

# A 60GHz 16QAM 11Gbps Direct-Conversion Transceiver in 65nm CMOS

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# Motivation

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- **60GHz CMOS direct-conversion transceiver for multi-Gbps wireless communication**

## IEEE 802.15.3c specification

- **57.24GHz - 65.88GHz**
- **2.16GHz/ch x 4channels**
- **QPSK → 3.5Gbps/ch**
- **16QAM → 7Gbps/ch**

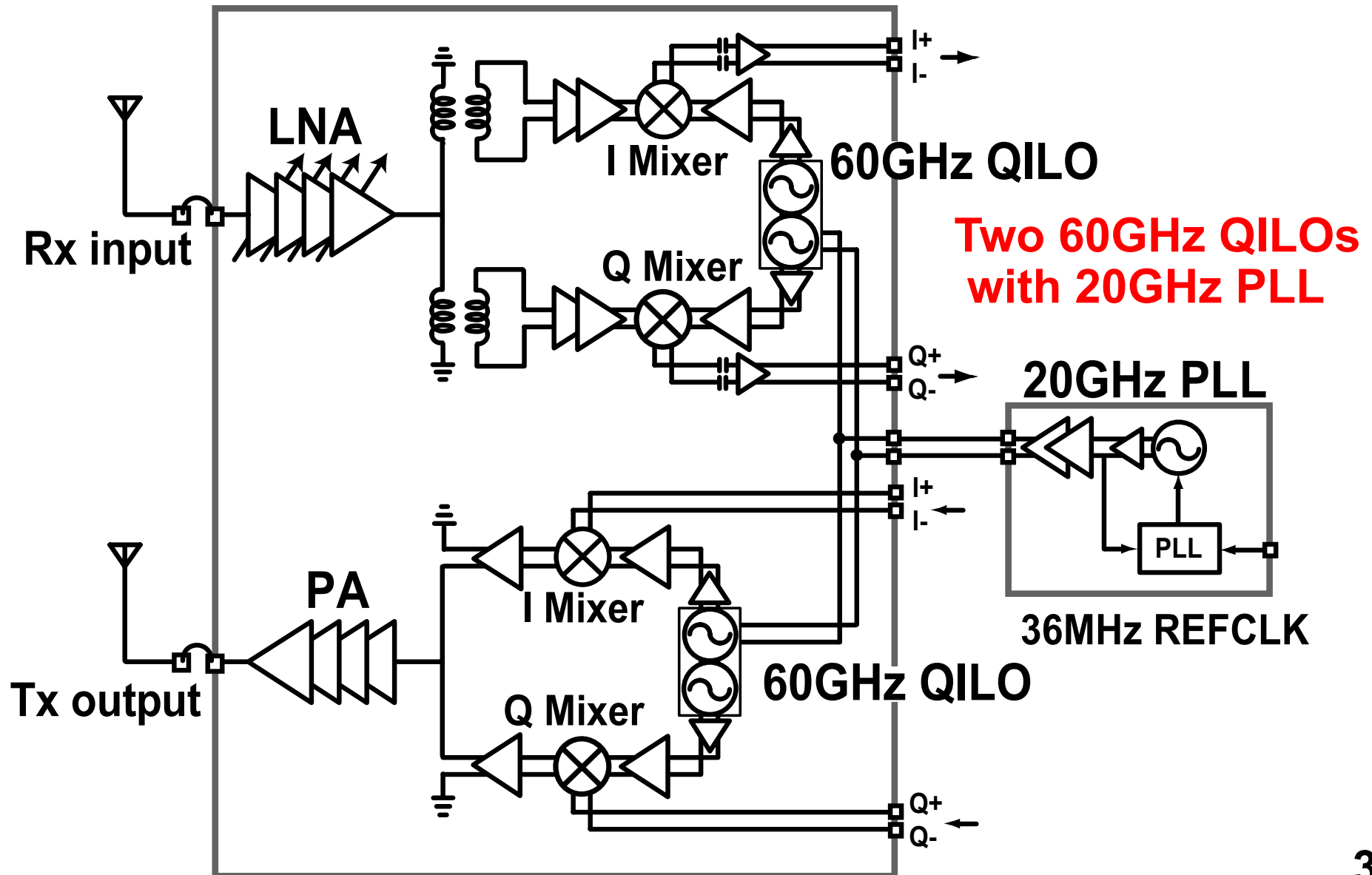


# 60GHz Transceiver Scenario

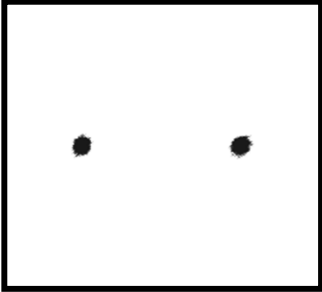
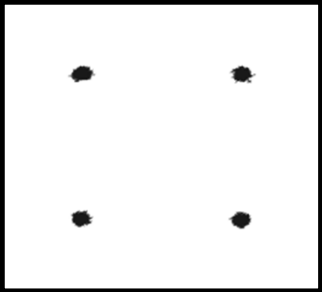

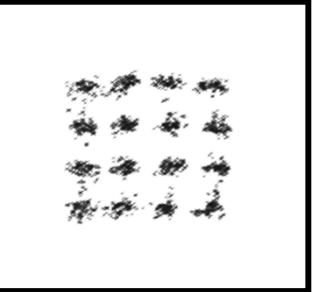
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- **60GHz quadrature ILO with 20GHz PLL** [1,2]
  - ILO: Injection-locked oscillator
  - Very wide tuning (58GHz-64GHz [2])
  - Excellent phase noise (**-96dBc/Hz@1MHz-offset** [2])
- **60GHz LNA**
  - Low NF & High linearity
  - Wide bandwidth (gain flatness)
- **60GHz PA**
  - 10dBm output
  - High PAE (>10%)

# Direct-Conversion Architecture



# Modulation Characteristics

<b>Constellation</b>	 1585 points	 3170 points	 4755 points	 6340 points
