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Millimeter-wave wireless communications for home network in fiber-to-the-room scenario

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Key words: Fiber-to-the-room; Millimeter wave; Q-band; Cloud virtual reality (cloud VR); Home network; Beamforming; Radio frequency integrated circuit (RFIC)

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FTTR + Q-band

- FTTR: infinite bandwidth for backhaul & inter-connection between APs
- Q-band: high data rate access & non-interference between APs in different rooms

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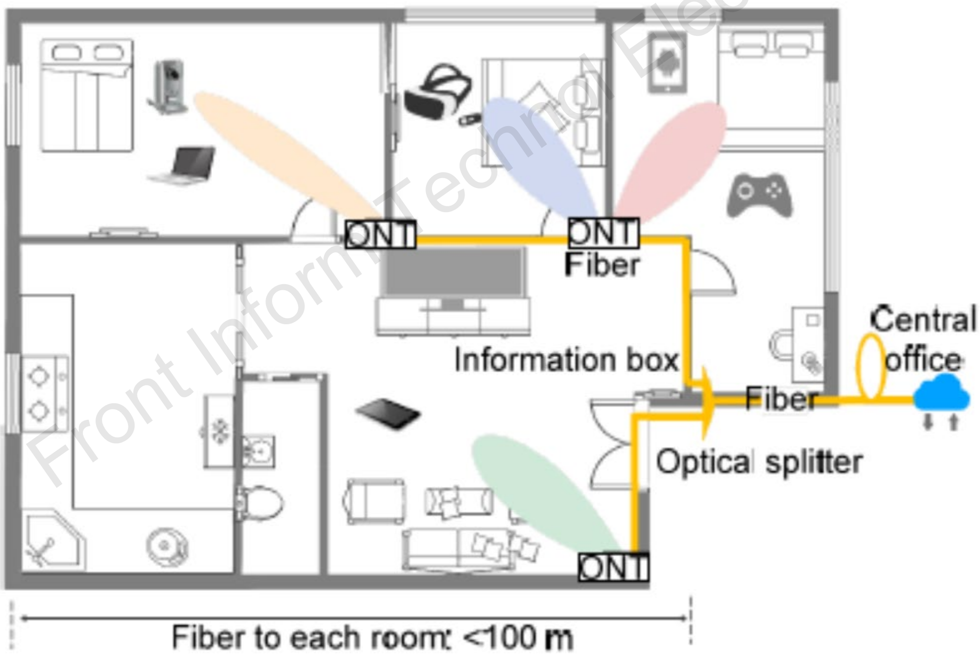

Fig. 1 Architecture schematic for fiber-to-the-room

Q-band mmWave technologies

Baseband signal processing: SC-based and OFDM-based

☐ Lower requirements for RF components

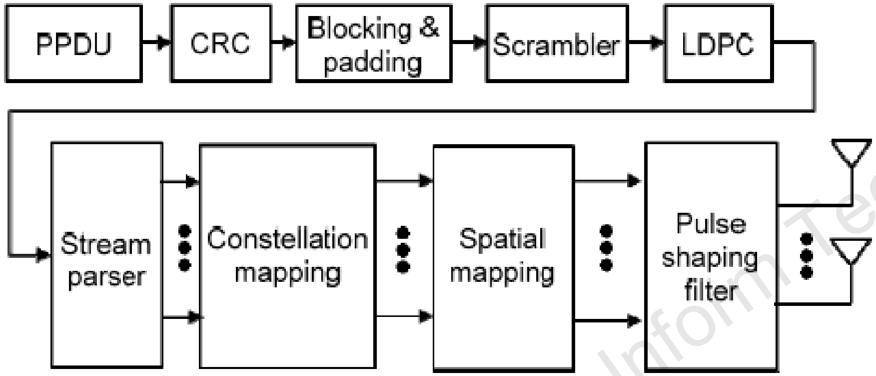

Fig. 2 Transmitter block diagram for data fields of CMMG SC mode PPDUs (IEEE, 2018)

