A 20GHz Push-Push Voltage-Controlled Oscillator for a MM-wave Frequency Synthesizer

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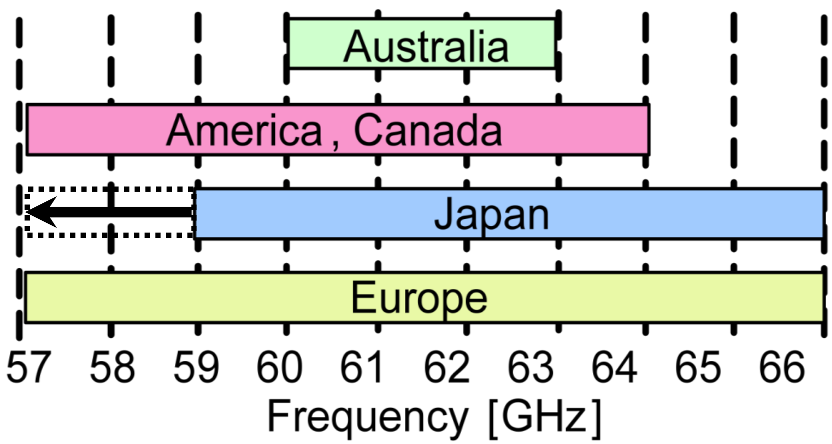
2012/9/12

Outline

- Background
- State-of-the-art 60GHz Local Oscillators
- Comparison of 20GHz vs 10GHz
- Proposed Schematic
- Measurement Results
- Performance comparison

Background

- **9-GHz unlicensed bandwidth at 60 GHz**
- **Several Gbps wireless communication**

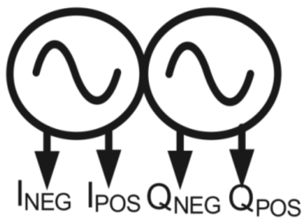


IEEE 802.15.3c | **Wireless HD** | **ECMA-387** | **WiGig** | **IEEE 802.11ad**

[1] http://www.tele.soumu.go.jp

60GHz LO Architectures

60GHz QPLL

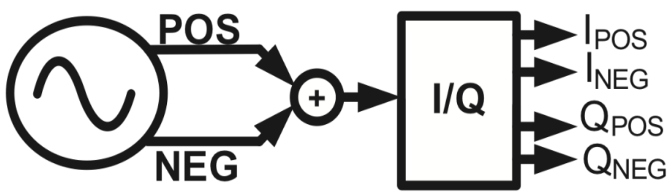


- 9GHz tuning range
- Low quality factor for capacitors

Poor Phase Noise

[1] IMEC, ISSCC 2009

30GHz PLL + Polyphase Filter

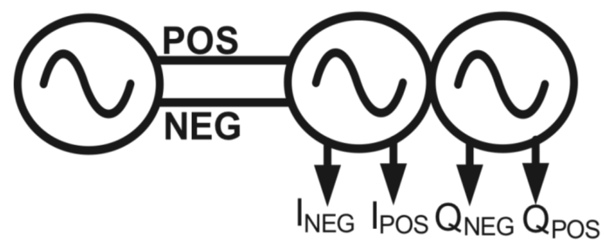


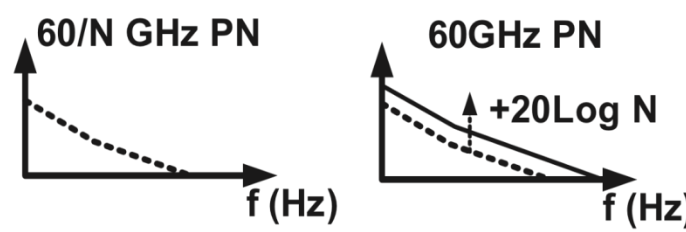
- 2^{nd} harmonic utilized
- Polyphase filter for quadrature generation

High power consumption
I/Q mismatch

[2] UCB, ISSCC 2009

20GHz PLL + Injection Locked Osc.





