IDEC Chip Design Contest

Design of wideband mixer for broadband communication

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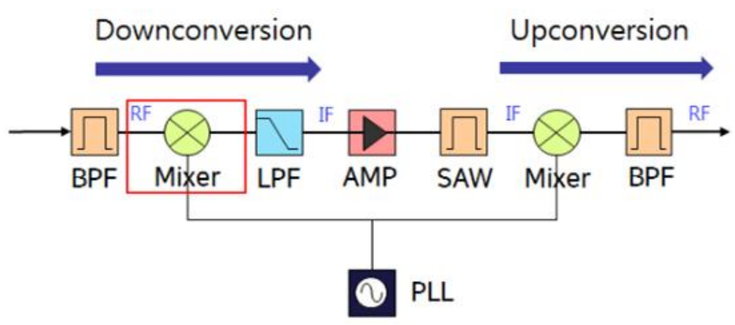
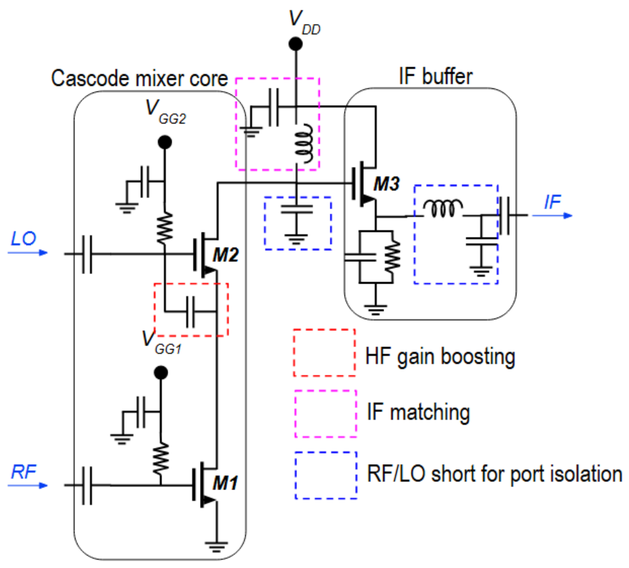
Introduction



Down-conversion mixers convert high-frequency RF signals to lower IF for easier processing in receivers. As wireless systems evolve, efficient mixer design with high gain, low power, and reduced LO leakage is essential.

This work presents a wideband down-conversion mixer optimized for focusing on improved conversion gain, low power consumption, and minimized LO leakage

Design



▲ Schematic of the proposed wideband frequency down converter

- A gate-source capacitor (red box) boosts high-frequency conversion gain by suppressing RF/LO leakage.
- The LC network (pink box) handles IF matching and simplifies biasing without coupling capacitors.
- To improve isolation, additional filtering (blue box) blocks RF and LO leakage at the IF port using a shunt capacitor and series inductor.

RF (GHz)	2GHz IF power (dBm) RF = - 20 dBm, LO = 5 dBm	
	No feedback cap	With 130 fF feedback cap
10	- 6.51	- 6.95
20	- 5.45	- 6.09
30	- 6.98	- 5.91
40	- 9.2	- 6.13
50	- 11.52	- 7.79
60	- 12.28	- 9.81

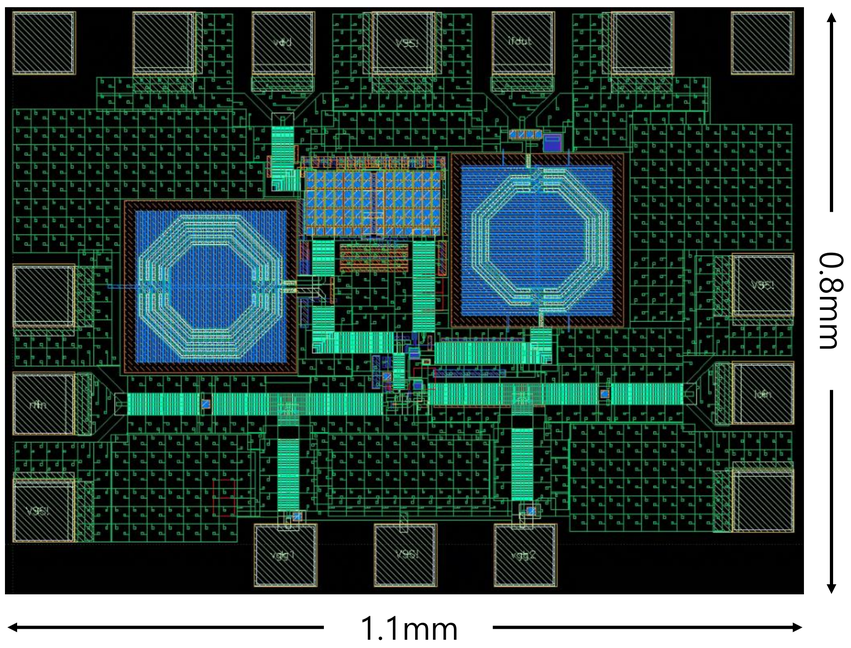
Table 1. Power comparison with and without boost capacitor

