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

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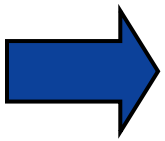
1. Background

TOKYO TECH Pursuing Excellence

- Ultra Wide-band (UWB) wireless interconnection

  Carrying huge amount of data of more than 480Mbps for personal area networks

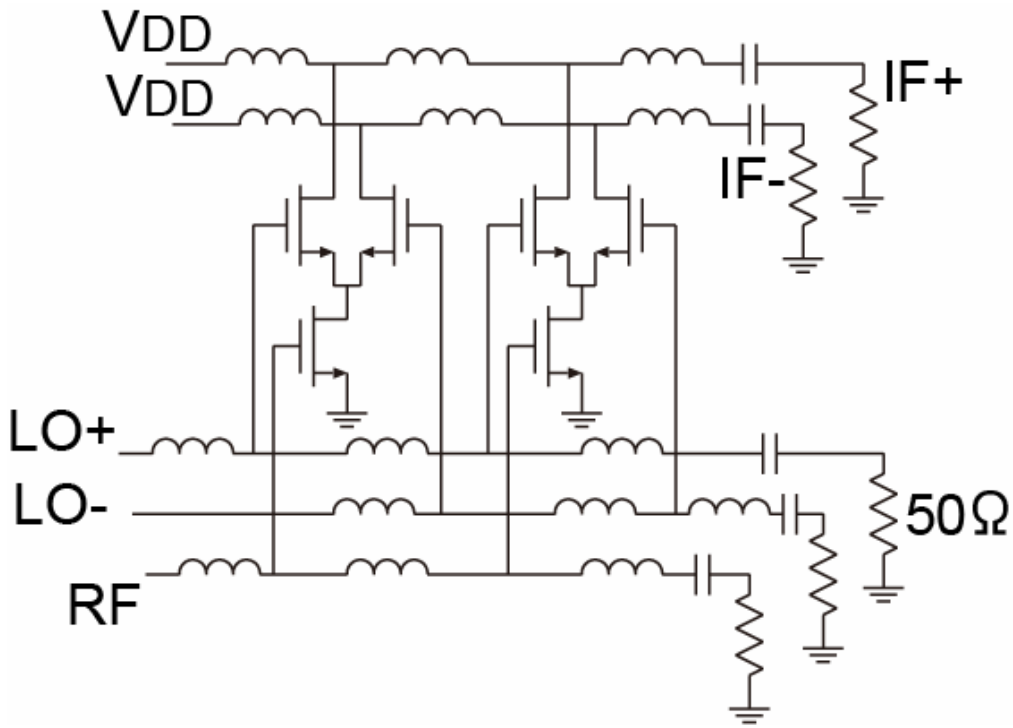
- Amplifiers and mixers covering wide bands are necessary for UWB receivers



Distributed mixers

Problem: they usually occupy a large areas

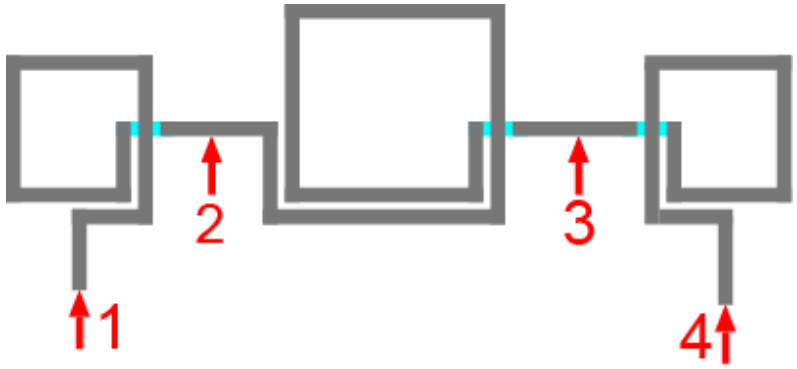
2. A 2-stage distributed mixer



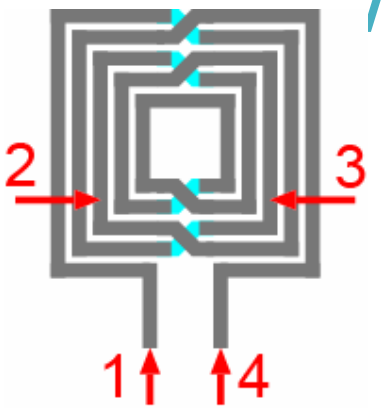
- Several 2-port spiral inductors are used for realizing LC network.
- Many inductors occupy a large area.

This work proposes the use of multi-port inductors to reduce inductor areas.

