MITSUBISHI ELECTRIC
Changes for the Better

28GHz Massive MIMO Technology for 5G by Mitsubishi Electric

February 20, 2018

MITSUBISHI ELECTRIC CORPORATION

Outline

1) Mitsubishi Electric Introduction

2) 5G with mm Wave

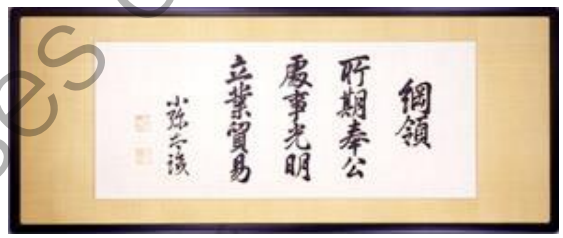
3) 28GHz band
   Massive MIMO trial system for 5G
   by Mitsubishi Electric

1) Mitsubishi Electric Introduction

About “Mitsubishi” — Mitsubishi Companies

- Mitsubishi companies share a founding management philosophy:
  - Corporate Responsibility to Society
  - Integrity and Fairness
  - Global Understanding through Business

- 40 member companies of the Mitsubishi Public Affairs Committee support a variety of philanthropic activities together



The Three Principles

Mitsubishi Electric Corporation **Electric & Electronics**	**Mitsubishi Heavy Industries, Ltd.** Ships, Aircraft, Steel Structures, Power Generation	**Mitsubishi Motors Corporation** Automobiles	**Mitsubishi Corporation** Trading
The Bank of Tokyo-Mitsubishi UFJ, Ltd. Banking	**Nikon Corporation** Cameras, Optical Equipment	**Tokyo Marine & Nichido Fire Insurance Co., Ltd.** Insurance	**Kirin Holdings Co., Ltd.** Food
Mitsubishi Estate Co., Ltd. Construction, Real Estate, Hotels	**Asahi Glass Co., Ltd.** Chemicals, Ceramics & Glass	**Mitsubishi Research Institute, Inc.** Consulting & Research	**JX Holdings, Inc.** Resources & Energy, Nonferrous Metals

The companies shown above represent some of the 40 member companies of the Mitsubishi Public Affairs Committee.

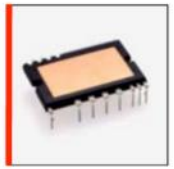
Mitsubishi Electric / Products & Services