RF (GHz)	2GHz IF power (dBm) RF = - 20 dBm, LO = 5 dBm	
	RF - IF Isolation	LO - IF Isolation
10	- 52.32	- 42.68
20	- 71.59	- 54.21
30	- 62.76	- 48.6
40	- 54.55	- 44.49
50	- 52.72	- 34.52
60	- 57.73	- 42.66

Table 2. RF and LO isolation of IF terminal

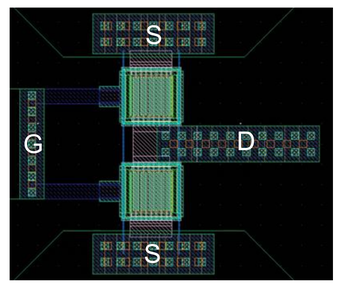
- The proposed isolation circuit improves simulated RF-IF and LO-IF isolation. Initially below 40 dB and 30 dB respectively, both isolations improved by over 10 dB on average with the added circuitry.
- With the added capacitor, IF power begins to improve above 30 GHz, achieving up to 3 dB gain enhancement. As a result, over 10 dB conversion gain is maintained across a wide 10–60 GHz RF range.

Results



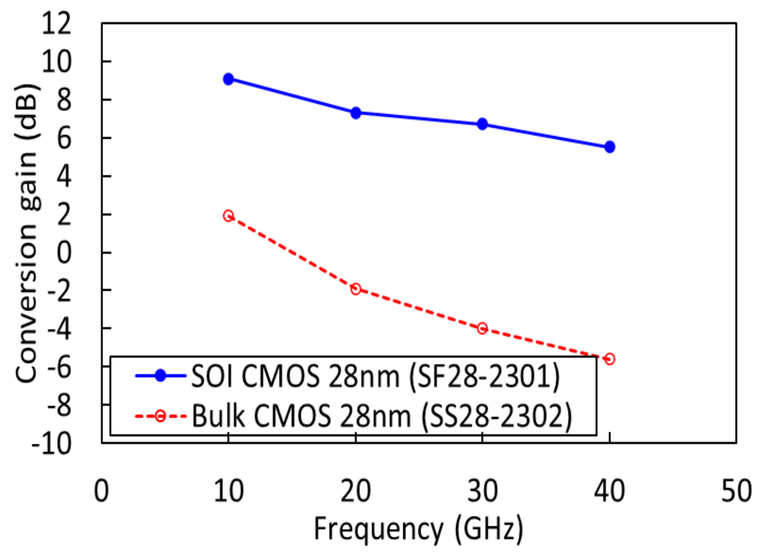
▲ Wideband frequency down converter Layout

- Designed and fabricated by Samsung 28nm CMOS Process
- FET : lvt_mmw_rf 2 × 32μm (total width 64μm)
- Size : 1100 μm × 800 μm



▲ Symmetry type NFET

Measurement Result



▲ Conversion gain of the fabricated cascode mixers according to frequencies

The fabricated mixer exhibits a conversion gain of 5 to 9 dB over a wide bandwidth from 10 to 40 GHz. A flatter conversion gain characteristic is expected after compensating for the cable loss over frequency. In particular, when compared to the measurement results of the same circuit designed with a conventional Bulk CMOS process, the SOI CMOS process shows an average conversion gain improvement of more than 10 dB.

Conclusions

If the proposed research is successfully carried out based on the design ideas introduced earlier, it is expected that it will be able to present a new approach to implementing communication semiconductor components in the future. Above all, it is possible to secure the source technology for broadband communication circuits that are expected to increase in demand for civilian and military use with the commercialization of 5G and 6G communication.

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