best phase noise reported

[3] Titech, JSSC 2011

Comparison of 10GHz and 20GHz

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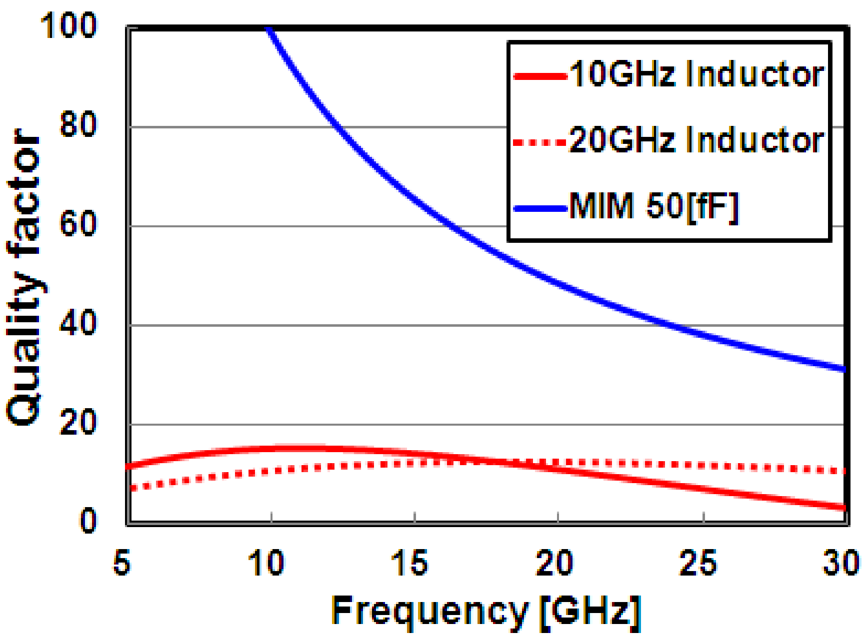
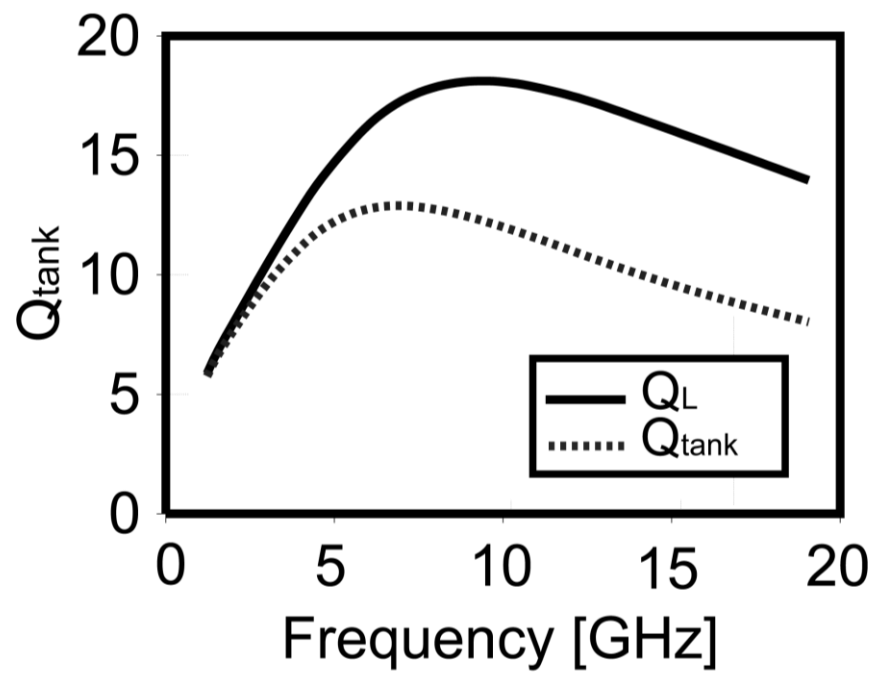


$$L(f_{offset}) = 10\log\left[\frac{2kT}{P_{sig}}\left(\frac{f_o}{2Q_{tank}f_{offset}}\right)^2\right]$$

