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A 110-GHz Push-Push Balanced Colpitts Oscillator Using 0.15-μm GaN HEMT Technology

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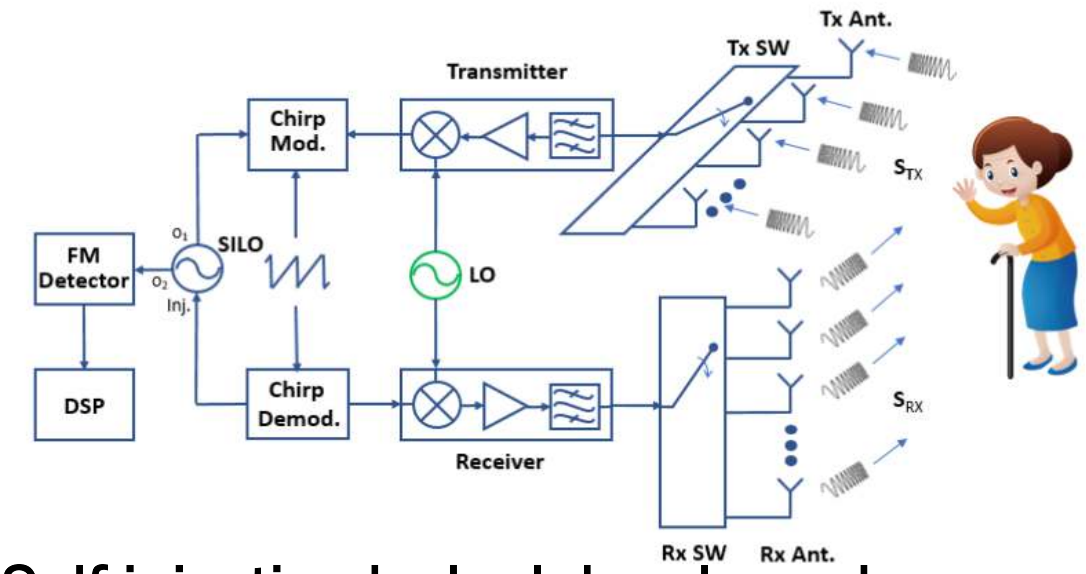
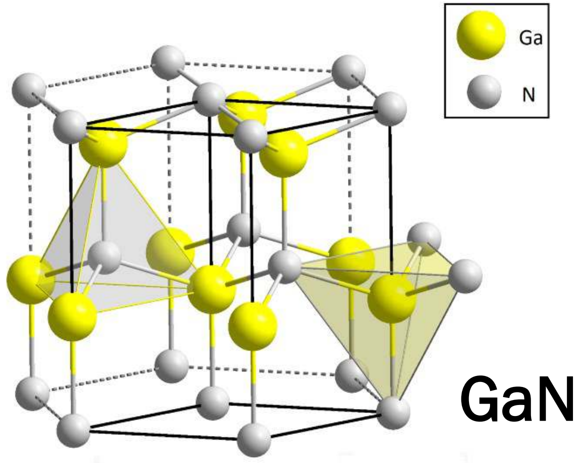
Outline

- Introduction and Background
- Recent Development in GaN Transistors
- Topology of the Oscillator
- Development of a Three-terminal Small Signal Model
- Oscillator Design and Optimization
- Measurement Results
- Comparison
- Conclusion