<b>Modulation</b>	<b>BPSK</b>	<b>QPSK</b>	<b>8PSK</b>	<b>16QAM</b>
<b>Data rate 2.16GHz-BW</b>	<b>1.76Gb/s</b>	<b>3.52Gb/s</b>	<b>5.28Gb/s</b>	<b>7.04Gb/s</b>
<b>EVM</b>	<b>-18dB</b> (-24dB with DFE)	<b>-18dB</b> (-28dB with DFE)	<b>-17dB</b>	<b>-17dB</b>
<b>Max distance (BER &lt; 10<sup>-3</sup>)</b>	<b>2.7m</b>	<b>2.7m</b>	<b>0.2m</b>	<b>0.2m</b>

**8Gb/s(QPSK) and 11Gb/s(16QAM) with wider-BW**

# Performance Comparison and Conclusion

	Data rate / Modulation	Architecture	Antenna
U. Toronto[3]	4Gbps/BPSK	Direct conversion w/o LO	External
UCB [2]	4Gbps/QPSK 7Gbps/QPSK (loop-back)	Direct conversion with 30GHz PLL and 90° hybrid	External
Tokyo Tech	1.76Gbps/BPSK 3.52Gbps/QPSK 5.28Gbps/8PSK 7.04Gbps/16QAM within 2.16GHz-BW >8Gbps/QPSK >11Gbps/16QAM	Direct conversion with 60GHz quadrature oscillators	In-package

[2] C. Marcu, *et al.*, ISSCC 2009 [3] A. Tomkins, *et al.*, JSSC, vol.44, no.8, pp.2085-2099, Aug.

- **The first 16QAM direct-conversion transceiver**
- **Full-rate 16QAM/8PSK/QPSK/BPSK for IEEE802.15.3c**
- **11Gb/s (16QAM), 8Gb/s (QPSK)**