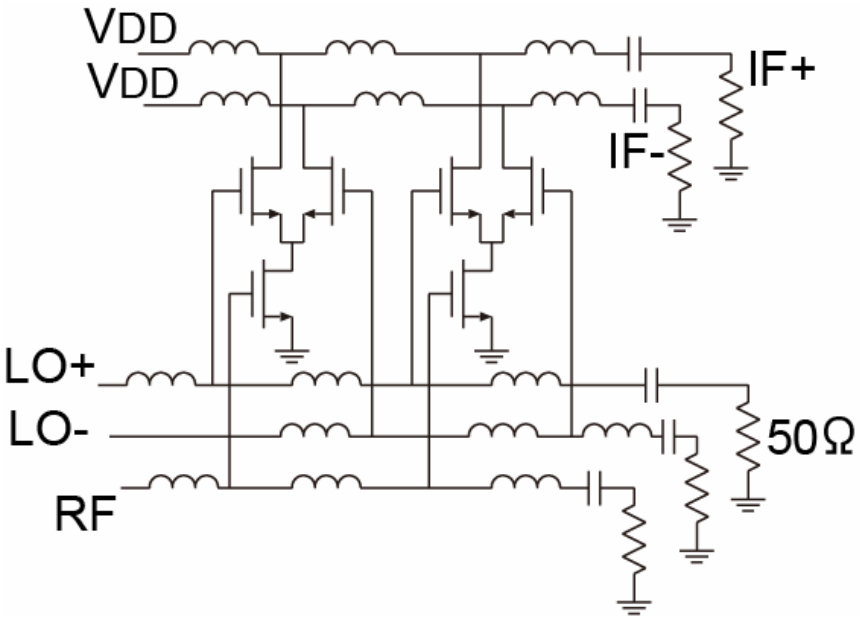
3. Multi-port inductors



Three 2-port Inductors



One 4-port inductor



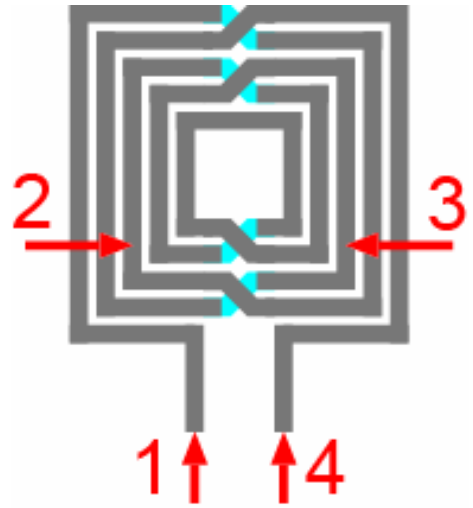
In the case the of 2-stage distributed mixer

15 :2-port inductors

5 :4-port inductors

The circuit area can be saved.

4. Characteristics of 4-port inductor

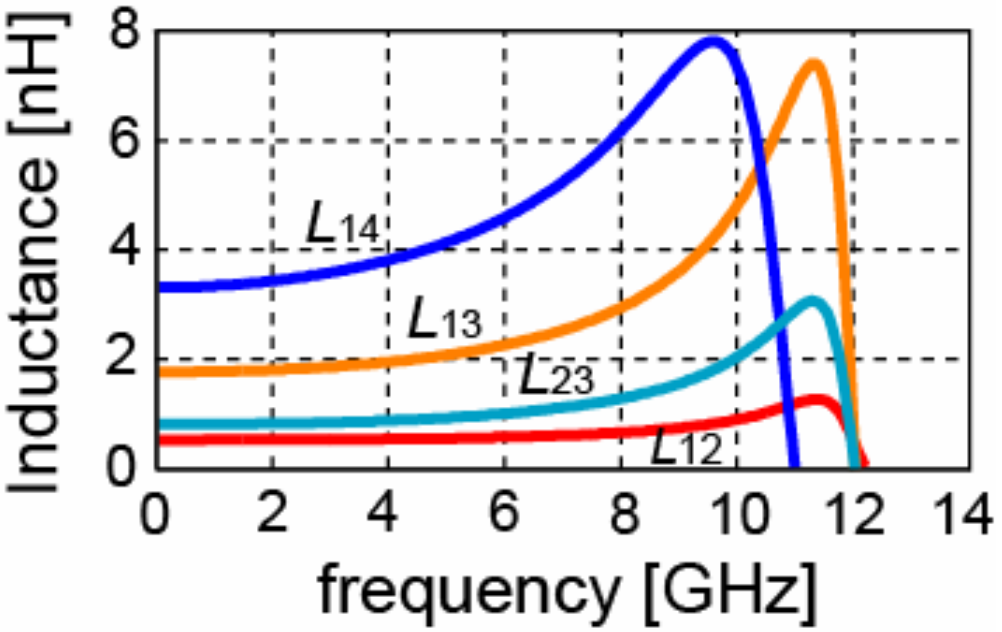


$$L_{lm} = \frac{1}{2\pi f}\mathrm{Im}\left(z_{ll} - \frac{z_{lm}z_{ml}}{z_{mm}}\right)$$