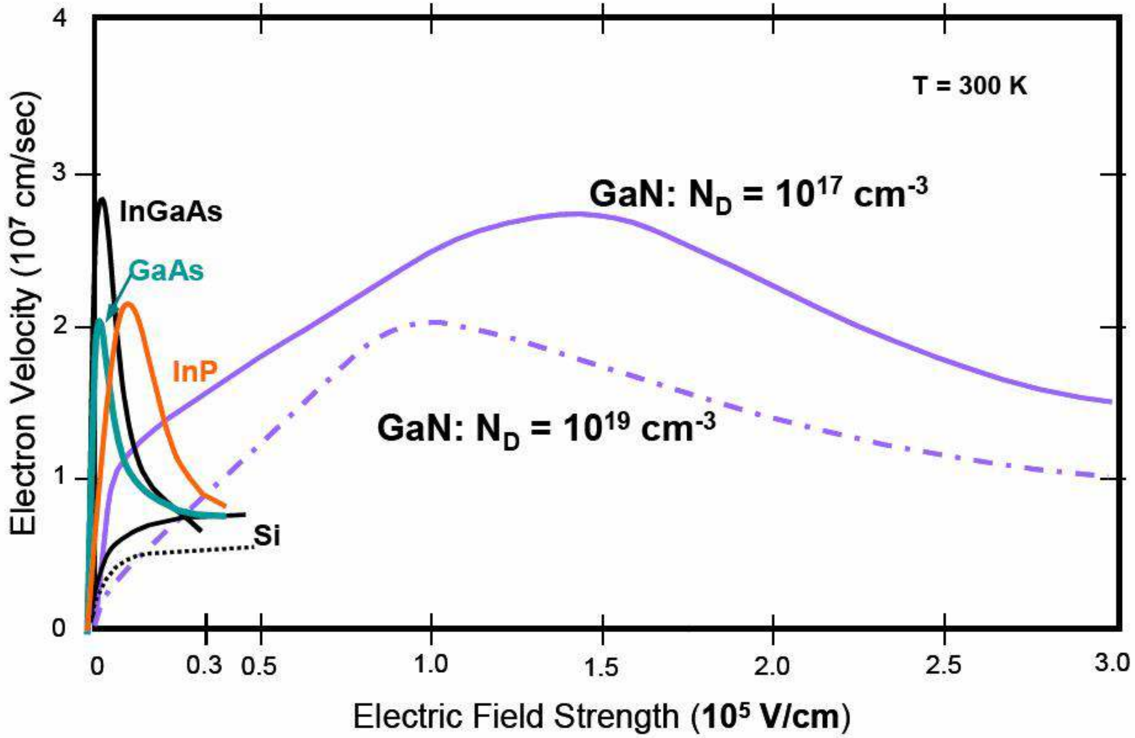
Introduction and Background



Self-injection locked doppler radar

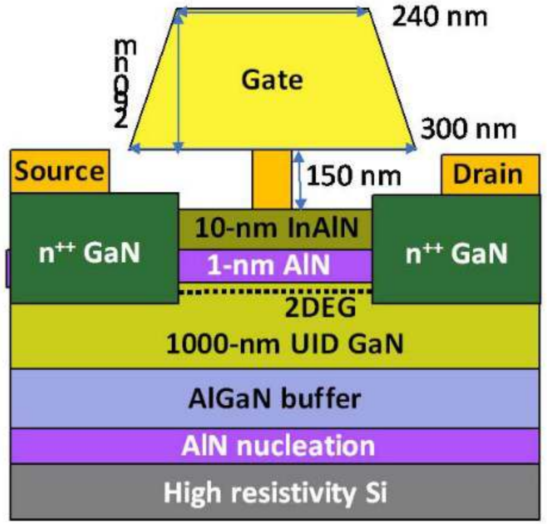


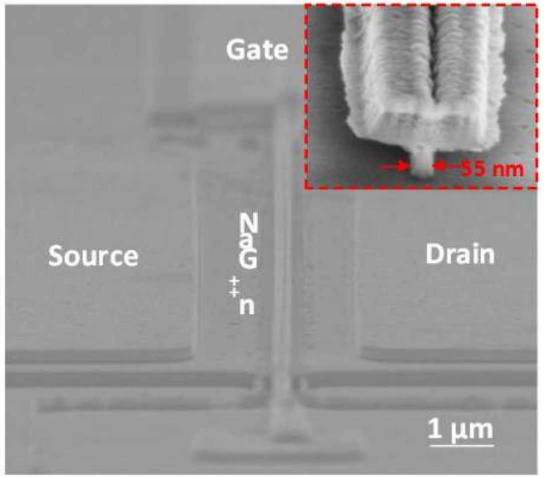
GaN crystal structure

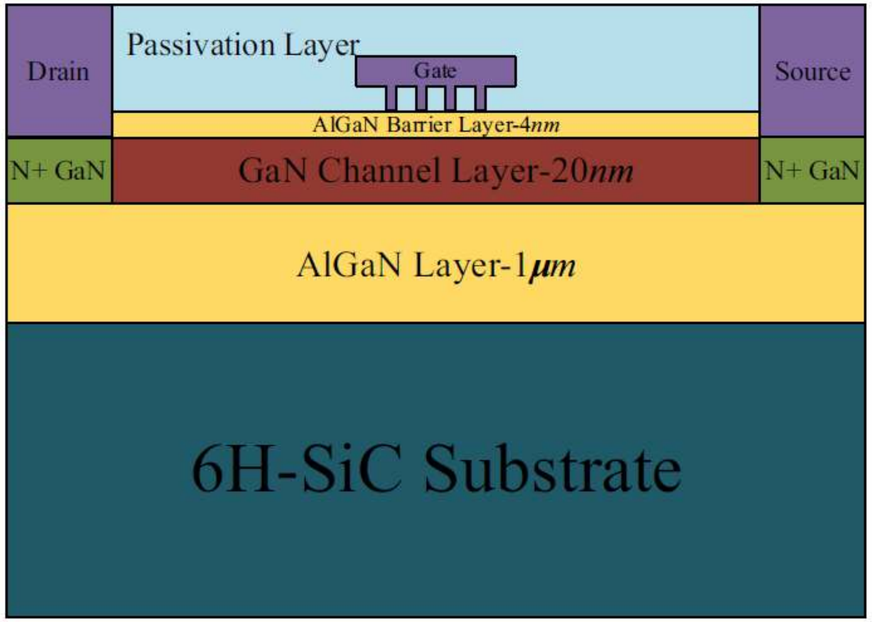


Superior electron velocity and electric field strength

