IDEC Chip Design Contest

W-band CMOS Sliding-IF Upconversion Mixer

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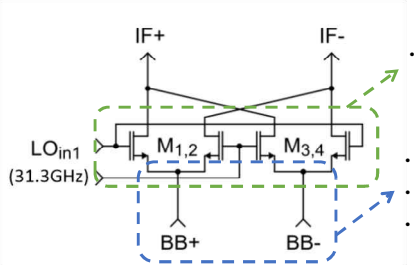
Introduction

W-band frequencies enable high-resolution radar and high-data-rate communication systems due to their short wavelengths and wide bandwidth. However, W-band upconversion mixer design is challenging because high-frequency local oscillator (LO) generation and distribution increase power consumption and circuit complexity. The Sliding-IF architecture mitigates this issue by employing an LO frequency lower than the RF frequency and deriving one LO from another through their tracking relationship, thereby easing high-frequency LO generation. Based on this concept, this work proposes a Sliding-IF W-band upconversion mixer that derives LO_2 from LO_1. The proposed design employs a Gilbert-cell mixer in the first stage and a square-law mixer in the second stage to achieve high conversion gain and stable W-band operation.

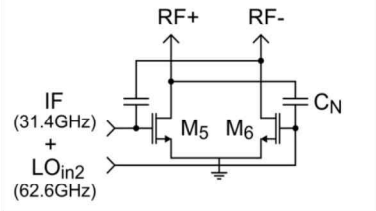
Implementation

• Common-Gate Gilbert-cell Upconversion Mixer



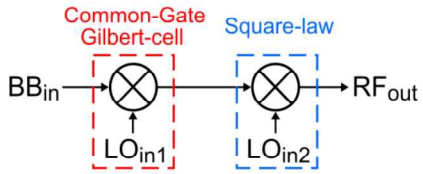
- Reduce LO leakage & even-order distortion
- Improved stability
- Low input matching loss
- High linearity

• Square-law Upconversion Mixer



- Simple architecture
- High conversion gain
- Stability ensured through cross-coupling

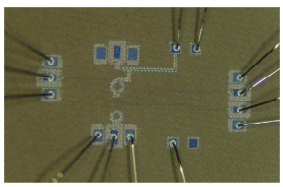
• Proposed Sliding-IF Upconversion Mixer



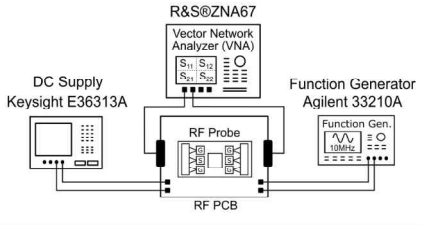
The proposed mixer adopts a cascaded architecture consisting of a first-stage Gilbert-cell mixer and a second-stage square-law mixer. The sliding-IF scheme reduces the burden of high-frequency LO generation, while the double-balanced Gilbert-cell mixer suppresses LO leakage and maintains signal separation even when the IF and LO frequencies are closely spaced. The square-law stage then compensates for the limited gain of the first stage, providing high overall conversion gain. As a result, this hybrid structure balances input matching, LO isolation, and high gain for high-frequency applications.

Results

• Chip micrograph

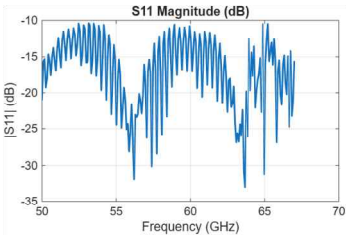


[Chip micrograph]

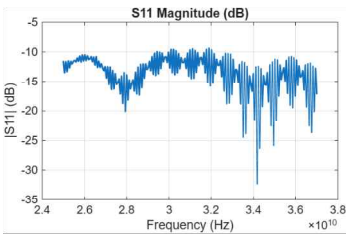


[S-parameter measurement setup]

• Measurement results



[S11 measurement of LO_1]



[S11 measurement of LO_2]

[Comparison table]

	[1]	[2]	[3]	This work*
Tech.	90 nm SiGe	65 nm CMOS	90 nm CMOS	28 nm CMOS
Freq [GHz]	81-86	62-85	94	94
CG [dB]	-2.5 to 3	-4.3	3.4	4.25
OP_{1dB} [dBm]	-17 to -14.5	-2.16	-6.6	-10.5
P_{LO} [mW]	68	-	-	0.96
P_{DC} [mW]	400	10.8	8.5	8.4

*: Simulated results

[1] N. Ebrahimi and J. F. Buckwalter, "A High-Fractional-Bandwidth, Millimeter-Wave Bidirectional Image-Selection Architecture With Narrowband LO Tuning Requirements," in IEEE Journal of Solid-State Circuits, vol. 53, no. 8, pp. 2164-2176, Aug. 2018, doi: 10.1109/JSSC.2018.2828855.
[2] Z. Chen et al., "A 62–85-GHz High Linearity Upconversion Mixer With 18-GHz IF Bandwidth," in IEEE Microwave and Wireless Components Letters, vol. 29, no. 3, pp. 219-221, March 2019, doi: 10.1109/LMWC.2019.2894979.
[3] Y. -S. Lin, C. -C. Chen, C. -C. Wang, Y. -W. Lin, R. -C. Liu and C. -C. Ji, "A low power and high conversion gain 94 GHz up-conversion mixer with excellent I/O matching and LO-RF isolation in 90 nm CMOS," 2016 IEEE Radio and Wireless Symposium (RWS), Austin, TX, USA, 2016, pp. 183-186, doi: 10.1109/RWS.2016.7444399.

Conclusion

This work demonstrates a W-band upconversion mixer through circuit-level simulations, achieving competitive performance in conversion gain and linearity. Although key performance metrics have not yet been experimentally measured, the simulation results confirm the validity of the proposed design approach and its suitability for W-band applications.