Building Systems

Factory Automation Systems

Information/
Communication Systems

Air Conditioning Systems



Semiconductors/Devices

Visual Information Systems

Space Systems

Transportation Systems

Public Systems

Energy Systems

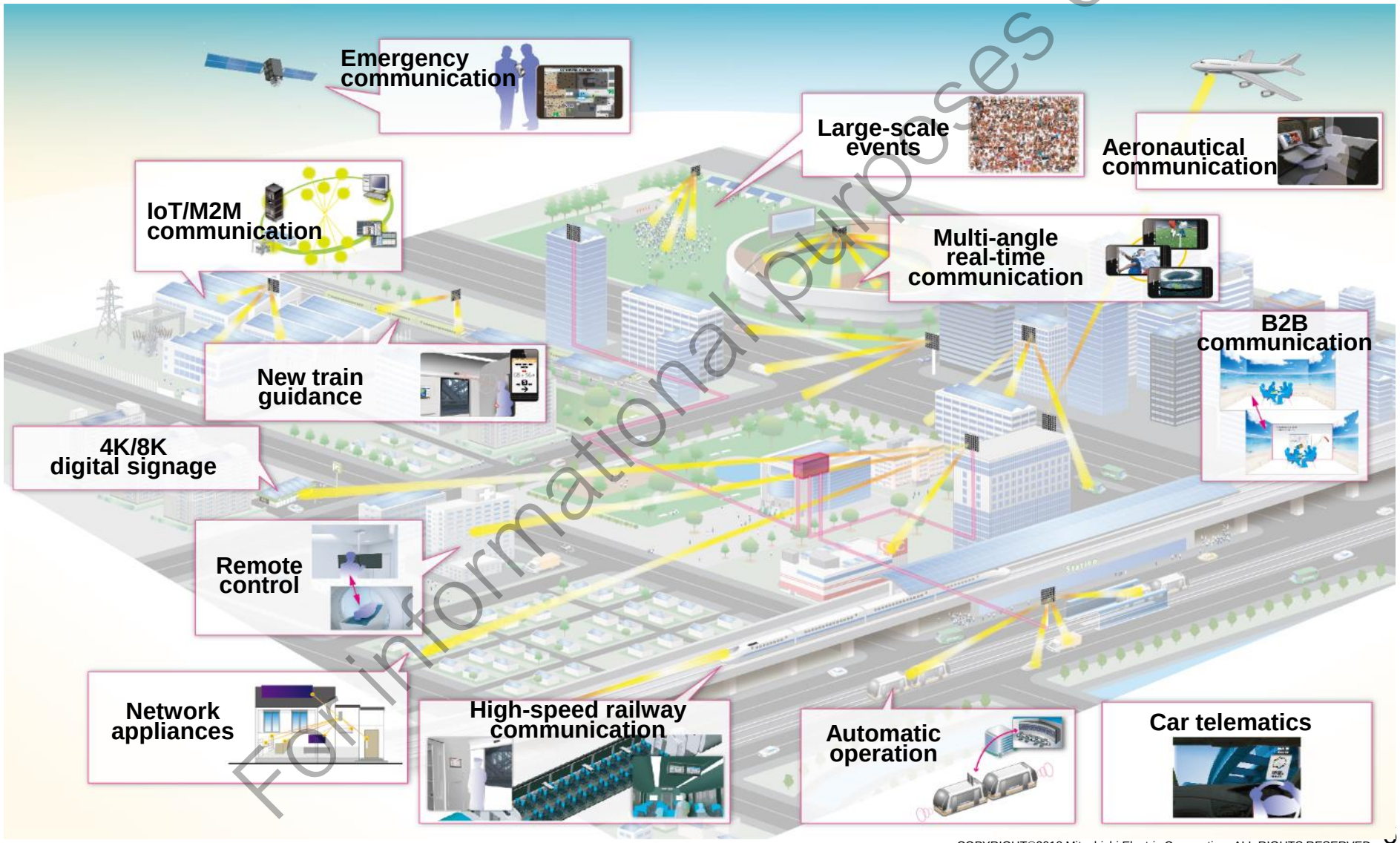
Automotive Equipment

Home Products

2) 5G with mm Wave

Mitsubishi Electric Perspective of 5G World

The 5G system will deliver new innovations, enhanced convenience, greater excitement and more resilient experiences everywhere!



Frequency bands for 5G

RADIO PROPAGATION		
← low	path loss	high →
← large	diffraction	small →
BANDWIDTH		
← narrow		wide →
ANTENNA		
← large		small →

1GHz 3GHz 6GHz 24.25GHz 86GHz

(already in use in 3G/4G)
Wide coverage
Conventional deployment
Relatively low bit rate
Backward compatibility

Broadband Enhancement

Ultra-broadband, High capacity
Very large scale array antenna
New type deployment (hotspot, linear cell)

** 11bands in 24.25-86GHz are candidate band for ITU-R WRC-19 AI1.13*

** Japan is considering 3.7GHz, 4.5GHz and 28GHz bands for 5G in 2020.*

All frequency ranges from sub-GHz to mmWave are important for 5G.
Especially, use of mmWave is highly expected to enhance user experiences dramatically.