$$Q_{L_{lm}} = \frac{\mathrm{Im}\left(z_{ll} - \frac{z_{lm}z_{ml}}{z_{mm}}\right)}{\mathrm{Re}\left(z_{ll} - \frac{z_{lm}z_{ml}}{z_{mm}}\right)}$$

[1]T. Ito, et al. IEEE A-SSCC, pp.359-362, 2006

Simulated



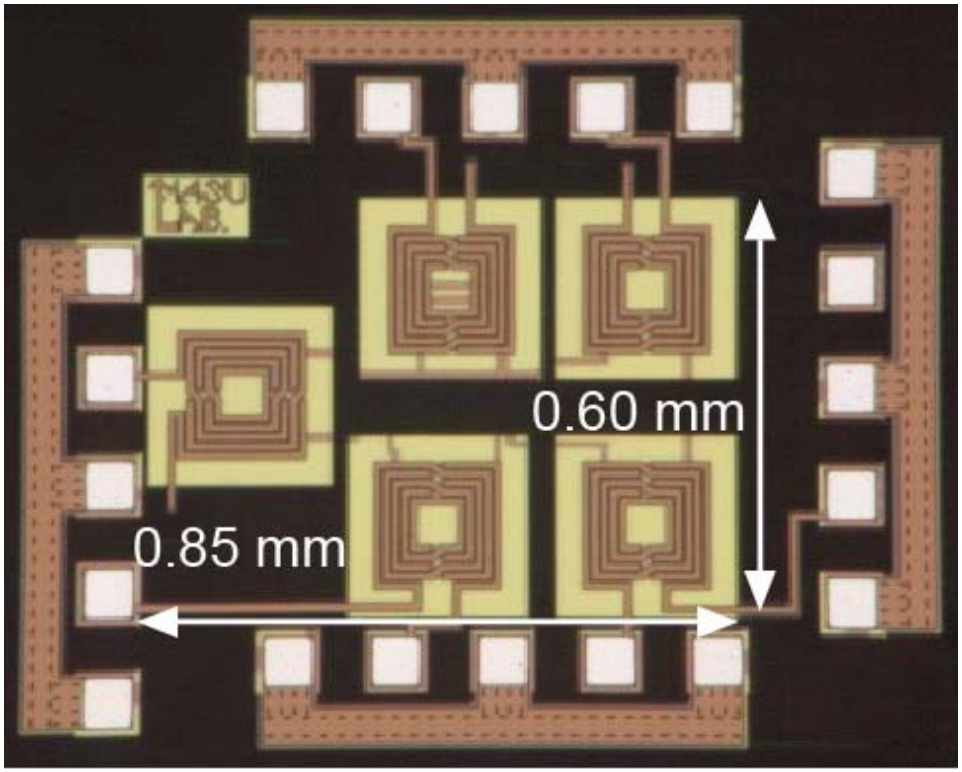
*L*12: 0.5nH, *L*23: 1.0nH

*L*13: 2.2nH, *L*14: 4.6nH @6.0GHz

Quality factors: 8.0 (at maximum)