Recent Development in GaN Transistors



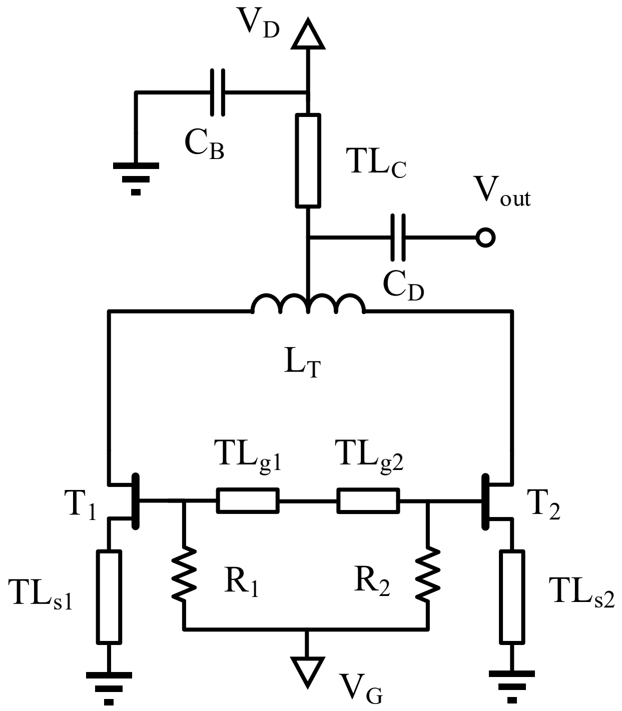




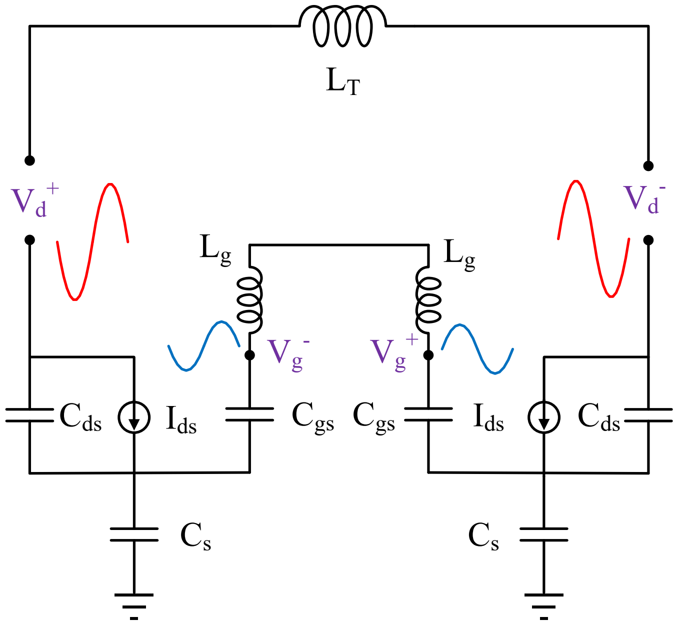
- GaN on Si
- T-shaped gate—Gate length of 55 nm
- Regrown n++-GaN source and drain contacts
- Reduced parasitic resistance
- f_{max}— 204 GHz / f_T— 250 GHz

