A K-Band GaN MMIC Voltage Controlled Oscillator with High Output Power and Low Phase Noise

HSDIC
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K頻帶低相位雜訊及高輸出功率之氮化鎵微波單片集成壓控振盪器電路

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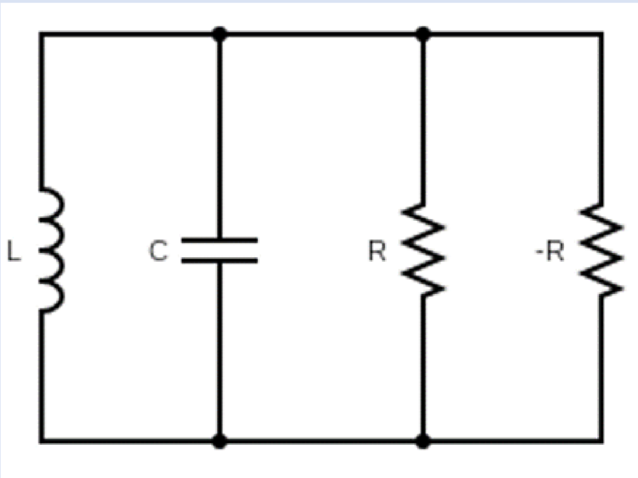
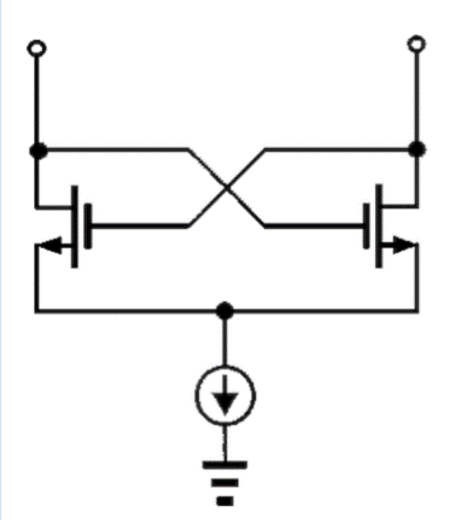
ABSTRACT

This is a novel design for a monolithic microwave integrated circuit (MMIC) oscillator, characterized by low phase noise and high output power, specifically tailored for radar and satellite applications. This oscillator utilizes the WIN 0.25um RF High Power GaN-on-SiC HEMT Technology, enabling the creation of a compact microwave oscillator, and the design, optimization, and analysis of the oscillator are conducted by advanced design system (ADS) simulator. The resulting voltage controlled oscillator generates the frequency within 21 GHz to 21.2 GHz and 1% of tuning range. The primary objective is to achieve high output power and low phase noise while adhering to specified criteria. The optimized microwave oscillator demonstrates promising outcomes, with the post-layout simulation of output powers of 16.8 dBm at 21 GHz and produces sinusoidal signals with amplitudes of 2.3 V. In addition, this design has a relatively low 0.61W power consumption compared with other works at similar output powers. The phase noise of the oscillator at 21GHz , utilizing the LC resonator, registers at -125.8 dBc/Hz at 1MHz offset and -149.7 dBc/Hz at a 10 MHz offset.

