IDEC Chip Design Contest

Novel Injection-locked Quadrature Voltage Contr olled Oscillator in CMOS

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Introduction

The increasing demand for wireless communication systems has driven significant advancements in the field of radio frequency (RF) design. Oscillators are the most fundamental blocks in various communication systems [1].

This study presents the design and analysis of a quadrature voltage-controlled oscillator (QVCO) with a novel injection-locking mechanism.

The proposed injection technique can provide better phase noise compared to classical parallel-QVCO (coupling and core transistors in parallel) without increasing the complexity of the circuit. The injection occurs in-phase when the core voltage reaches its peak, which enables improved phase noise performance.

Designed Structures & Simulation Results

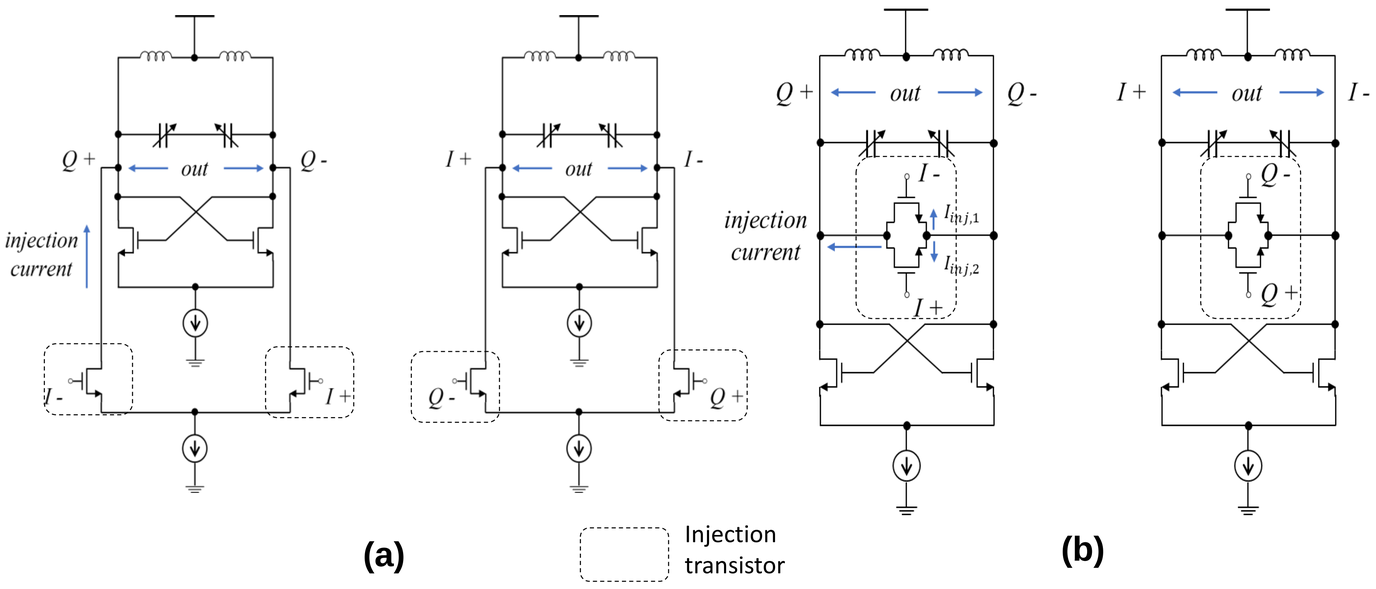
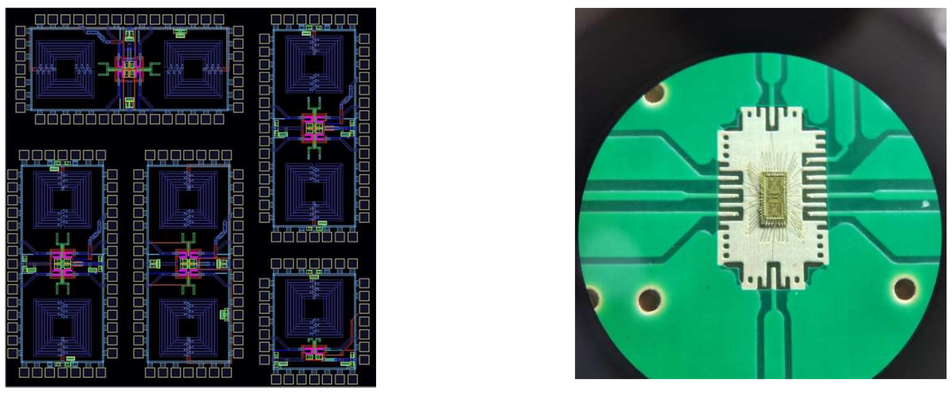


Fig. 1. Structure of (a) Parallel-QVCO, and (b) NIL-QVCO with NMOS coupling transistors.



(a)

(b)

Fig. 2. (a) Layout of QVCOs, and (b) a mounted chip on test PCB for chip measurement.