- GaN on SiC
- Reduced parasitic capacitance and transit time
- f_{max}— 239.5 GHz / f_T— 331.5 GHz

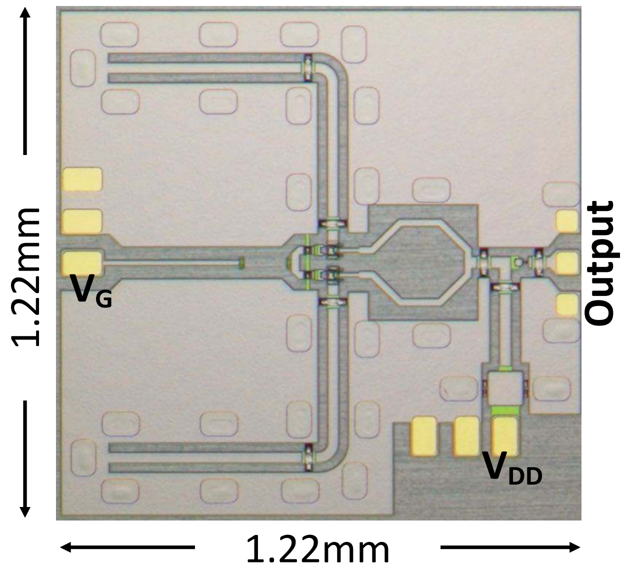
Topology of the Osicllator



Schematic of the push-push structure

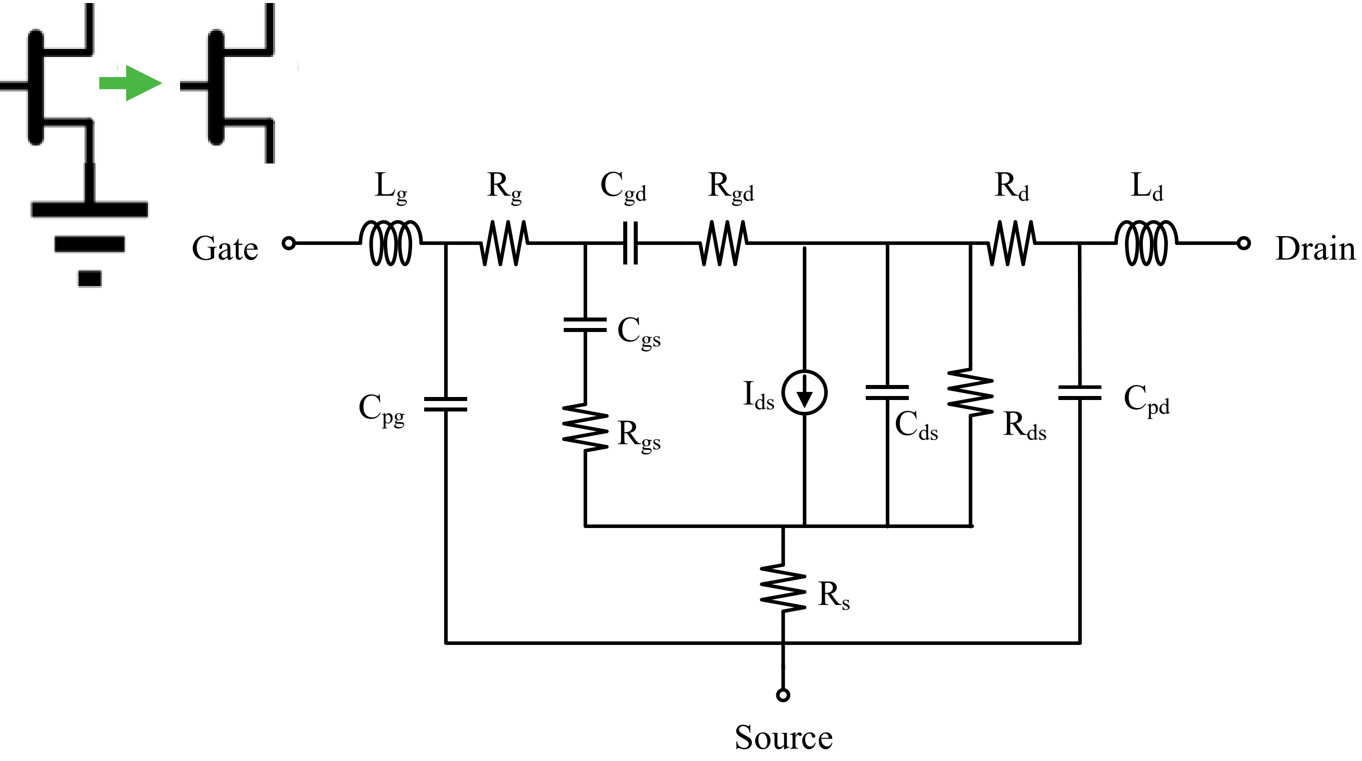


Differential operation

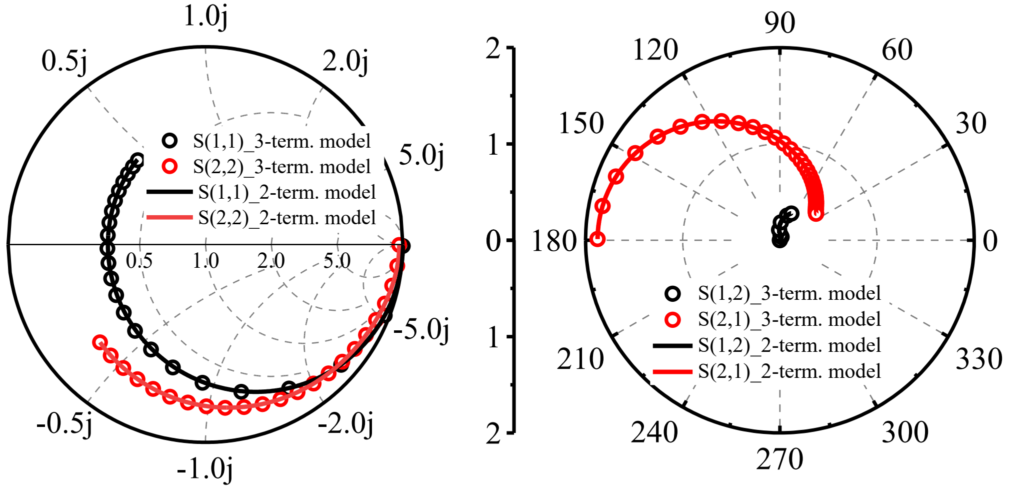


