IDEC Chip Design Contest

An Octave TR Quad-Core Quad-Mode VCO with Coupled Dual-Path Inductor

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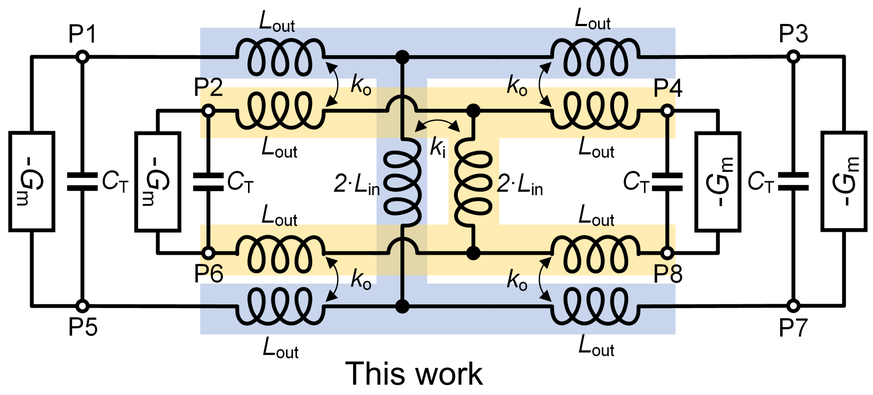
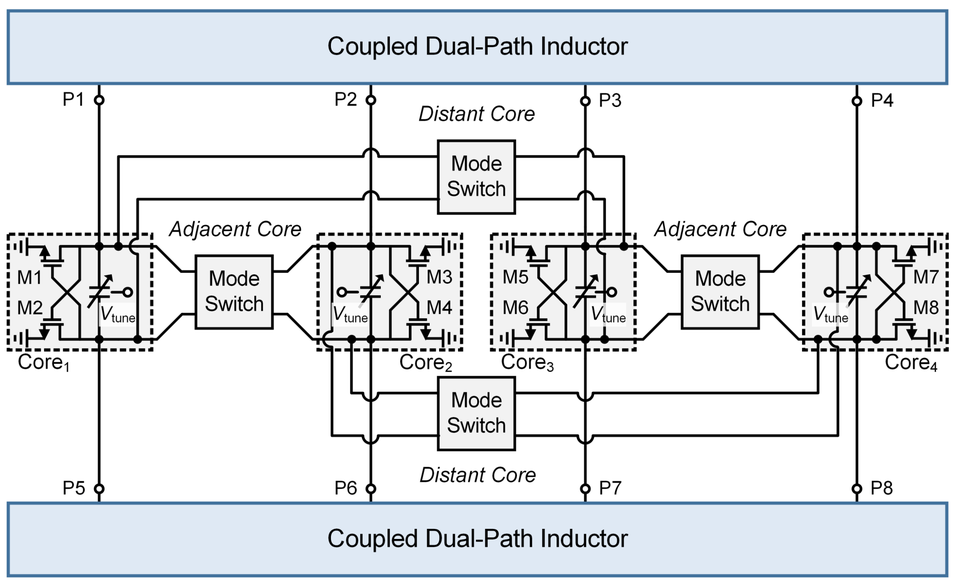
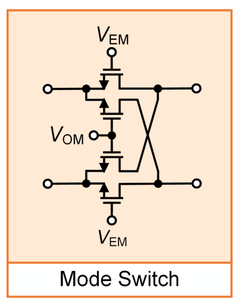
Introduction

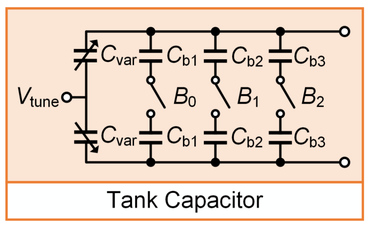
- **Mm-wave VCOs face challenges in**
  - Maintaining low phase noise (PN) due to low LC tank Q
  - Worsening PN with extended tuning range (TR)
- **Multicore VCOs offer PN improvement**
  - Coupling N cores improves PN by 10logN dB
  - Mode switching allows multi-mode operation without switch loss