L12 is inductance between port-***1*** and -***2***

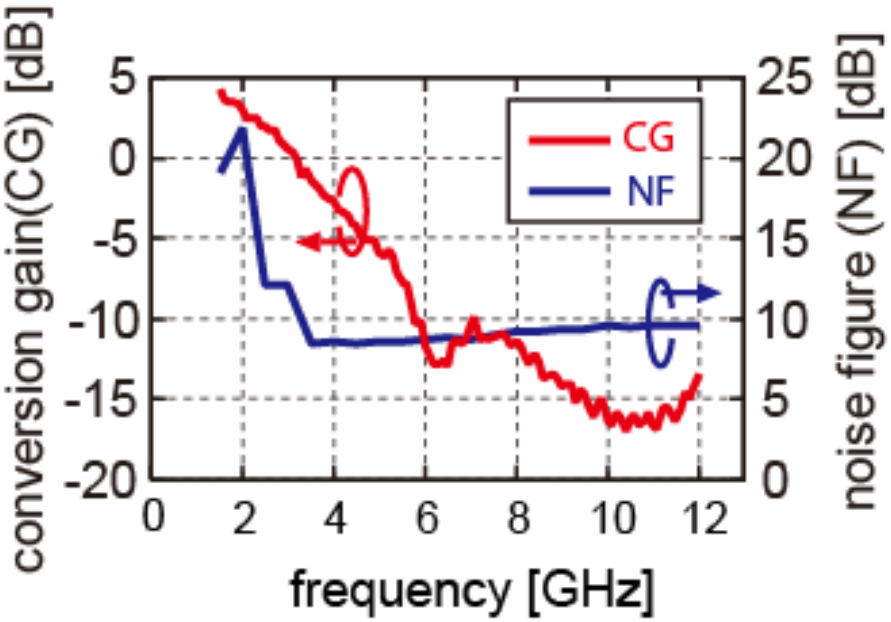
5. Micrograph

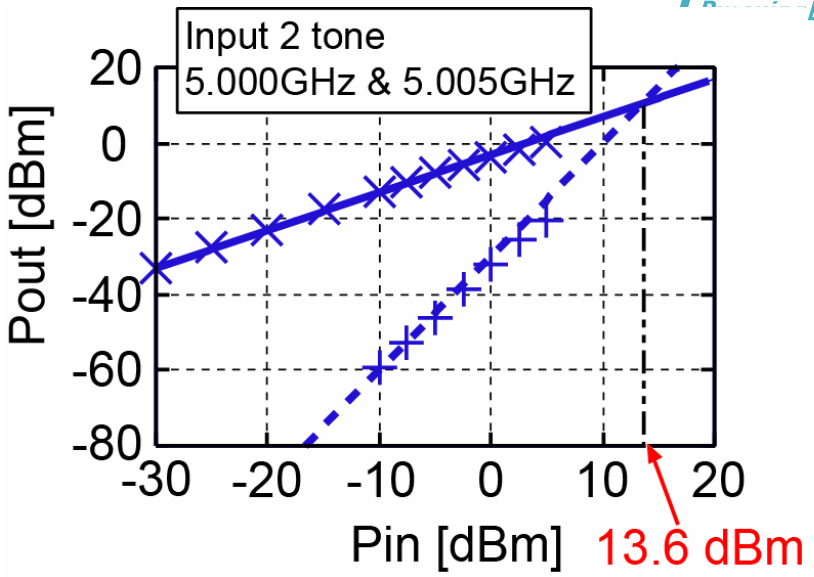


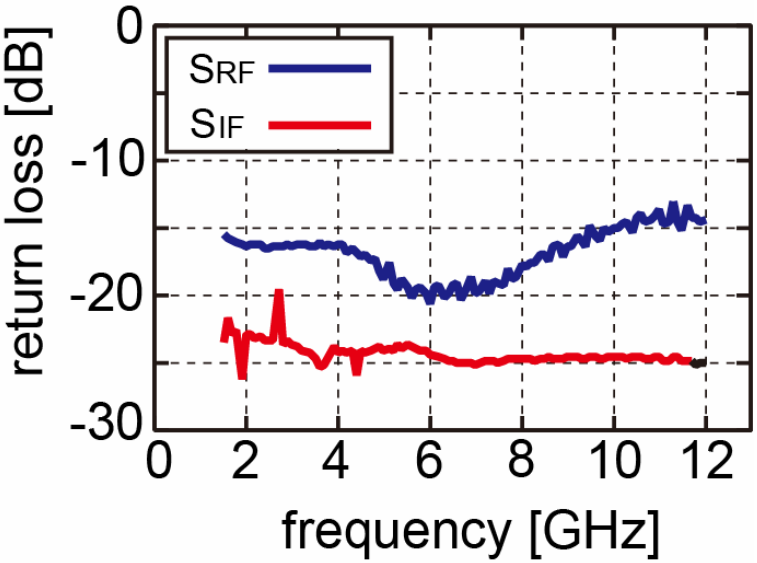
- 2-stage distributed mixer
- 0.18μm CMOS process
- Circuit area : 0.51mm^2 (4-port inductor)
  ⟺ 1.60mm^2 (2-port inductor) [2]

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

6. Measurements







Performance summary

Input RF power : -20dB, LO power: 7dB

IF frequency: 500MHz

CG > -10dB (@1.5~6.0GHz)

NF < 15dB (@2.3~12.0GHz)

IIP3 : 13.6dBm (@5.0GHz)

Return Loss < -10dB (@1.5~12.0GHz)

7. Summary and conclusion

- A novel small-area distributed mixer with multi-port inductors is proposed.

- The proposed mixer achieved 2.3-6.0GHz range down-conversions and 67% smaller area than conventional distributed mixer.