STRUCTURE

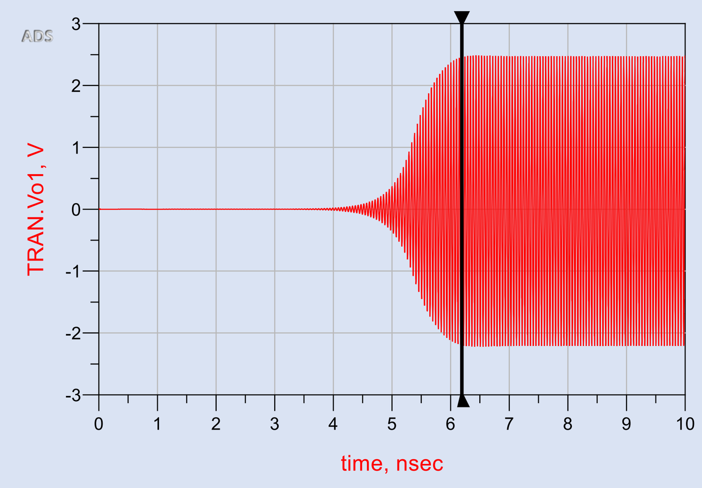


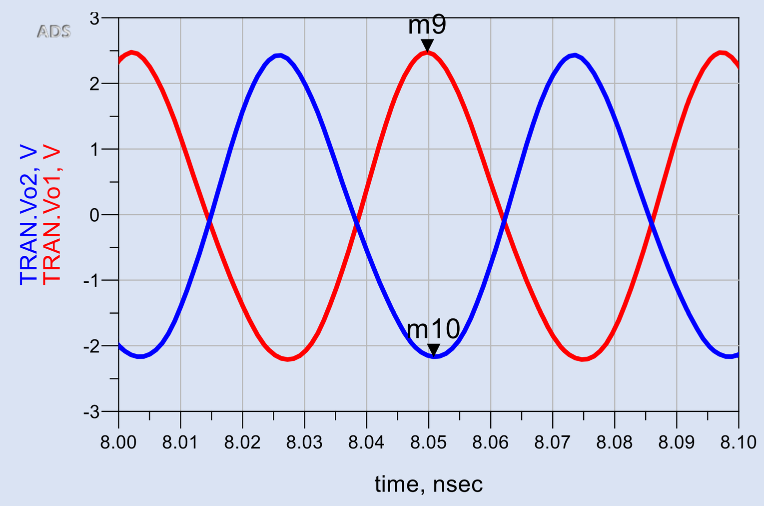


The basic oscillator architecture consists of two main components (1) LC tank and (2) negative impedance or positive feedback system. Because LC components inherently have losses and cannot sustain oscillation, it is necessary to provide negative impedance through the characteristics of active components to counteract the losses of LC elements. The oscillator design in this work employs the traditional Cross-Coupled Pair to provide negative impedance for the continuation of oscillation.

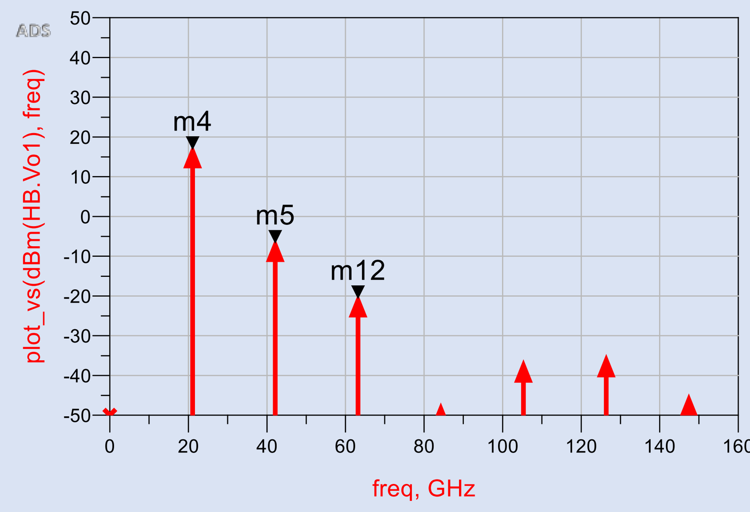
In terms of oscillator performance, phase noise plays a particularly crucial role. Many studies have explored methods to reduce phase noise, such as increasing the swing of the oscillator or using inductors and capacitors with high Q values to reduce the decay and noise of the LC tank. In addition to selecting V_{dd}, I_{bias}, and inductance to maximize the oscillation swing as much as possible, this design also incorporates a matching network at the output to further maximize the oscillation swing.