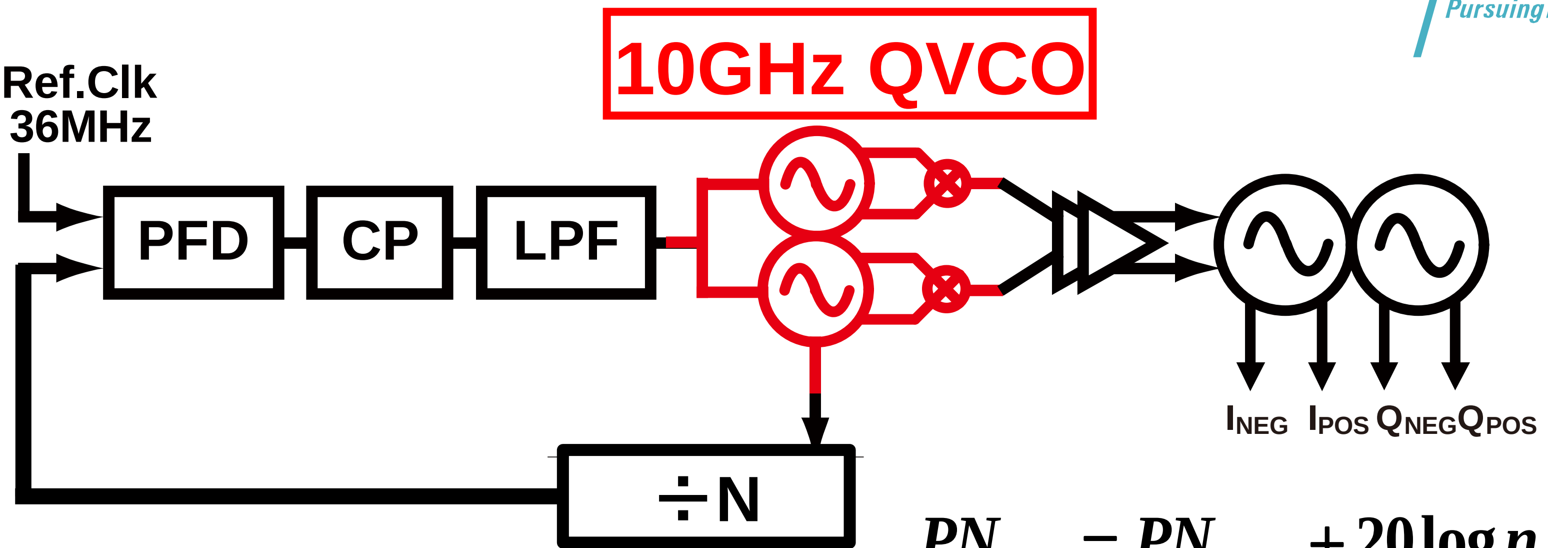
Quality factor of resonator: $$Q_{tank} = \frac{Q_L \cdot Q_C}{Q_L + Q_C}$$



