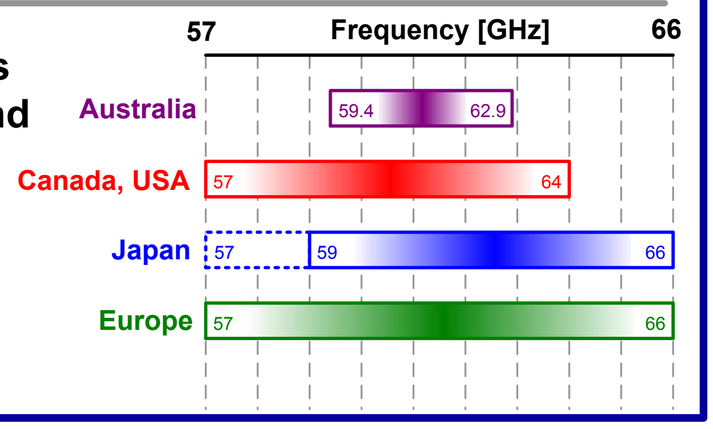
A 20GHz Push-Push Voltage-Controlled Oscillator for a 60GHz Frequency Synthesizer

Teerachot Siriburanon, Takahiro Sato, Ahmed Musa, Wei Deng, Kenichi Okada and Akira Matsuzawa
Matsuzawa and Okada Lab, Tokyo Institute of Technology, Japan

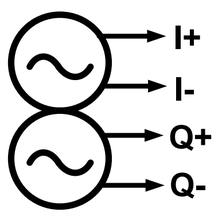
1. Motivation

- 60 GHz Communications
  - 9 GHz unlicensed band at 60 GHz
- Several Gbps wireless communications
  - 3.5 Gbps/ch (QPSK)
  - 7 Gbps/ch (16QAM)



2. Conventional 60GHz LOs

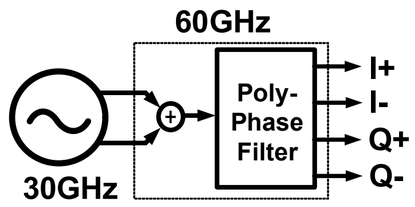
a) 60GHz QPLL



- 9GHz tuning range
- Low quality factor for capacitor

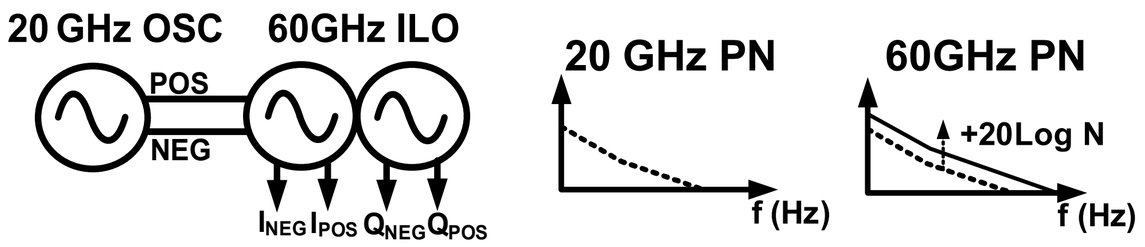
[1] IMEC, *ISSCC 2009*

b) 30GHz PLL + Polyphase Filter



[2] UCB, *ISSCC 2009*

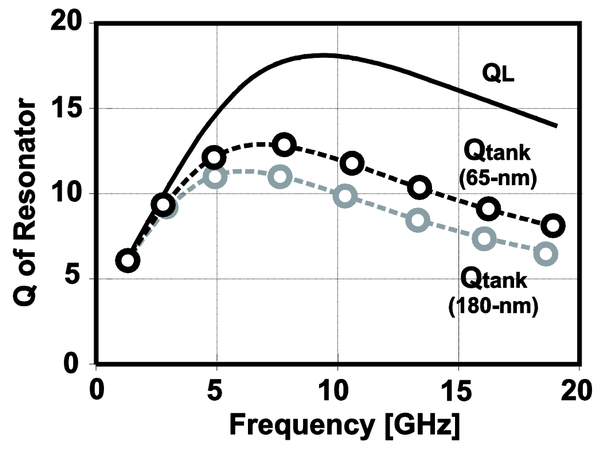
c) 20GHz PLL + Injection Locked Oscillator