Die photo

Development of Three-terminal Small Signal Model

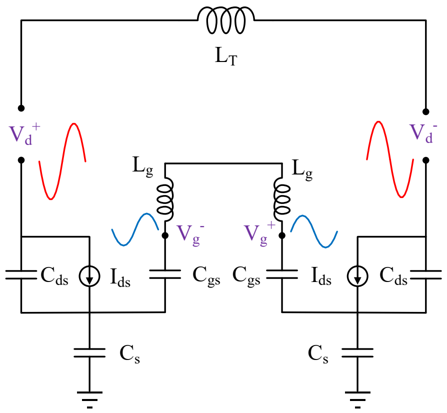


12-parameter small signal model

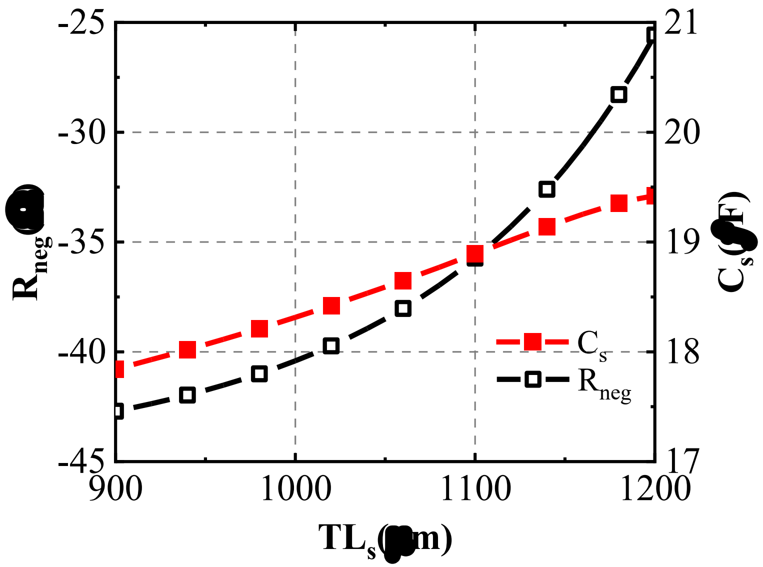


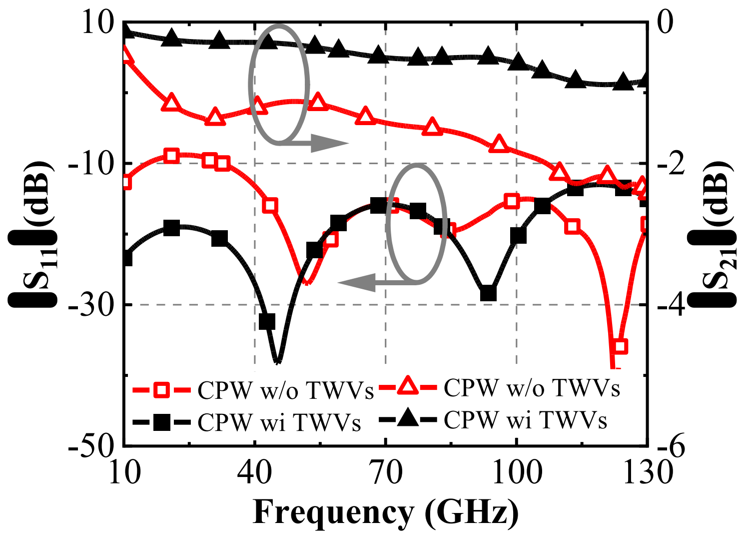
S-parameter comparison between the proposed model and foundry model