At 10GHz, quality factor of resonator is relatively higher

[4] Murakami, *et al.*, MWSCAS 2009

Proposed VCO in 60GHz LO



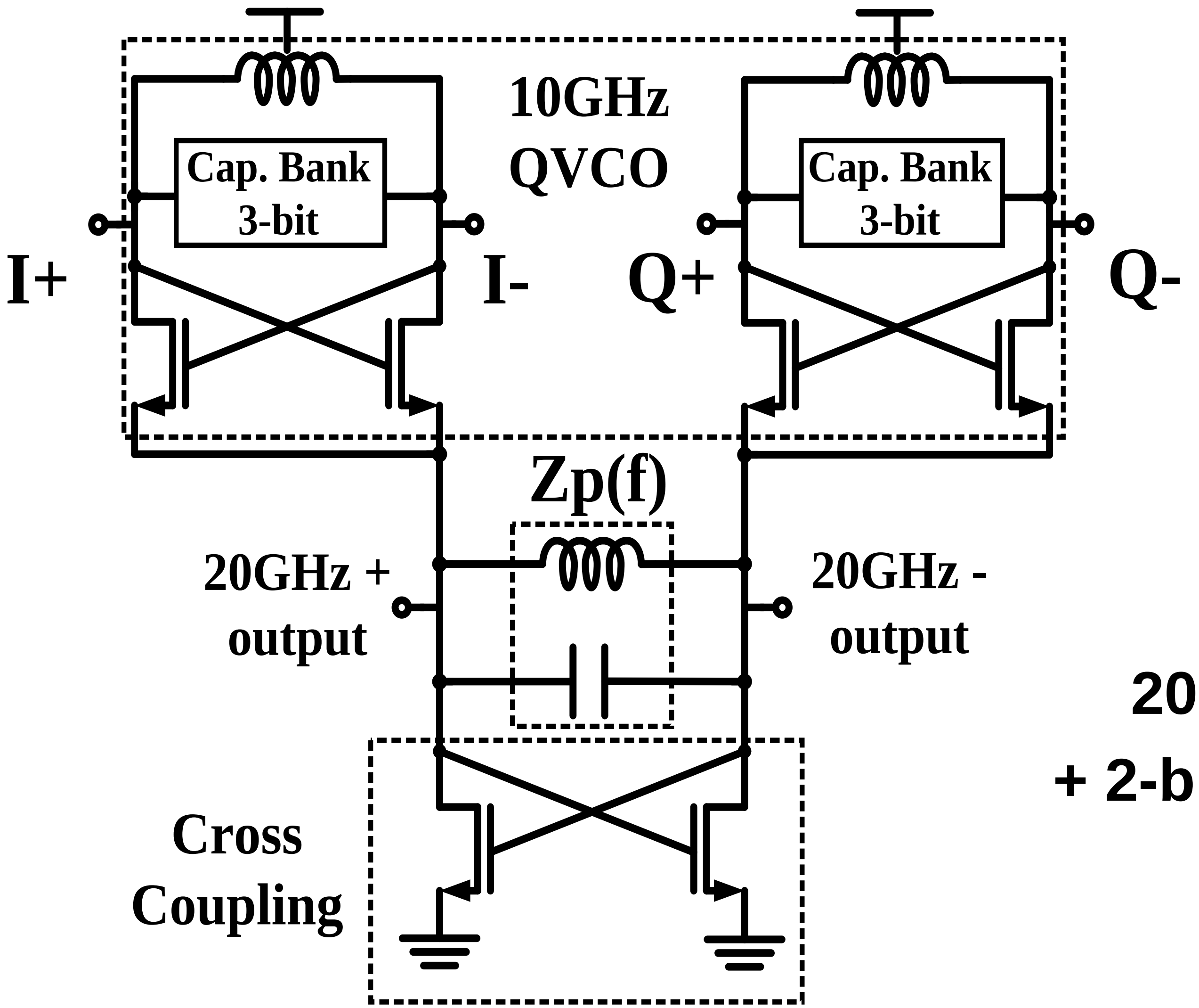
$$PN_{ILO} = PN_{input} + 20\log n$$

$$PN_{ILO} = PN_{10GHzPLL} + 15.5dB$$

- ☺ Higher Quality Factor of tank
- ☺ Less concern for parasitics
- ☺ High frequency prescaler can be eliminated
- ☹ Low output power
- ☹ Large Area

	10GHz	60GHz
PN requirement (16QAM)	-105.5 dBc/Hz	-90 dBc/Hz
Tuning range	9.5-11 GHz	57-66 GHz

