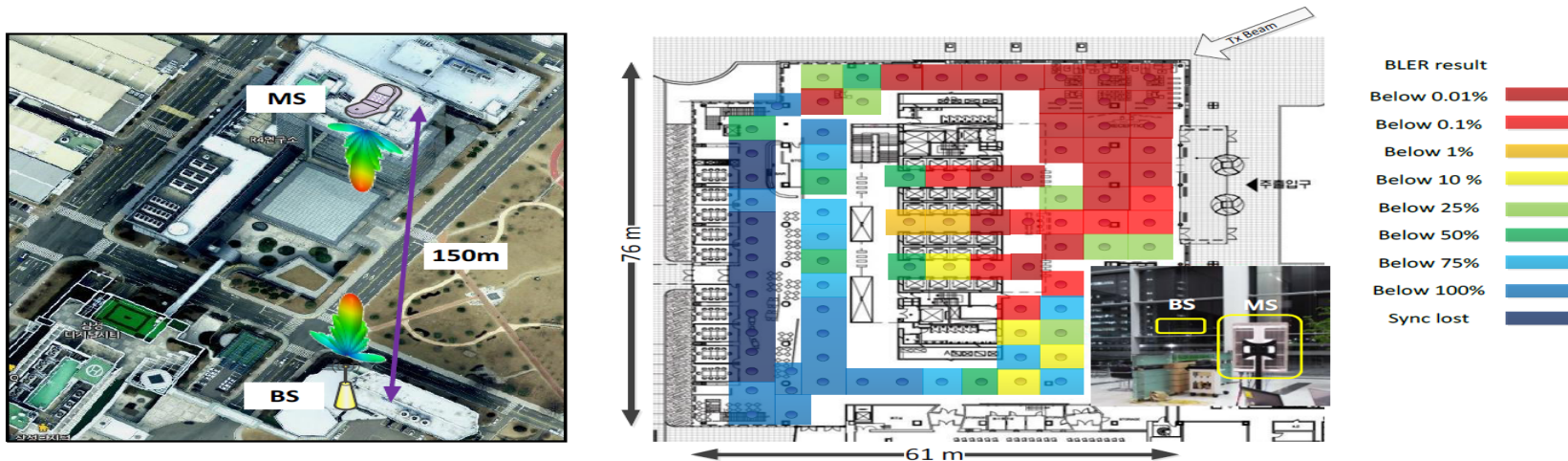


Recent R&D Results - mmWave Testbed

SAMSUNG

Outdoor-to-Indoor Penetration Tests

Most signals successfully received by indoor MS from outdoor BS

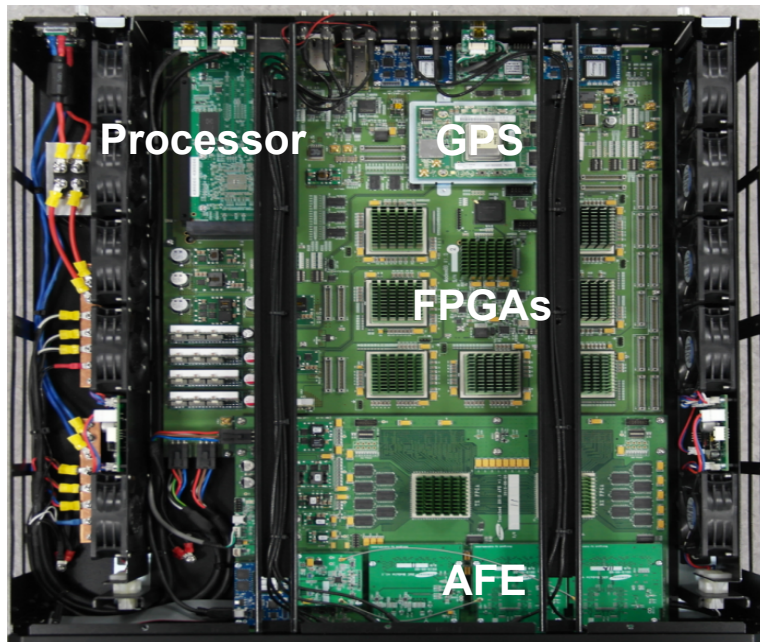


Wonil Roh, et al., "Millimeter-Wave Beamforming as an Enabling Technology for 5G Cellular Communications: Theoretical Feasibility and Prototype Results," IEEE Communications Magazine, Feb. 2014.

Recent R&D Results - mmWave Testbed

SAMSUNG

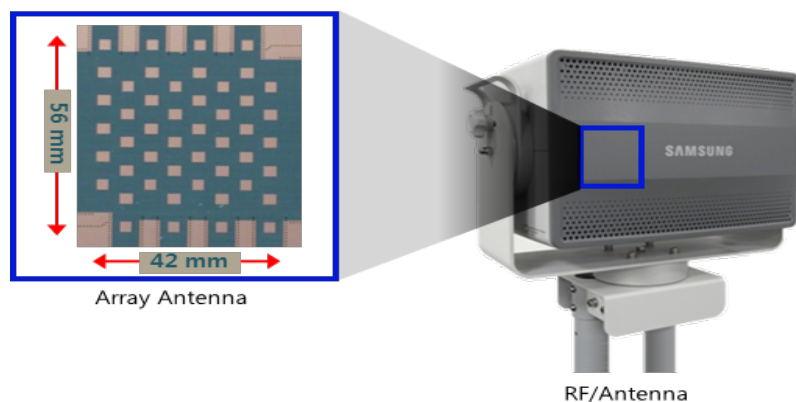
■ Integrated Digital Unit with Baseband Modem and Processor