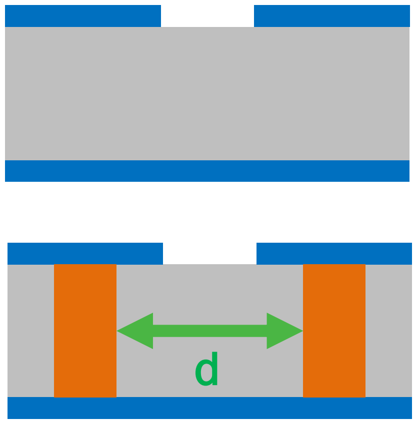
Oscillator Design and Optimization



Z_{neg}

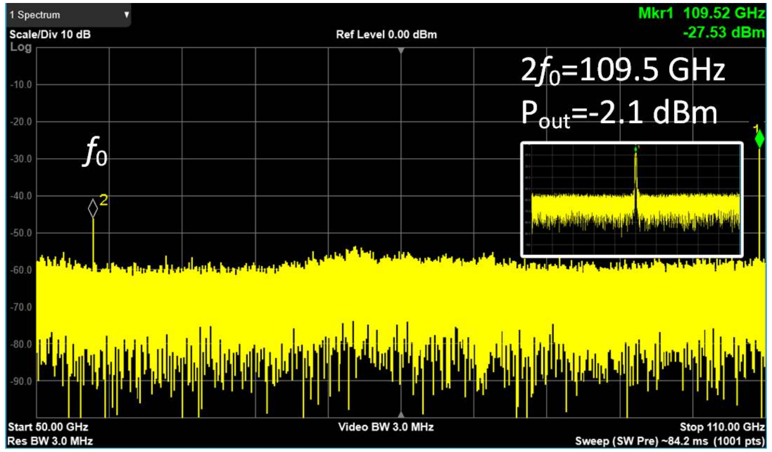


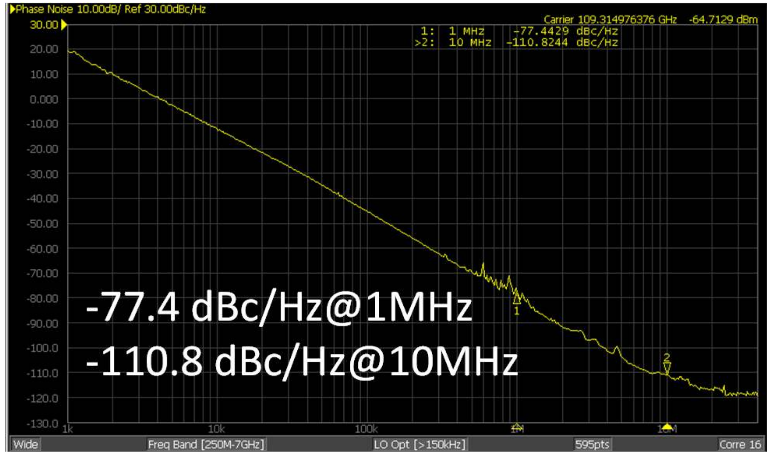




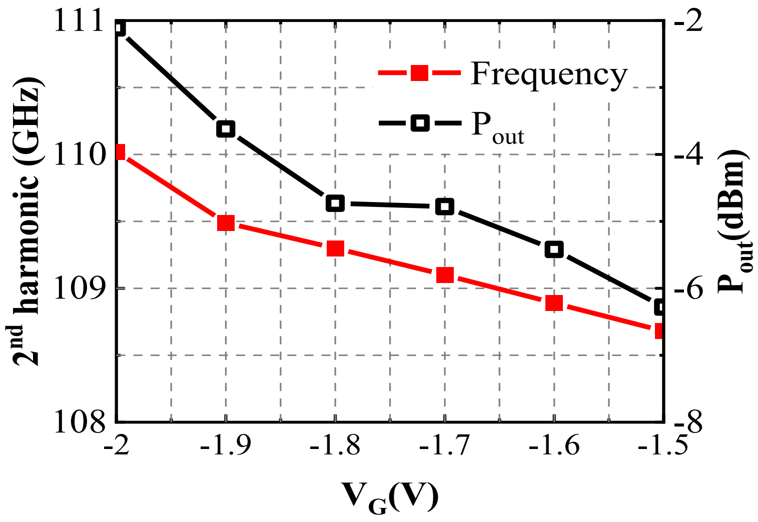
(a) Negative resistance of the balanced core and the equivalent capacitance C_s of TL_s versus the length of TL_s (b) Return loss and insertion loss of the two CPWs with and without the TWVs.

Measurement Results





Measured (a) spectrum and (b) phase noise of the proposed oscillator.



2^{nd} harmonic frequency and P_{out} v.s. V_G

Comparison with the State-of-the-art

Refs	GaN HEMT Tech.	Topology	Frequency (GHz)	f_0/f_T	f_0/f_{max}	P_{out} (dBm)	P_{DC} (mW)	PN (dBc/Hz)
[1]	60 nm	Push-push	180.6*	0.47	0.36	9.3	920	-88.2@10MHz
[2]	60 nm	Common-gate Colpitts	84	0.44	0.34	-0.67	340	-120@10MHz
[3]	100 nm	Single-end	89.2	1.11	0.44	10.2	650	-90.2@1MHz
This work	150 nm	Push-push balanced Colpitts	109.5*	1.71	0.4	-2.1	295.5	-77.4@1MHz -110.8@10MHz

1. D. Kim and S. Jeon, "W- and g-band gan voltage-controlled oscillators with high output power and high efficiency," *IEEE Trans. Microwave Theory Tech.*, 2021, vol. 69, no. 8, pp. 3908-3916, Aug. 2021
2. T. N. Thi Do, Y. Yan, and D. Kuylenstierna, "A low phase noise w-band mmic gan hemt oscillator," in *Proc. APMC'20*, 2020, p. 113-115.
3. R. Weber, D. Schwantuschke, P. Bruckner, R. Quay, F. v. Raay, and O. Ambacher. "A 92 GHz GaN HEMT voltage-controlled oscillator MMIC," in *Proc. IMS'14*, 2014, p. 1-4.

Conclusion

- A W-band push-push oscillator was proposed and designed.
- In-house 3-terminal small signal model was developed
- Colpitts feedback oscillator was proposed and optimized
- Measured performance exhibits competitivity among reported GaN oscillators
- The proposed oscillator is well-suited for future millimetre wave and sub-THz radar and imaging systems

Thank you