Proposed Schematic

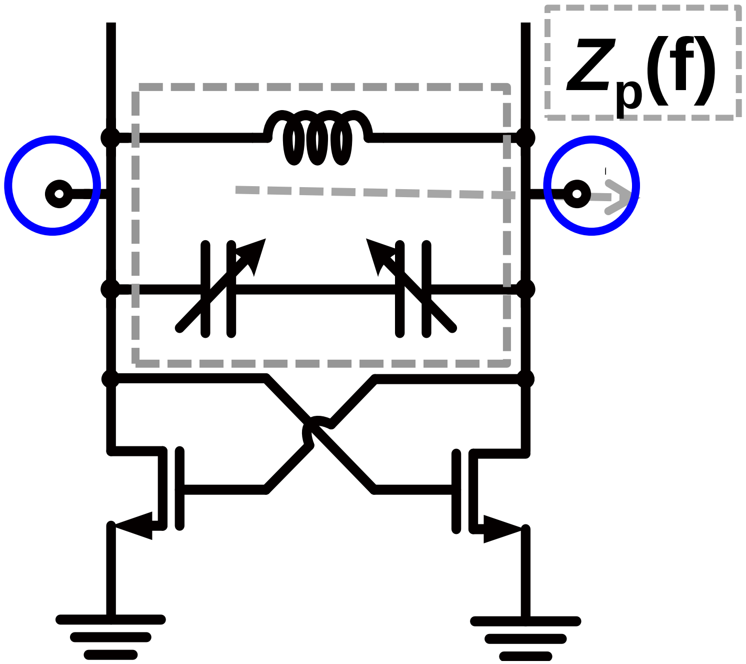


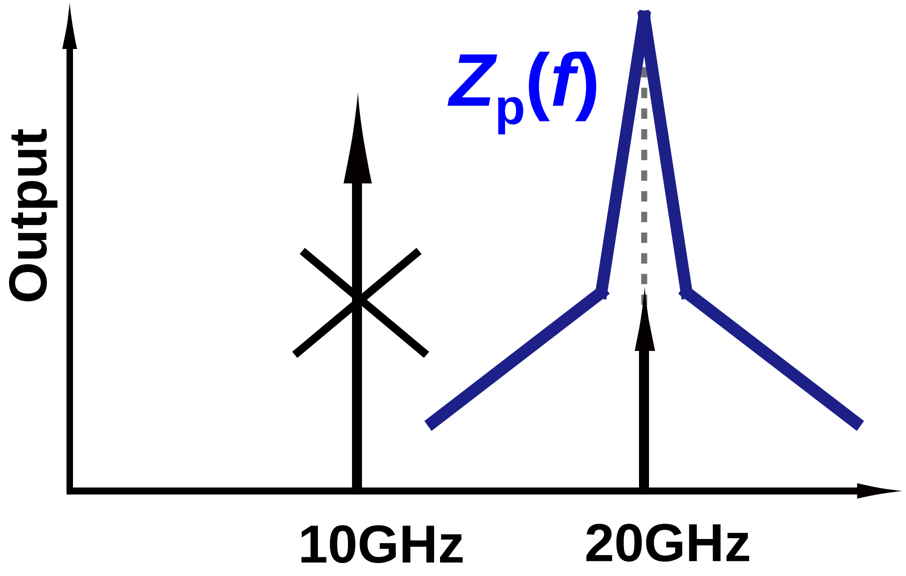
10GHz QVCO
+ 3-bit capacitor bank

20GHz resonator
+ 2-bit capacitor bank

20GHz Resonator