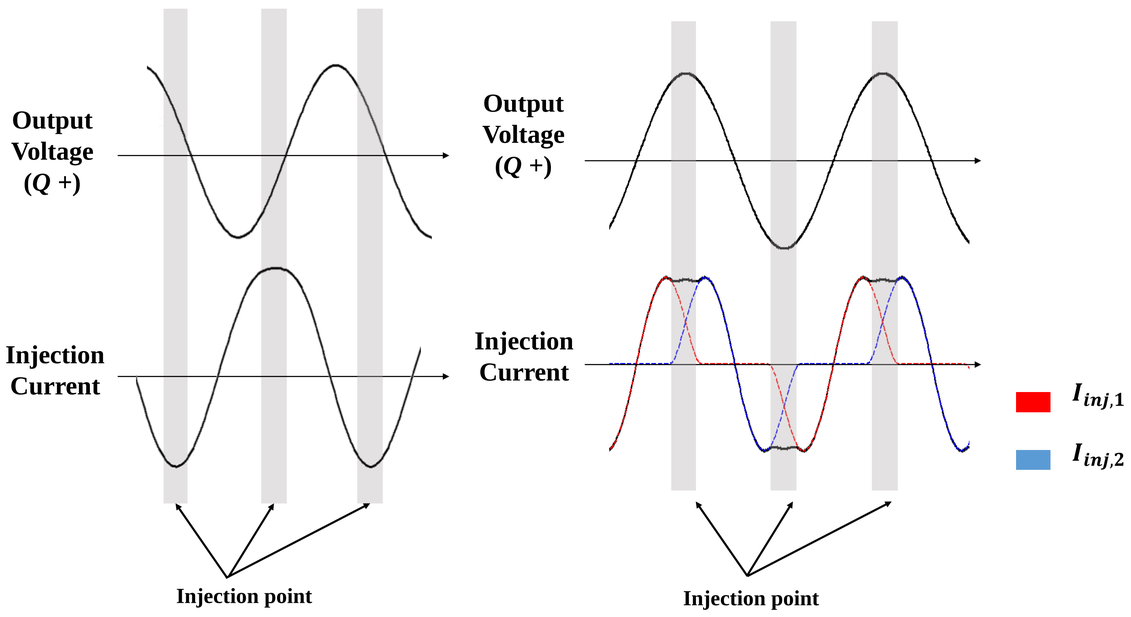
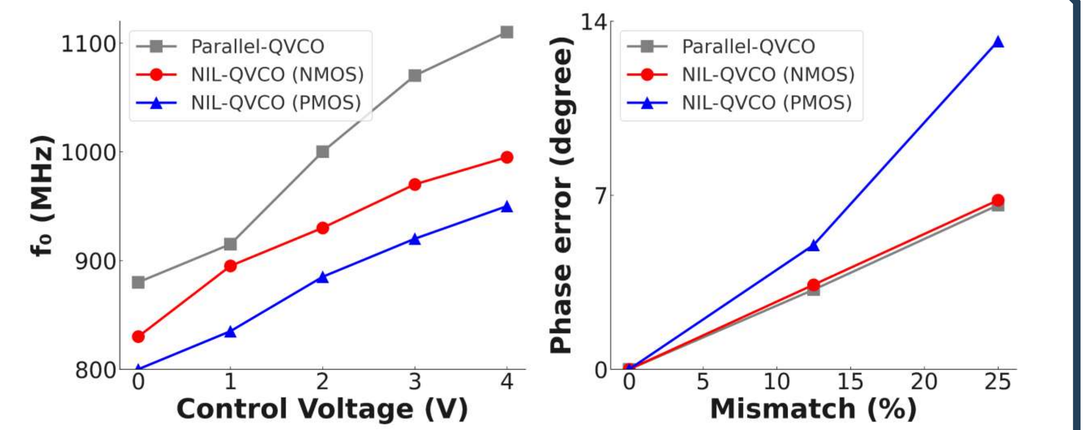
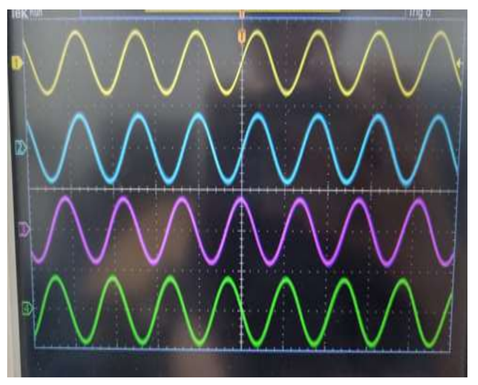


Fig. 3. Simulation results of QVCOs waveform.

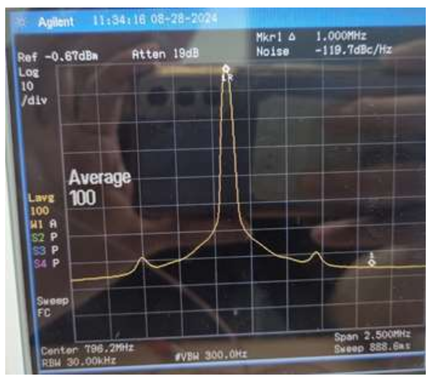


Structure	Phase Noise (dBc/Hz@1MHz)
Classical parallel-QVCO	120.8
NIL-QVCO (NMOS)	122.2
NIL -QVCO (PMOS)	128.8

Measurements Results



(a)



(b)

Fig. 4. (a) Measured waveform and (b) phase noise of the NIL-QVCO (NMOS).

The chip operates correctly at the designed oscillation frequency (f_0) and shows phase noise performance similar to simulation results.

However, errors in coupling between the VCOs were observed, likely due to mismatches in the current sources or issue in the test PCB design.

These issues would be resolved through modifications to the current source layout and improvements in the PCB layout to ensure accurate measurement.

Conclusion

The simulation verified the phase noise of each circuit, the oscillation frequency (f_0) with Vcont, and the phase error under intentional mismatch to confirm coupling strength.

The proposed circuit represents improvements of 1.4 dBc/Hz (NMOS coupling) and 8 dBc/Hz (PMOS coupling), respectively, compared to the classical parallel-QVCO.

References & Acknowledgment

[1] S. R. Mghabghab and J. A. Nanzer, "Impact of VCO and PLL Phase Noise on Distributed Beamforming Arrays With Periodic Synchronization," IEEE Access, vol. 9, pp. 56578-56588, Apr. 2021.

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