EXPERIMENTAL RESULT



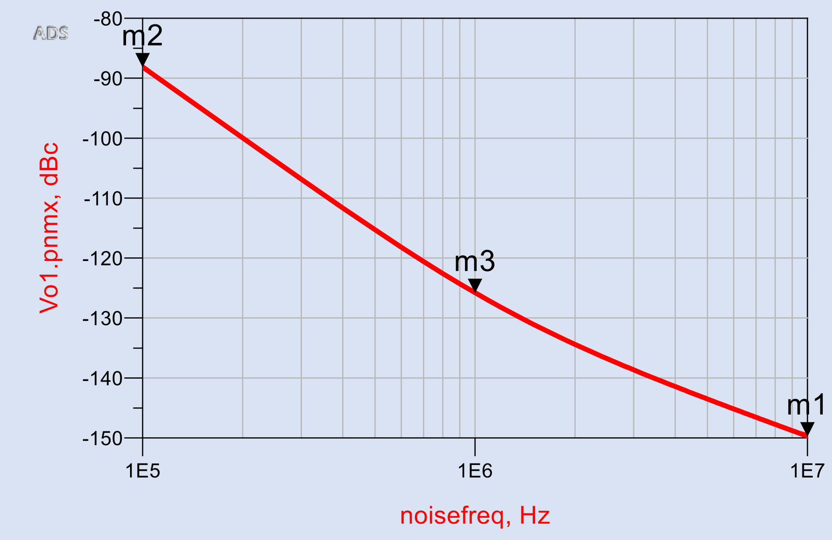


- Oscillation Start-up time = 6.2 ns
- $V_{peak\text{-}to\text{-}peak}$ = 4.65V



Output power

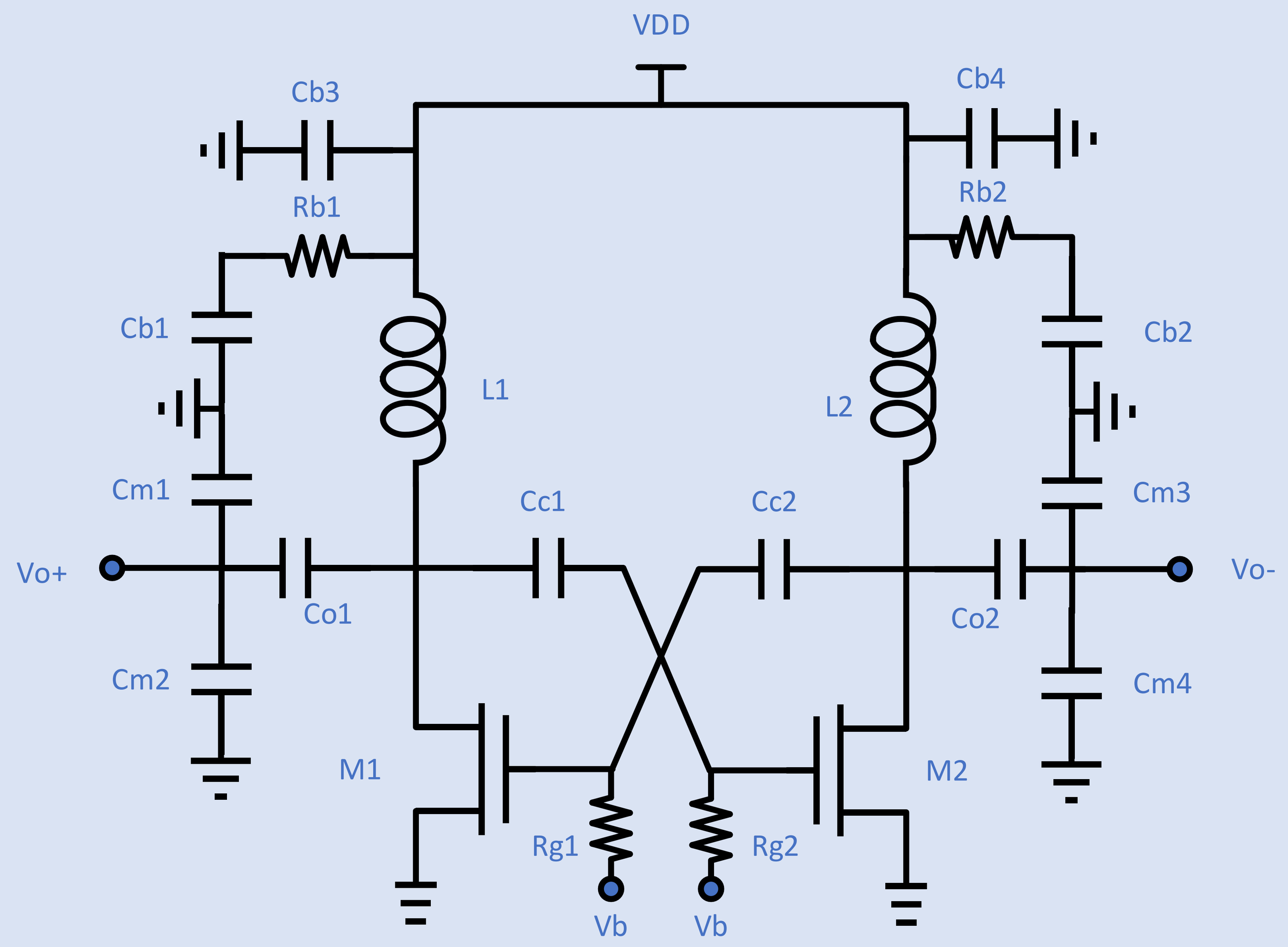
- At fundamental frequency: 16.8 dBm
- 2nd harmonic: -6.8 dBm
- 3rd harmonic: -20.4 dBm