- **Impedance of resonator can be tuned by 2-bit capacitor**



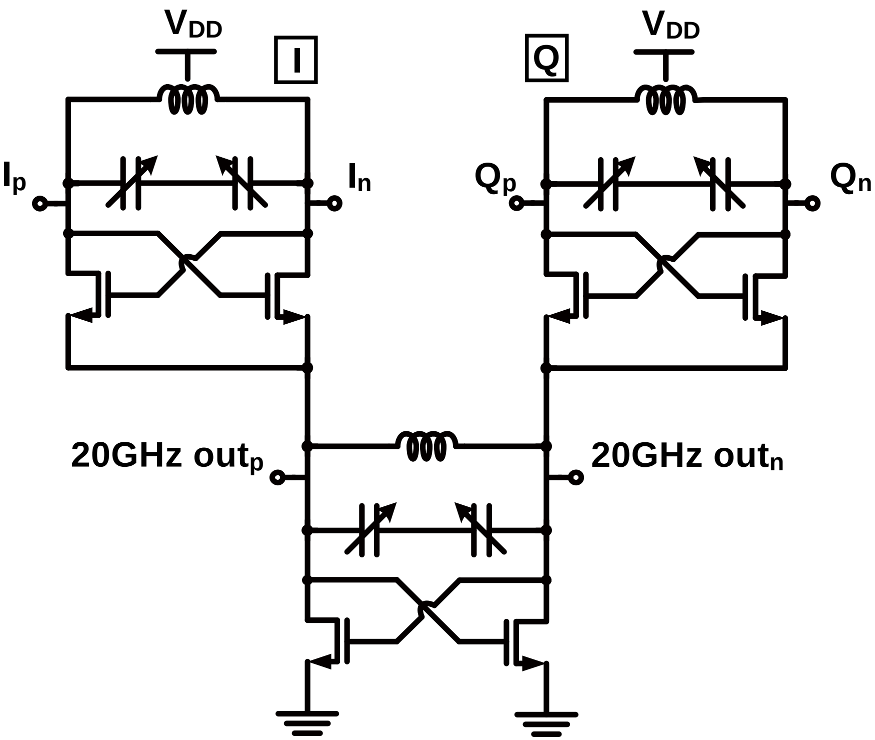


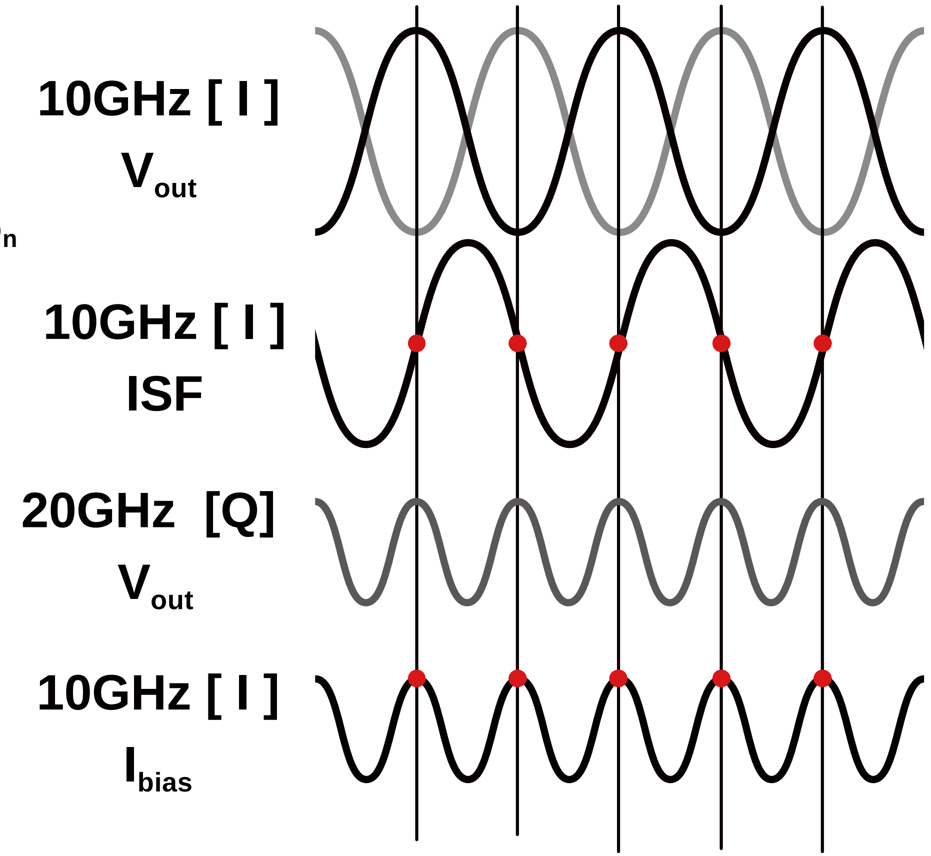
Improves **1) phase noise (as tail filtering)***