Best phase noise reported

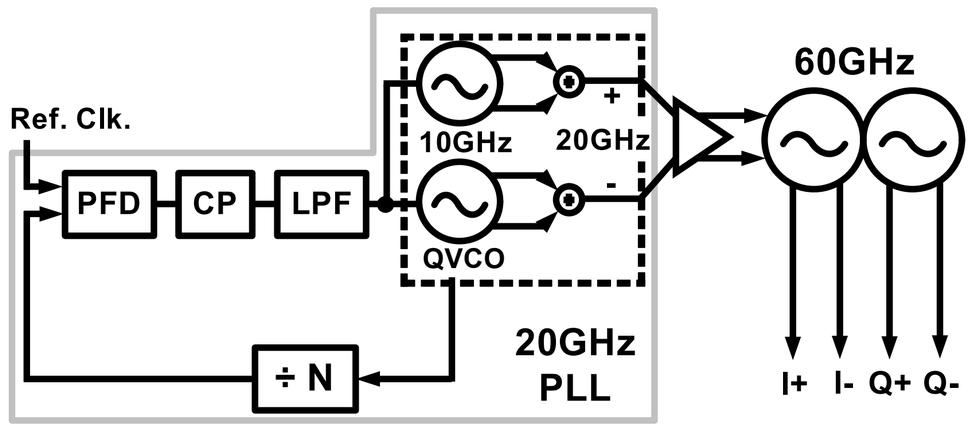
[3] Titech, *JSSC 2011*

3. Design Considerations



- Higher Quality Factor of LC-resonator tank
- Less concern for parasitic capacitance
- Power-hungry high frequency prescaler can be eliminated
- At 10GHz, the quaility factor of LC resonator is relatively higher than that at 20GHz.