KEY PARAMETERS FOR DIGITAL UNIT

Parameters	Values
Signal Bandwidth	800 MHz
FFT Size	4096-FFT
Subcarrier Spacing	300 KHz
Modulation	QPSK, 16-QAM, 64-QAM
Code Rates	$\frac{1}{2}$ and $\frac{3}{4}$ LDPC code

■ Base Station RF Unit Supporting 3D Adaptive Beamforming



KEY PARAMETERS FOR BS RF UNIT

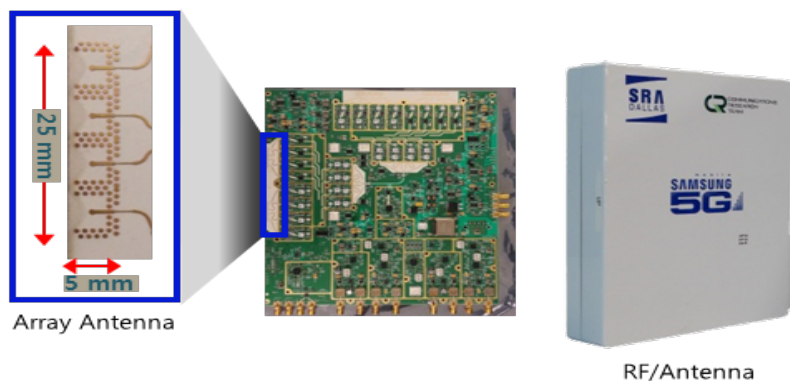
Parameters	Values
Carrier Frequency	27.925 GHz
Bandwidth	800 MHz
Effective Isotropic Radiated Power (EIRP)	59 dBm
Array Antenna Configuration	8 x 6 (48 Antennas)
Half-Power Beam Width (HPBW)	10° (Horizontal/Vertical)
Beam Scanning	±40° (Horizontal) / ±10° (Vertical)

- 2 independent channels for various multi-antenna schemes such as MIMO & diversity
- Sub-array architecture to reduce the hardware complexity
- 3D beamforming in the intended horizontal and vertical angles

Recent R&D Results - mmWave Testbed

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■ Mobile Station RF Unit with Wide Beam Coverage Antenna Array



KEY PARAMETERS FOR MS RF UNIT

Parameters	Values
Carrier Frequency	27.925 GHz
Bandwidth	800 MHz
Effective Isotropic Radiated Power (EIRP)	30 dBm
Array Antenna Configuration	4 x 1 (4 Antennas)
Half-Power Beam Width (HPBW)	20° (Horizontal) / 60° (Vertical)
Beam Scanning	±40° (Horizontal)

- 2 independent channels for various multi-antenna schemes such as MIMO & diversity
- Single multi-layer board design
- Small form factor

Recent R&D Results - mmWave Testbed

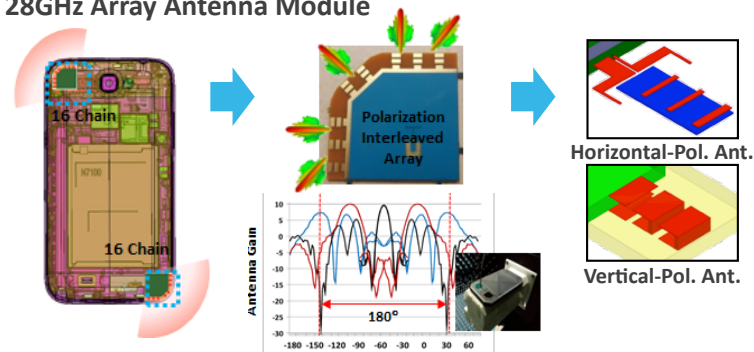
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■ Antenna/RFIC for Mobile Device

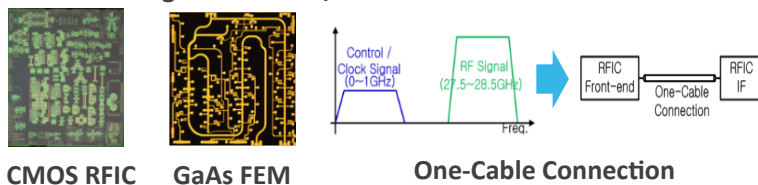
- Polarization interleaved array and CMOS RFIC/GaAs FEM at 28 GHz
- 360° coverage antenna and 16 chain CMOS RFIC at 60GHz

28GHz Antenna/RFIC

28GHz Array Antenna Module

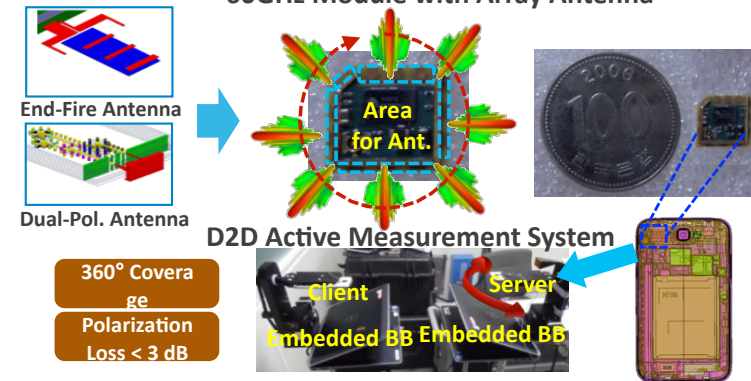


Beamforming CMOS RFIC / GaAs FEM



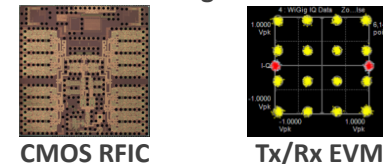
60GHz Antenna/RFIC

60GHz Module with Array Antenna



360° Coverage
Polarization Loss < 3 dB

Beamforming CMOS RFIC



EVM -25 dB

16-chain Beamforming