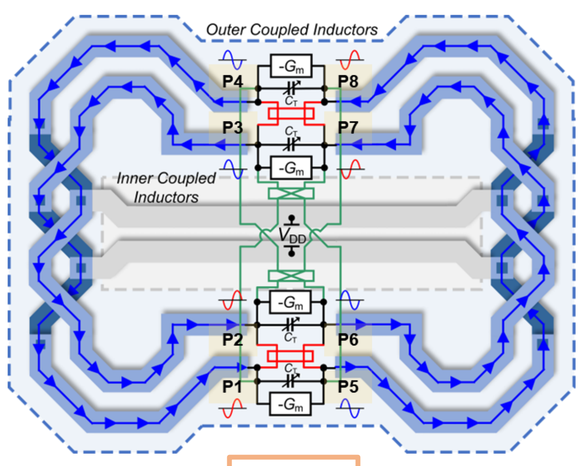
Circuit Design



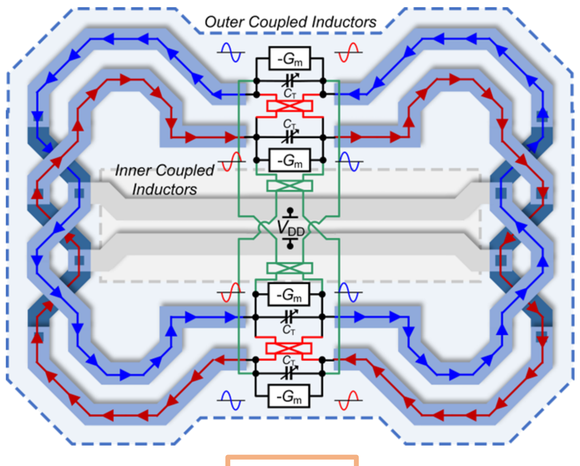




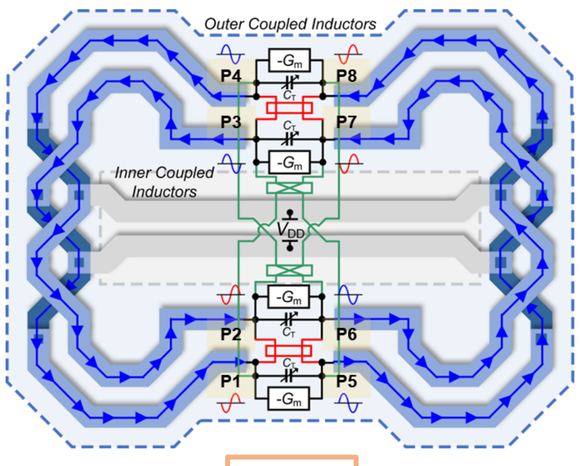
- Inductor network consists of 6 coupled inductors
- Quad-mode operation by four distinct VCO oscillation modes
- Mode 1 (Low band)
  - $L_{eff} \approx L_{out}(1+k_o)+2\times L_{in}(1+k_i)$
- Mode 2 (Mid-low band)
  - $L_{eff} \approx L_{out}(1-k_o)+2\times L_{in}(1-k_i)$
- Mode 3 (Mid-high band)
  - $L_{eff} \approx L_{out}(1+k_o)$
- Mode 4 (High-band)
  - $L_{eff} \approx L_{out}(1-k_o)$