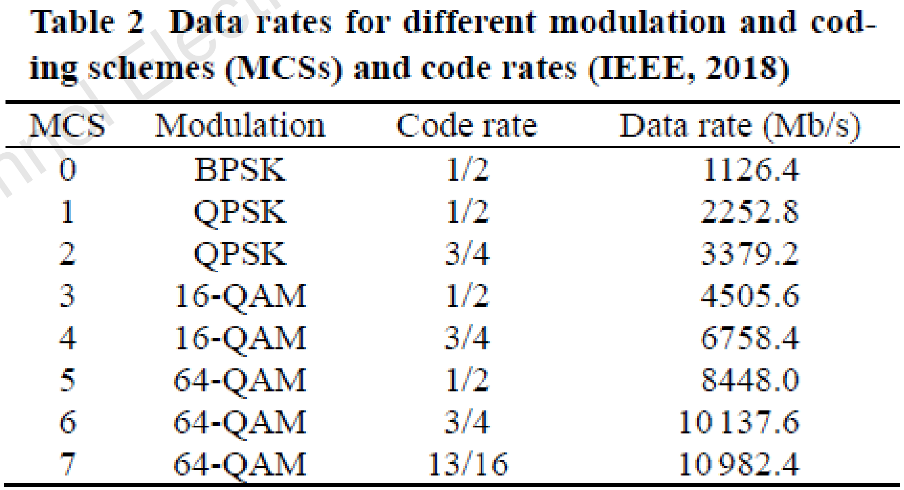

Table 2 Data rates for different modulation and coding schemes (MCSs) and code rates (IEEE, 2018)

MCS	Modulation	Code rate	Data rate (Mb/s)
0	BPSK	1/2	1126.4
1	QPSK	1/2	2252.8
2	QPSK	3/4	3379.2
3	16-QAM	1/2	4505.6
4	16-QAM	3/4	6758.4
5	64-QAM	1/2	8448.0
6	64-QAM	3/4	10 137.6
7	64-QAM	13/16	10 982.4

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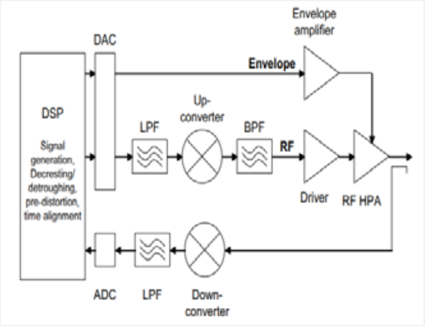
Q-band mmWave technologies (Cont'd)

RFIC techniques and design

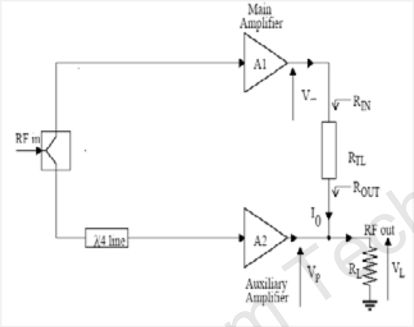
☐ Higher power efficiency for PAs

☐ Higher intergraded level for antennas

ET



Doherty



Efficiency

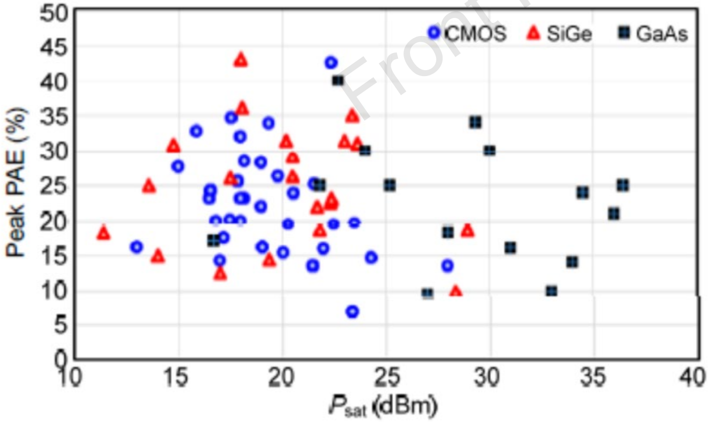
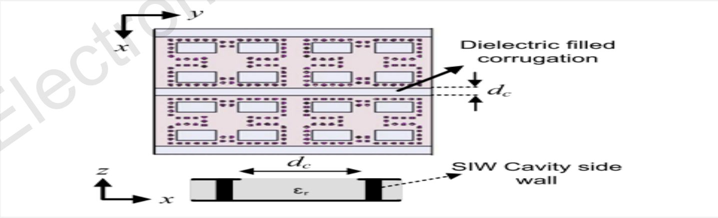
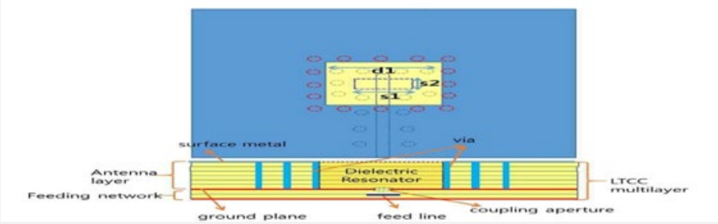


