Small-Area CMOS RF Distributed Mixer Using Multi-Port Inductors

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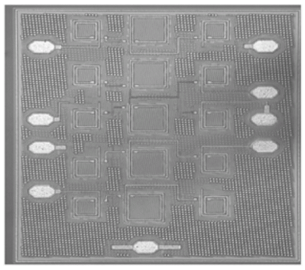
Background

Ultra Wide-band (UWB) wireless interconnection

- Huge amount of data (>480Mbps) for PAN.
- Wideband amplifiers and mixers are necessary.



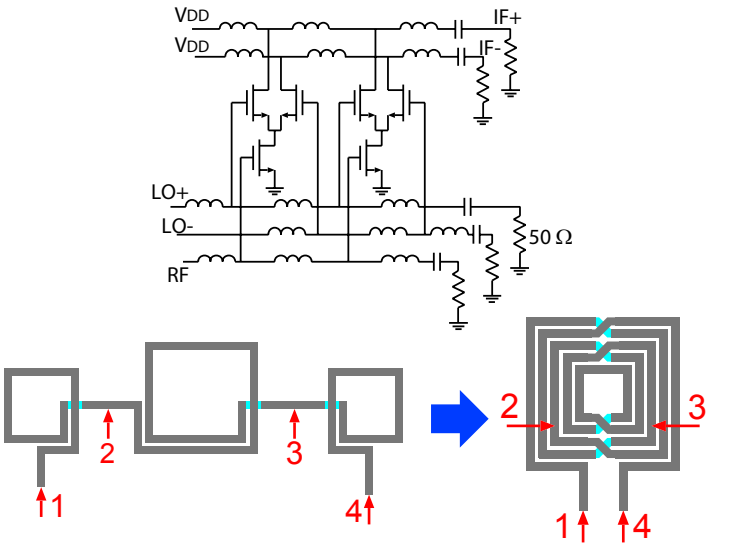
Distributed mixers have been proposed.[1]

Many indactors occupy a large area.

[1] A. Q. Safarian, *et al.*, IEEE Trans. VLSI Syst.vol. 13, No. 5, pp. 618-629, May 2005.

A multi-port inductor

A 2-stage distributed mixer

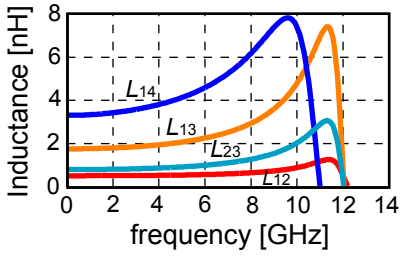


Three 2-port inductors

One 4-port inductor

Area saving

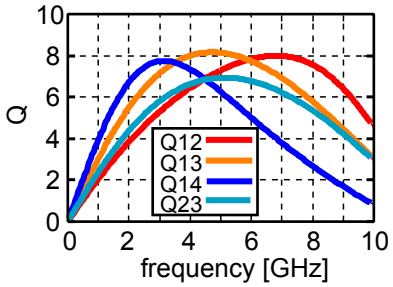
Simulated inductance and Q



$$L_{lm} = \frac{1}{2\pi f}\,\mathrm{Im}\; z_{ll} - \frac{z_{lm}z_{ml}}{z_{mm}}$$ [2]

L_{12}: 0.5nH L_{23}: 1.0nH
L_{13}: 2.2nH L_{14}: 4.6nH
@6.0GHz

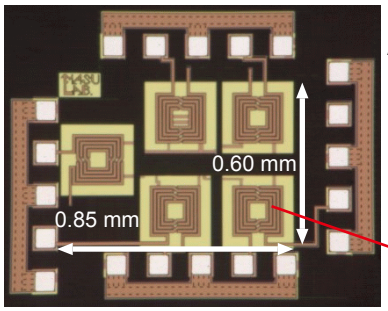
[2] T, Ito, *et al.*, IEEE ASSCC . pp.359-362, 2006.



$$Q_{L_{lm}} = \frac{\mathrm{Im}\; z_{ll} - \frac{z_{lm}z_{ml}}{z_{mm}}}{\mathrm{Re}\; z_{ll} - \frac{z_{lm}z_{ml}}{z_{mm}}}$$ [2]

The maximum Q factor: 8

The proposed small-area distributed mixer



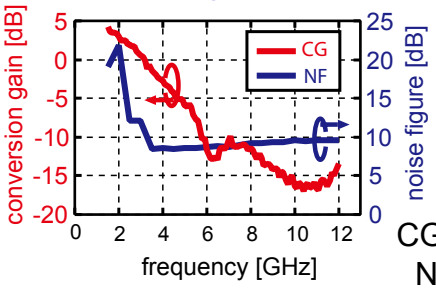
A 2-stage distributed mixer
0.18μm CMOS process

Circuit area: 0.51mm^2
⟷ 1.60mm^2 [1]

A 4-port inductor
0.032mm^2 (0.18mm×0.18mm)

Measurement results

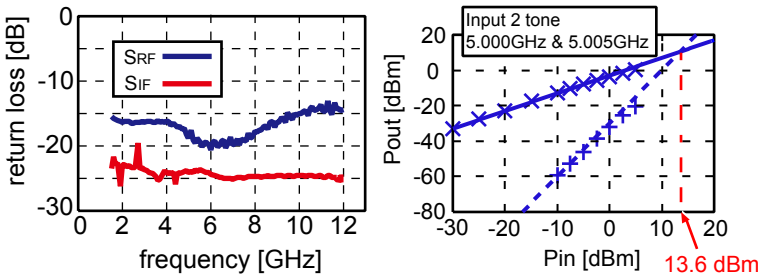
Conversion gain & noise figure



RF power: -20dBm
LO power: 7dBm
IF frequency: 0.5GHz

CG>-10dB@1.5~6.0GHz
NF<15@2.3~12.0GHz

Return loss & IIP3



Performance comparison

	RF frequency	conversion gain	power consumption	process	circuit area
this wotk	2.3-6.0 GHz	-2.2 dB	50.4 mW	0.18μm CMOS	0.51 mm^2
[1]	3-8.72 GHz	3.0 dB	10.4 mW	0.18μm CMOS	1.6 mm^2
[3]	3-22 GHz	3.6 dB	129 mW	0.18μm CMOS	3.02 mm^2
[4]	1-14 GHz	1.0 dB	——	GaAs MESFET	2.7 mm^2
[5]	6-10.6 GHz	14~17 dB	0.2 mW	0.18μm CMOS	0.73 mm^2
[6]	18-28 GHz	-2~0.7 dB	8.0 mW	0.13μm CMOS	0.47 mm^2

[1], [3], [4]: distributed mixer

[3] X. Fan, *et al.*, IEEE Int. SOC Conf., pp. 93-96, Sep. 2004.
[4] I. D. Rovertson, *et al.*, IEEE Colloquium on Multi-Octave Microwave Circuits, pp. 4/1-4/7, Nov. 1991.
[5] T.-T. Hsu and C.-N. Kuo,IEEE ISCAS, pp. 5704-5707, 2006.
[6] A. Verma, *et al.*IEEE Trans. on Microwave Theory and Tech., vol. 54, no. 8, pp. 3295-3300, Aug. 2006.

Conclusion

- We proposed a novel small-area distributed mixer using multi-port inductors.
- The proposed mixer has a frequency range of 2.3GHz to 6.0GHz, CG > -10 dB, NF < 15 dB, IIP3 of 13.6 dBm, and return loss of -10dB.