Proposed 60GHz Quadrature LO using a 20GHz push-push VCO in a 20GHz PLL

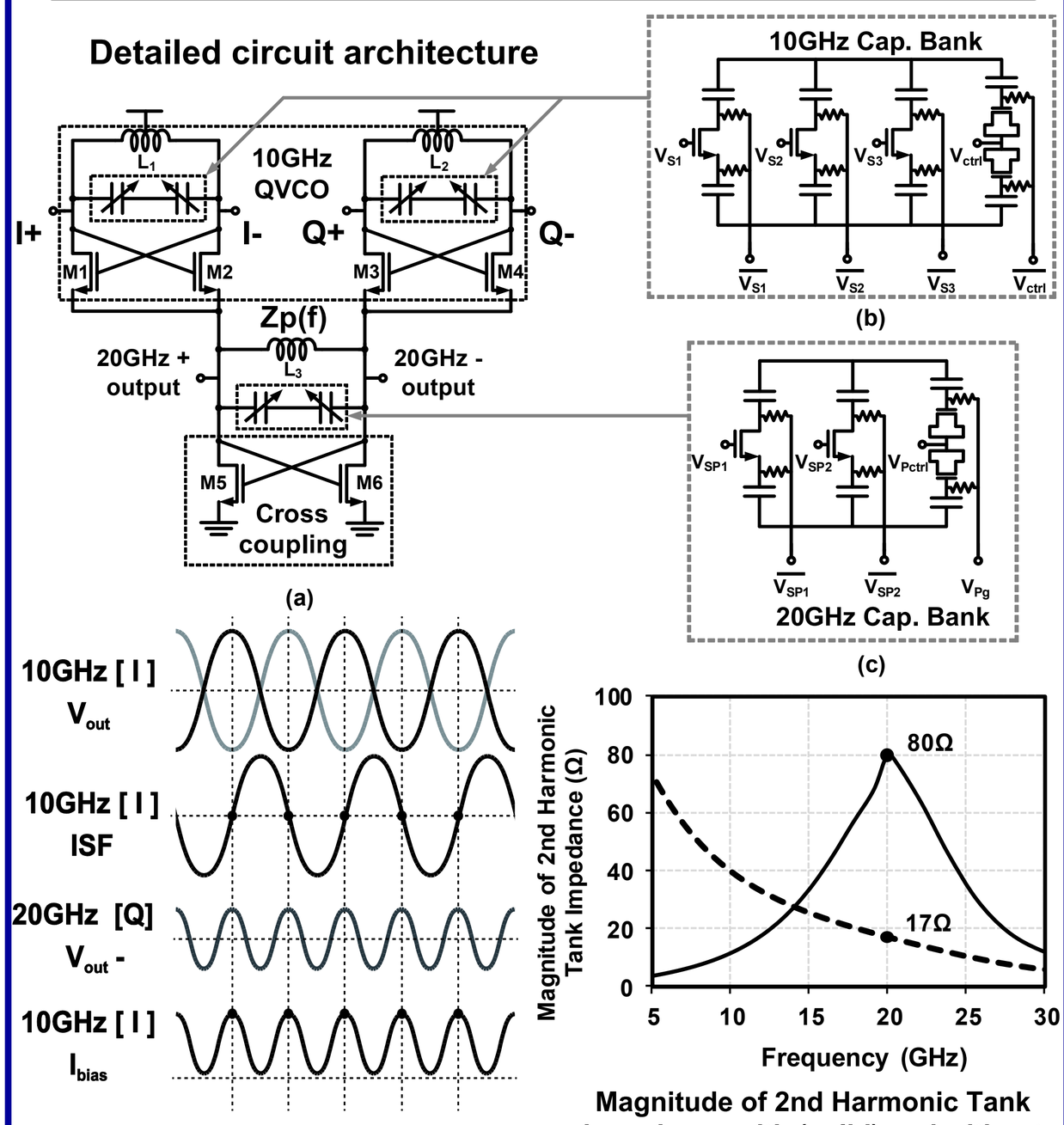


Requirements for a VCO in a 60GHz Sub-harmonic Injection Architecture

	10GHz	20GHz	60GHz
Phase noise@1MHz offset (dBc/Hz)	-106	-100	-90
Tuning range (GHz)	9.5-11	19-22	57-66

4. Proposed Push-Push VCO

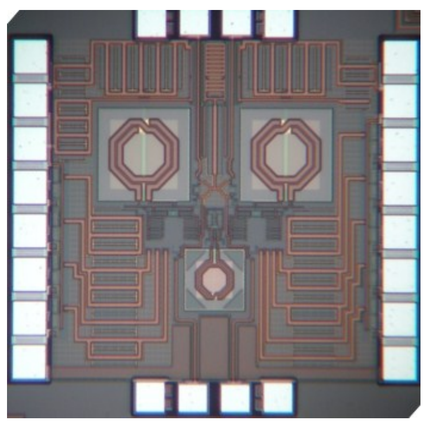
Detailed circuit architecture



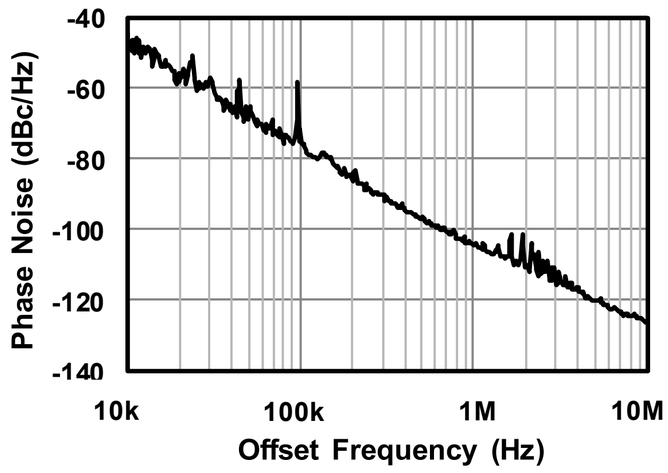
Tail Modulation Mechanism

Magnitude of 2nd Harmonic Tank impedance with (solid) and without (dotted) second harmonic resonator

5. Measurement Results



Chip microphptograph



Phase noise characteristic

	Features	CMOS Tech.	Frequency [GHz]	Phase noise [dBc/Hz]	Power [mW]	FoM [dBc/Hz]	Output type
[1]	QVCO@60GHz	45nm	57-66	-75@1MHz	28.8	-157	Quad.
	Direct 60GHz QPLL	45nm	57-66	-75@1MHz	78	-	Quad.
[2]	Push-push VCO@30GHz	90nm	29.8-32	-79@1MHz	9.8	-159	Diff.
	VCO + Polyphase filter	90nm	59.6-64	-73@1MHz	76	-	Quad.
[3]	VCO@20GHz	65nm	17.9-21.2	-106@1MHz	19	-179	Diff.
	Sub-harmonic Injection	65nm	58-63	-96@1MHz	80	-	Quad.
This work	Push-push VCO@10GHz	65nm	16.1-19.6	-106@1MHz	10.3	-181	Diff.
	Sub-harmonic Injection (based on calculation)	65nm	48.3-58.8	-96@1MHz	-	-	Quad.

The proposed 20GHz push-push VCO based on a 10GHz super-harmonic coupled QVCO achieves an improvement of 2.3dB in FoM over previously-implemented 20GHz VCO [3]