Fig. 3 Peak PAE versus P_{sat} of 40–50 GHz PAs

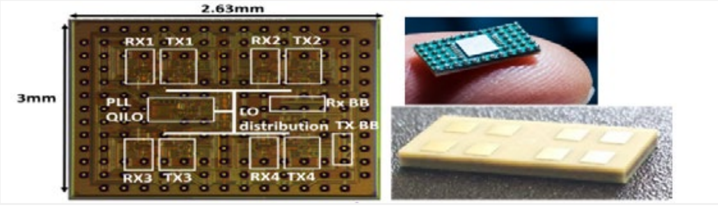
SIW



Dielectric antenna



AIP



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Q-band mmWave technologies (Cont'd)

- Efficient beam alignment and tracking
- Improving roaming efficiency

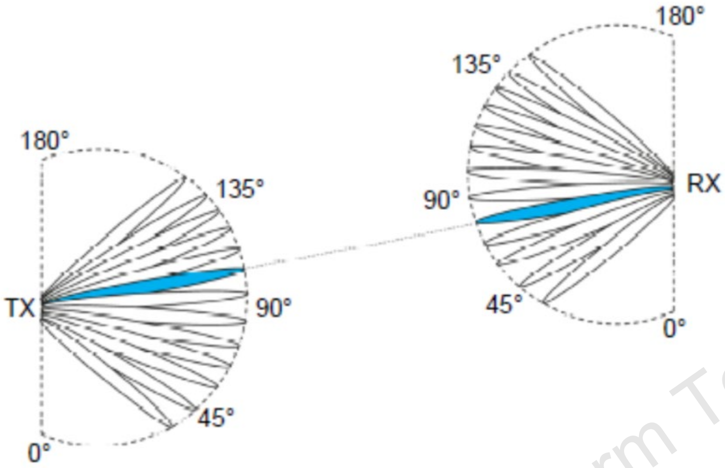
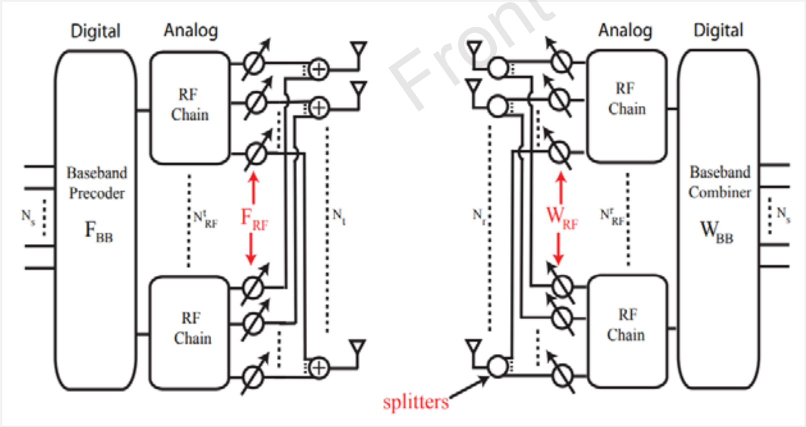


