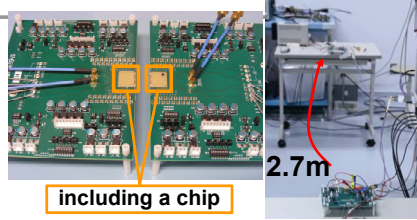


A 60-GHz 16QAM 11Gbps Direct-Conversion Transceiver in 65nm CMOS

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1. Abstract

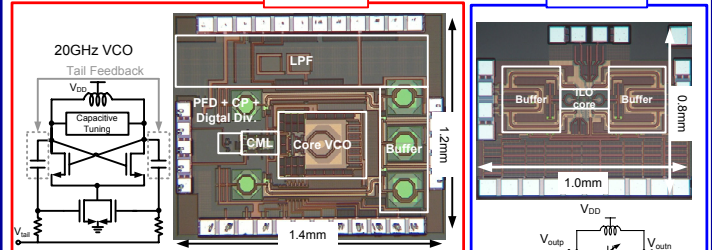
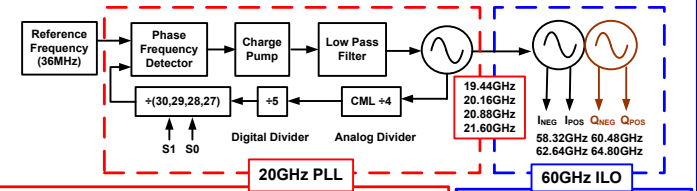
The 60GHz transceiver successfully achieves **7Gbps** using **16QAM** and **3.5Gbps** using **QPSK** at a distance of 2.7m.



including a chip

3. 60GHz Local Oscillator (LO)

- The LO is composed of a 20GHz PLL and a 60GHz frequency tripler(ILO) to achieve a low phase noise and 9GHz frequency tuning range[1].



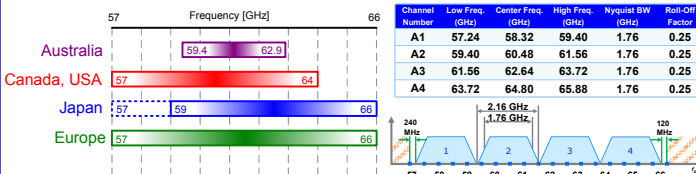
	This work	[2]	[3]	[4]	[5]
Freq.[GHz]	54~61	57 ~ 66	64 ~ 66	51 ~ 53	58 ~ 60
P _{dc} [mW]	91	78	72	87	80
Ref. [MHz]	36.0	100.0	251.3	203.2	234.0
PN@1MHz[dBc/Hz]	-94.2	-75	-84	-85	-85
Output Phase	Quad.	Quad.	Diff.	Diff.	Diff.

[1]A. Musa, et al., ASSCC 2010.
[2]K. Scheir, et al., ISSCC 2009
[3]K.-H. Tsai, et al., RFIC 2008
[4]C. Lee, et al., TCAS-II, 2008.
[5]C. Lee and S. L. Liu, ISSCC 2007

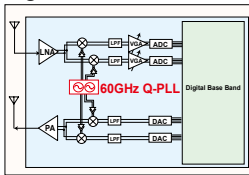
- LO achieves **-94.2dBc/Hz@60.48GHz**
- This phase noise enables **16QAM** modulation, which is capable for **7Gbps/ch**.

2. Background

- 60 GHz Communications
9 GHz unlicensed band at 60 GHz
- Several Gbps transfer rate speed
3.5 Gbps/ch (QPSK)
7 Gbps/ch (16QAM)



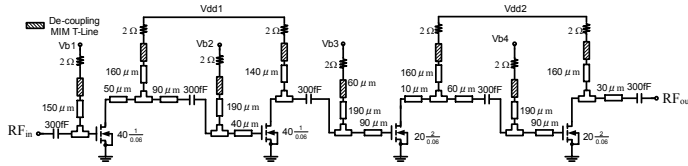
- Target



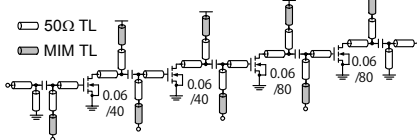
Direct conversion architecture for single chip implementation
- Small area
- Low power dissipation

4. 60GHz TRX

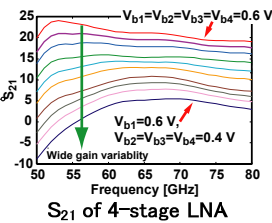
- 60GHz Low Noise Amplifier and Power Amplifier
- Low loss transmission line is used
- CMOS 65nm technology



Circuit of 4-stage LNA



Circuit of 4-stage PA



Comparison of PA

	[1]	[2]	[3]	[4]	This work
Tech.	90nm	90nm	65nm	90nm	65nm
Topology	CS	Cas.	Diff.Cas	Cas.	CS-CS
Stage	3	2	3	3	4
BW[GHz]	5	8	7.7	14	17
Gain[dB]	15.0	15.5	19.3	20.0	24
NF[dB]	4.4	6.5	6.1	6.8	4.0-7.6
Power[mW]	3.9	86	35	36	30

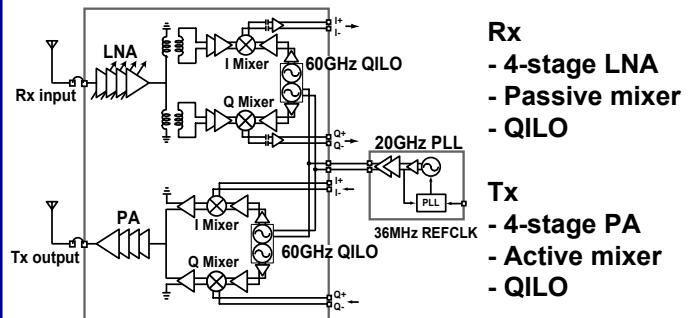
	[1]	[2]	This work
Tech.	65nm	45nm	65nm
Freq.[GHz]	60	60	61.5
Gain[dB]	15.8	13.8	20.5
P1dB[dBm]	2.5	11	9.9
PAE[%]	3.95	-	6.68

[1] W. L. Chan, et al., ISSCC 2009 (IMEC)
[2] K. Raczkowski, et al., ISSCC2009 (Arizona Univ.)

[1]E. Cohen, et al., RFIC 2008. [2]S. Pellerano, et al., JSSC 2008.
[3]C. Weyers, et al., ISSCC2008. [4]Y.Natsukari, et al., VLSI Circuits 2009.

Very good NF and PAE have been achieved.

5. Meas. result and Conclusion



- Rx
- 4-stage LNA
 - Passive mixer
 - QILO
- Tx
- 4-stage PA
 - Active mixer
 - QILO

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

-This transceiver can transmit every full-rate of 16QAM, 8PSK, QPSK, and BPSK for IEEE standard.

-The maximum data rates are 11Gb/s in 16QAM and 8Gb/s in QPSK mode.