2) Improve output power

*[5] E. Hegazi, *et al.*, JSSC 2001

Tail Modulation

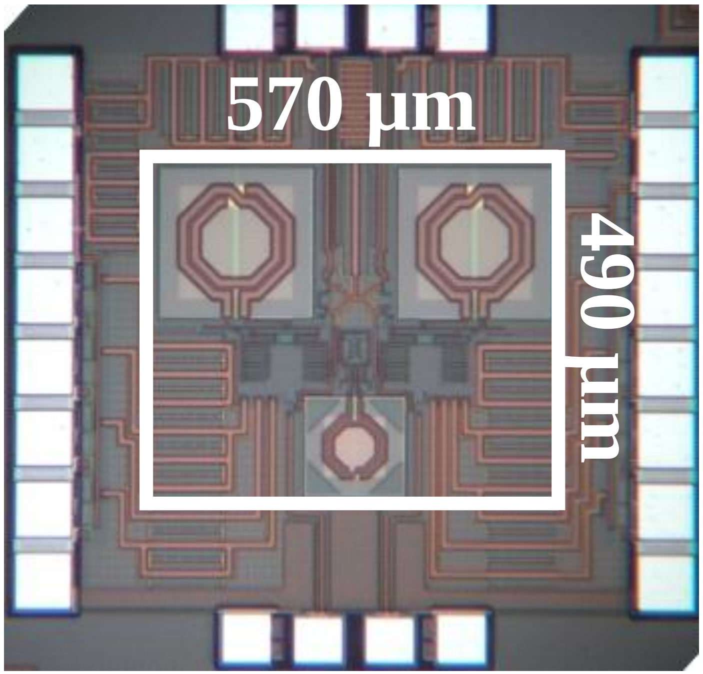




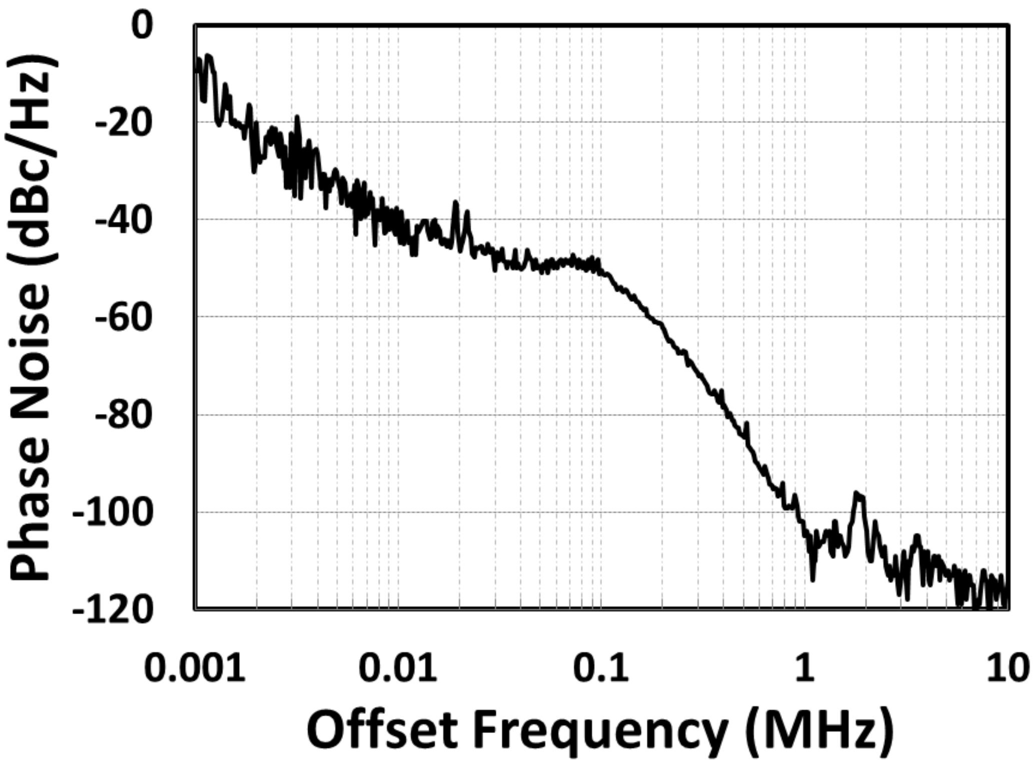
This mechanism acts as tail feedback modulation [3]

[3] A. Musa, *et al.*, JSSC 2011

Measurement Result



Die Photo



Phase noise at 19.1GHz

-105dBc/Hz @ 1MHz offset

PLL Performance Comparison

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	Features	CMOS Tech.	Frequency [GHz]	Phase Noise [dBc/Hz]	Power [mW]	Output type
[1]	QVCO@60GHz+ Foreground Calibration	45nm	57 - 66	-75@1MHz	78	Quad.
[2]	Push-push VCO@30GHz+ Hybrid Coupler	65nm	59.6 - 64	-73@1MHz	76	Quad.
[3]	VCO@20GHz	65nm	17.9-21.2	-105@1MHz	19.2	Diff.
	Sub-harmonic Injection	65nm	58 – 65.4	-96@1MHz	80	Quad.
This	Push-push VCO@10GHz	65nm	16.3-19.3	-105@1MHz	7.5	Diff.
	Push-push VCO@10GHz + 60GHz ILO [3] (based on calculation)	65nm	-	-96@1MHz	-	Quad.

[1] K. Scheir, *et al.*, ISSCC 2009

[2] C. Marcu, *et al.*, ISSCC 2009

[3] A. Musa, *et al.*, JSSC, 2011

Conclusion

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- **A 10GHz QVCO for 20GHz push-push operation is implemented in 65nm CMOS process.**

- **It shows capability of maintaining low phase noise while consuming 14% less power consumption than previously-implemented 20GHz VCO for 60GHz sub-harmonic injection LO**

Thank you for your attention