Fig. 4 Beam alignment



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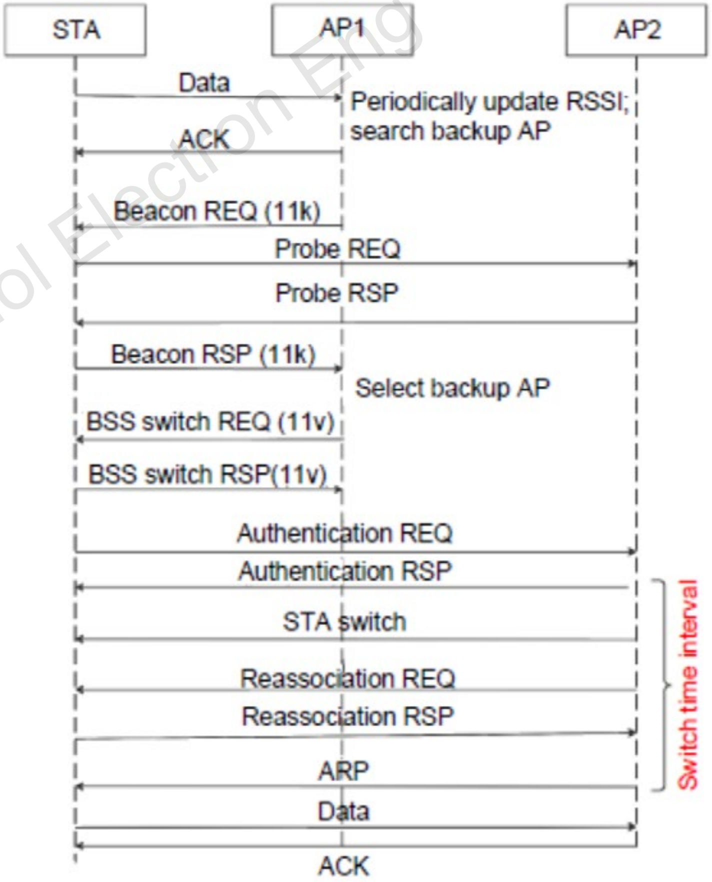

Fig. 5 Typical AP switching procedures (IEEE, 2008a, 2008b, 2011)

Commercialization of Q-band products

☐ Cloud VR and relevant network requirement

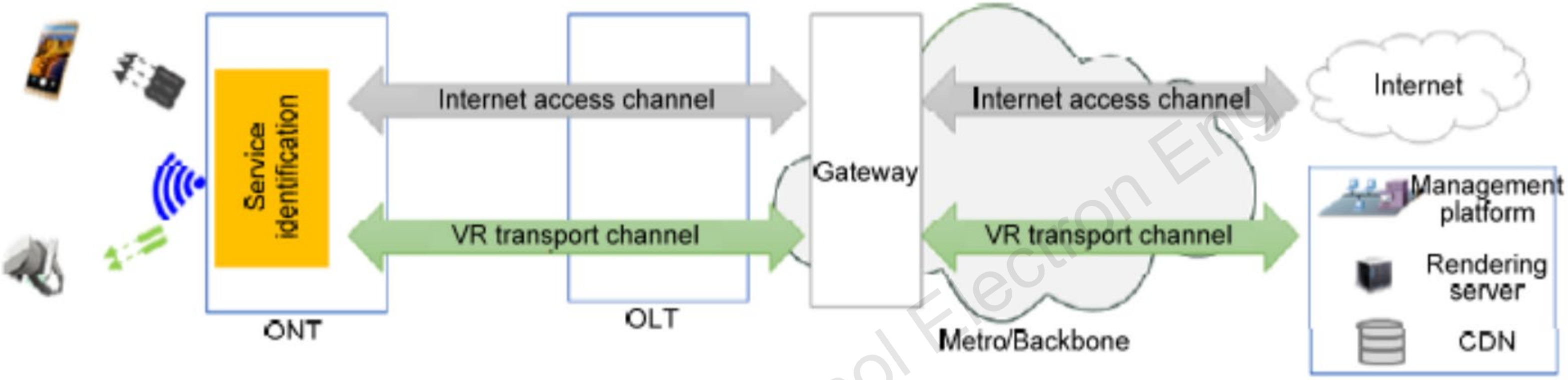

Fig. 6 Schematic of the architecture for FTTR (ETSI F5G Industrial Specification Group, 2021)
ONT: optical network terminal; OLT: optical line terminal; VR: virtual reality; CDN: content delivery network