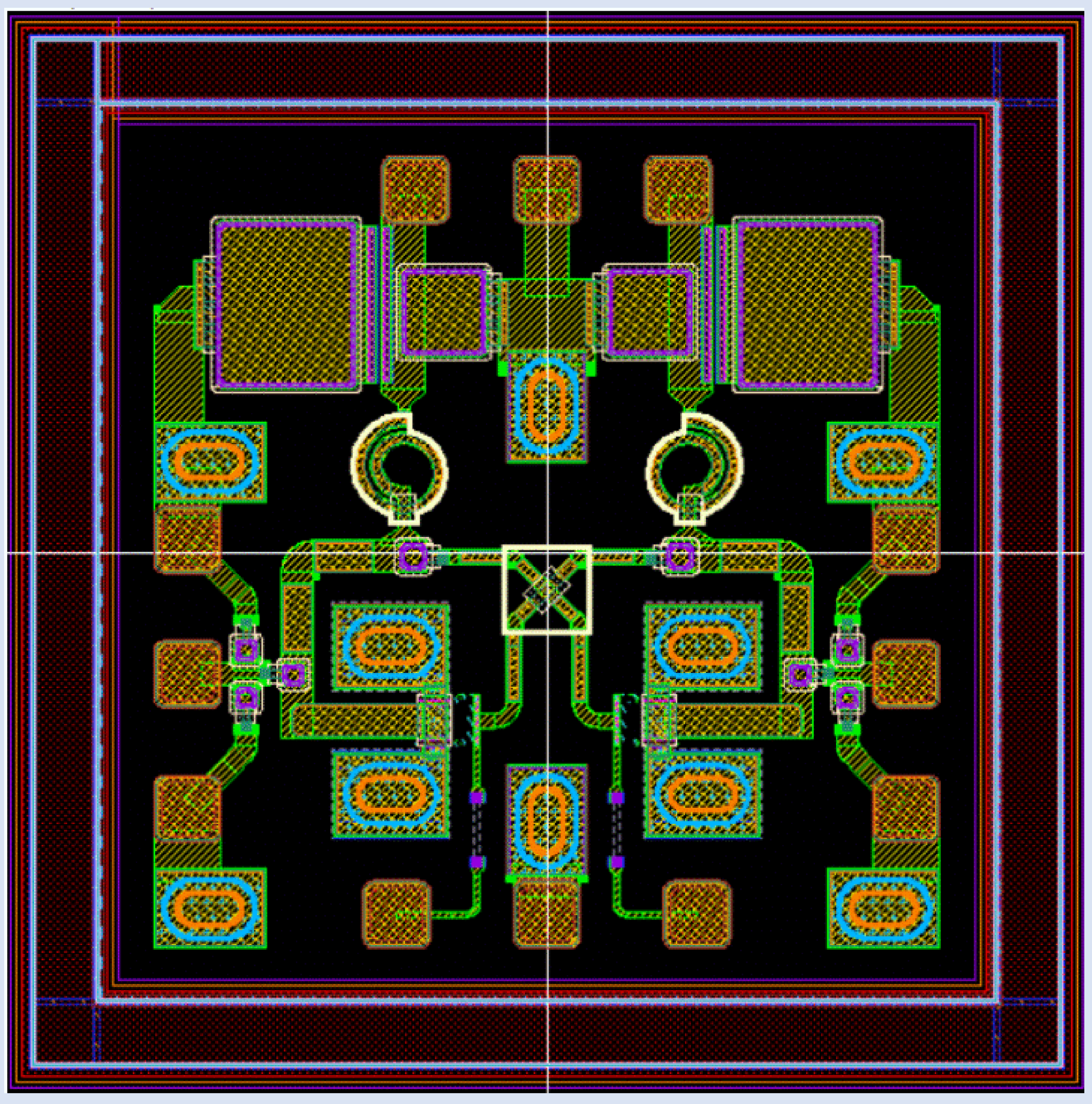
Phase noise

- At 100kHz offset: -88.1 dBc/Hz
- At 1MHz offset: -125.8 dBc/Hz
- At 10MHz offset: -149.7 dBc/Hz

SCHEMATIC



LAYOUT



- Chip Size: 1 x 1 mm^2
- Transistor Count: 2
- Power Dissipation: 0.61 W
- Operation Frequency: 21GHz

COMPARISON TABLE

Parameter	[4]	[3]	[2]	This work	SPEC
Process	GaN25	GaN25	GaN25	GaN25	GaN25
Power Suppy (V)	19	----	----	17	---
DC Power [mW]	2204	1456	747	608.6	---
Output Power [dBm]	27.9	21	16	16.8	---
DC to RF Efficiency	28%	8.6%	5.3%	4.5%	---
Tuning Range	1.1%	----	2.1%	1%	---
Size [mm^2]	3	0.66	0.71	1	=1mm^2
Phase Noise@1MHz [dBc/Hz]	-121.6	-135	-109.4	-125.7	<-110
Frequency [GHz]	9.35~9.46	7.9	23.9~24.4	20.9~21.1	>20
FoM [dBc/Hz]	167.6	-181.3	-176.8	-184.3	<-180

CONCLUSION

This study has successfully achieved a combination of low phase noise and high output power, making it highly promising for applications in radar or short-range communications. This underscores the considerable potential of GaN technology in millimeter-wave applications, showcasing its suitability even for outer space satellite communications.

REFERENCE

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