B. Park et al., "Highly Linear mm-Wave CMOS Power Amplifier," in IEEE Transactions on Microwave Theory and Techniques, vol. 64, no. 12, pp. 4535-4544, Dec. 2016, doi: 10.1109/TMTT.2016.2623706.
[3] S. Lee, S. Kang and S. Hong, "A 28-GHz CMOS Linear Power Amplifier With Low Output Phase Variation Over Dual Power Modes," in IEEE Microwave and Wireless Components Letters, vol. 29, no. 8, pp. 551-553, Aug. 2019, doi: 10.1109/LMWC.2019.2922507.

Acknowledgement

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