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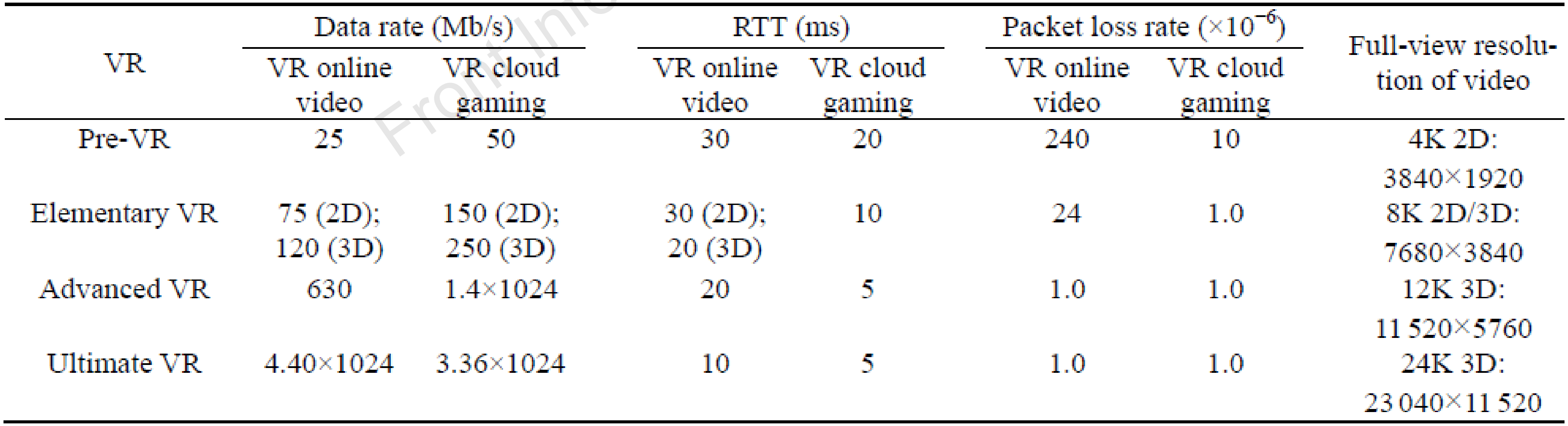
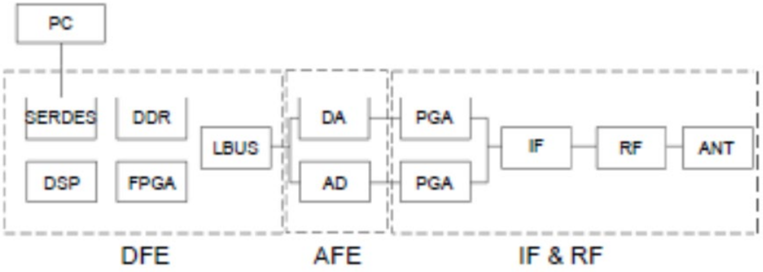
Table 3 Network requirements of could VR