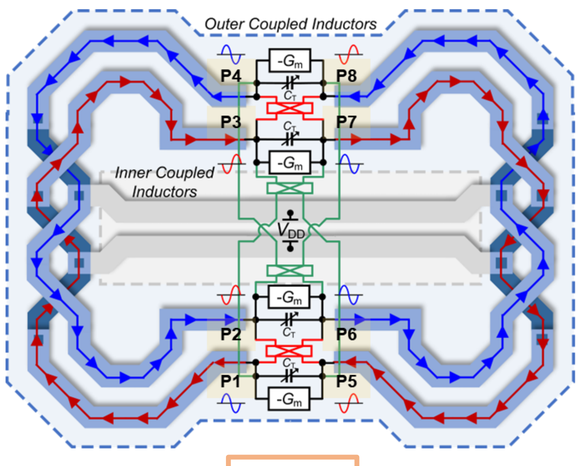
Mode 1



Mode 2

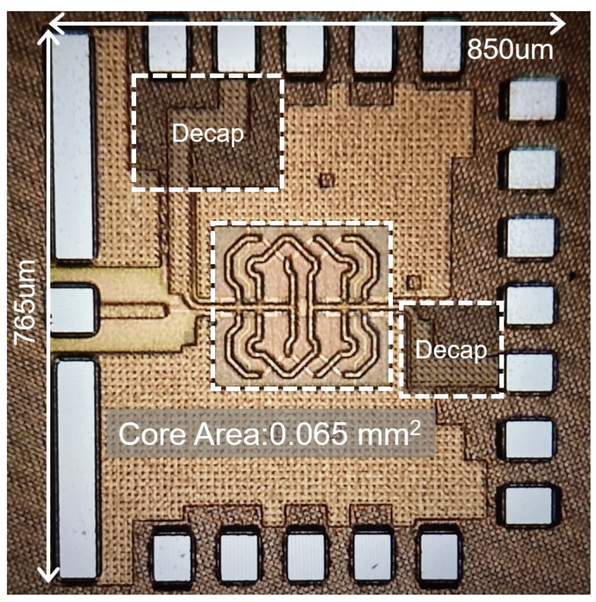


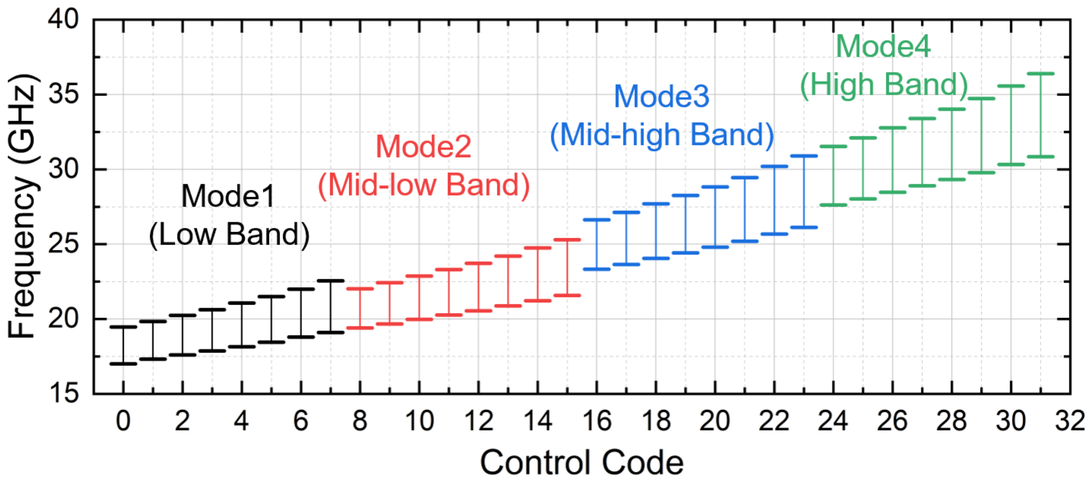
Mode 3

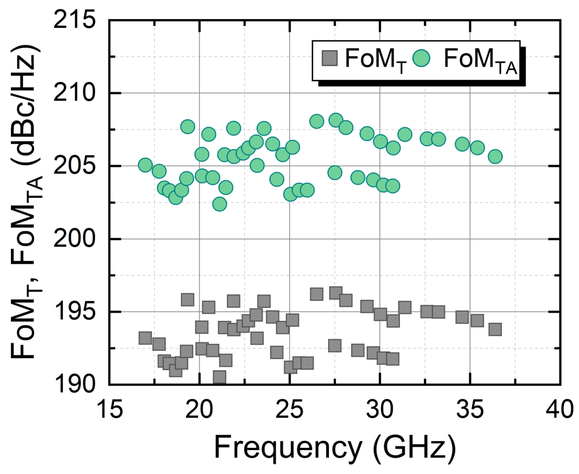


Mode 4

Measurement Results







- 17.0 – 22.6 GHz, 19.4 – 25.3 GHz, 23.3 – 30.9 GHz, 27.6 – 36.4 GHz
- Tuning range: 72.6 % (w/o mode ambiguity)
- Fabricated in 28nm CMOS, the VCO exhibits 72.6% TR, fully covering the K-band, with a peak FoMT of 196.3 dBc/Hz and peak FoMTA of 208.1 dBc/Hz

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