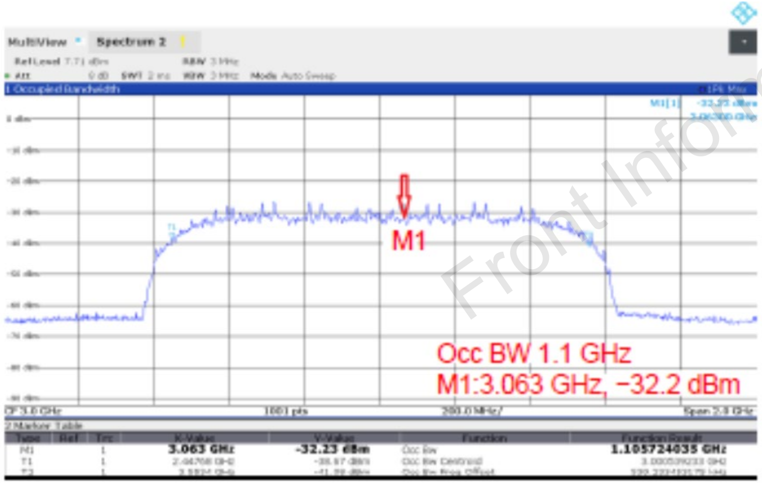


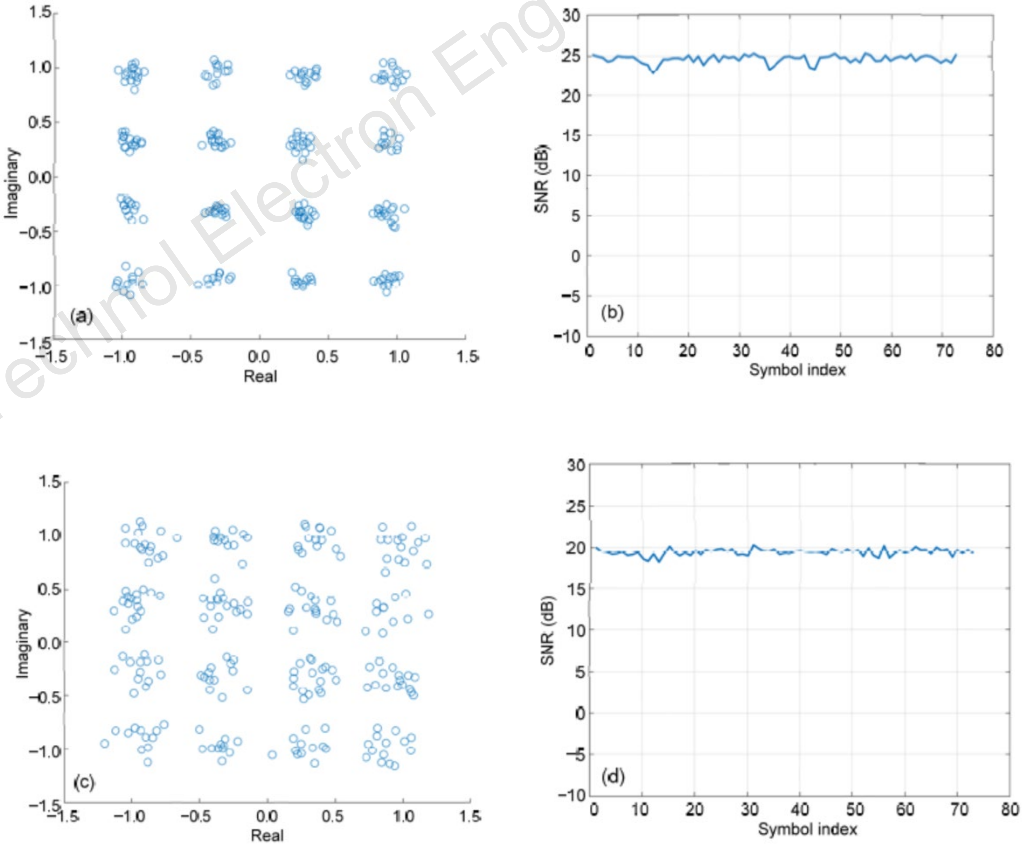
VR	Data rate (Mb/s)		RTT (ms)		Packet loss rate ($\times10^{-6}$)		Full-view resolution of video
	VR online video	VR cloud gaming	VR online video	VR cloud gaming	VR online video	VR cloud gaming	
Pre-VR	25	50	30	20	240	10	4K 2D: 3840×1920
Elementary VR	75 (2D); 120 (3D)	150 (2D); 250 (3D)	30 (2D); 20 (3D)	10	24	1.0	8K 2D/3D: 7680×3840
Advanced VR	630	1.4×1024	20	5	1.0	1.0	12K 3D: 11 520×5760
Ultimate VR	4.40×1024	3.36×1024	10	5	1.0	1.0	24K 3D: 23 040×11 520

Prototype measurements

- ☐ SISO, 540 MHz @25 dB, 1080 MHz @20 dB
- ☐ 4×4 MIMO, 64-QAM @10 Gb/s+







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Future outlook

	Outlook
Channel model	- Reliable channel measurement scheme - Effects of molecular absorption on propagation fading - Complete space-time-frequency and non-stationary channel characteristics
Baseband processing	- Beamforming - Roaming - RF nonlinear and mismatch compensation
RF & antenna	- CMOS PA - High integrated antennas
Applications	- Positioning & detection - Health-care - Home security - SLAM

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