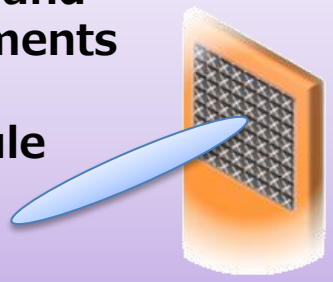
3) 28GHz band

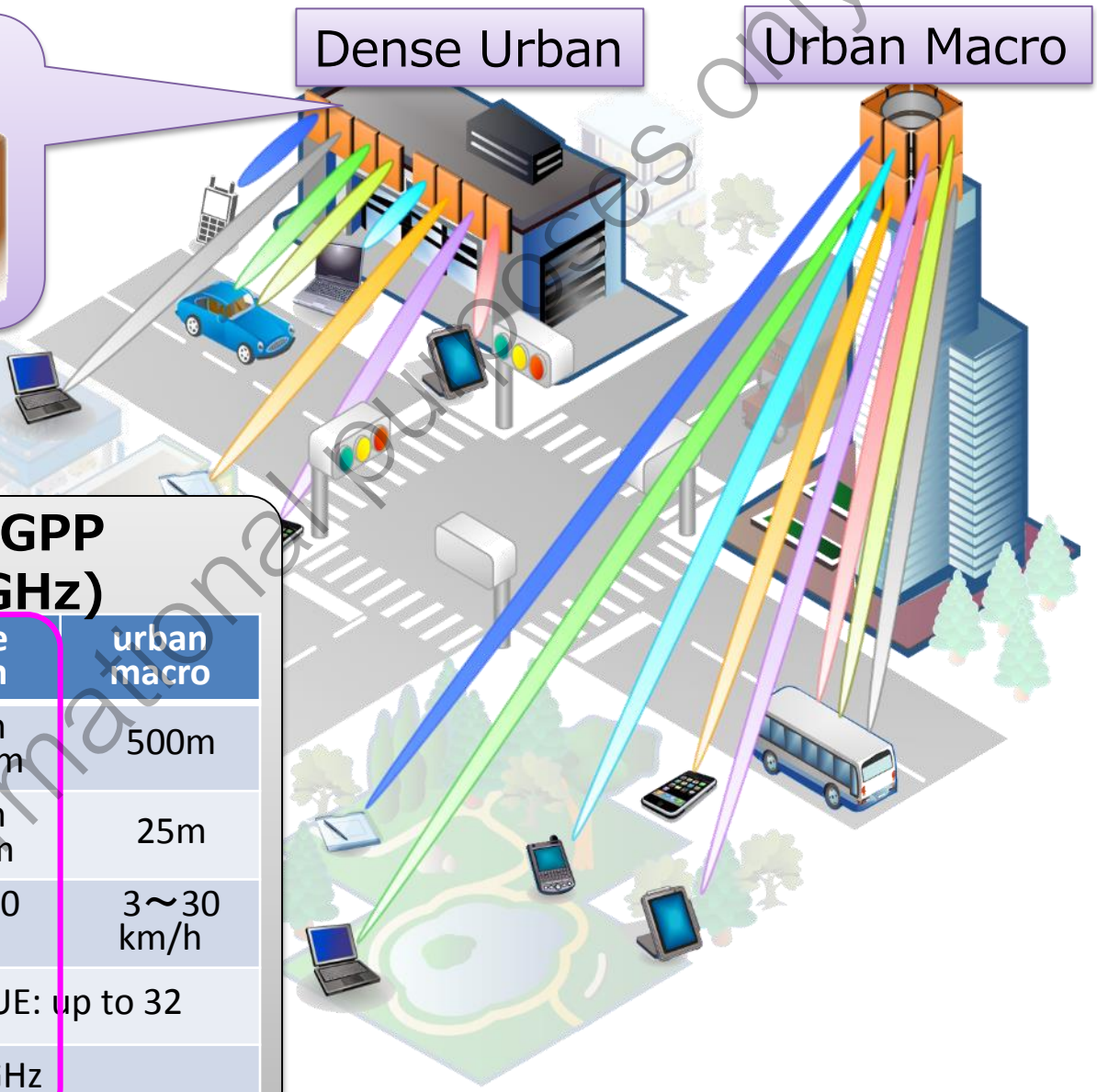
Massive MIMO trial system for 5G

by Mitsubishi Electric

28GHz Wide Band Massive MIMO System for 5G trial (by Mitsubishi Electric) : Use Case

28GHz band
256 elements
Antenna
RF Module





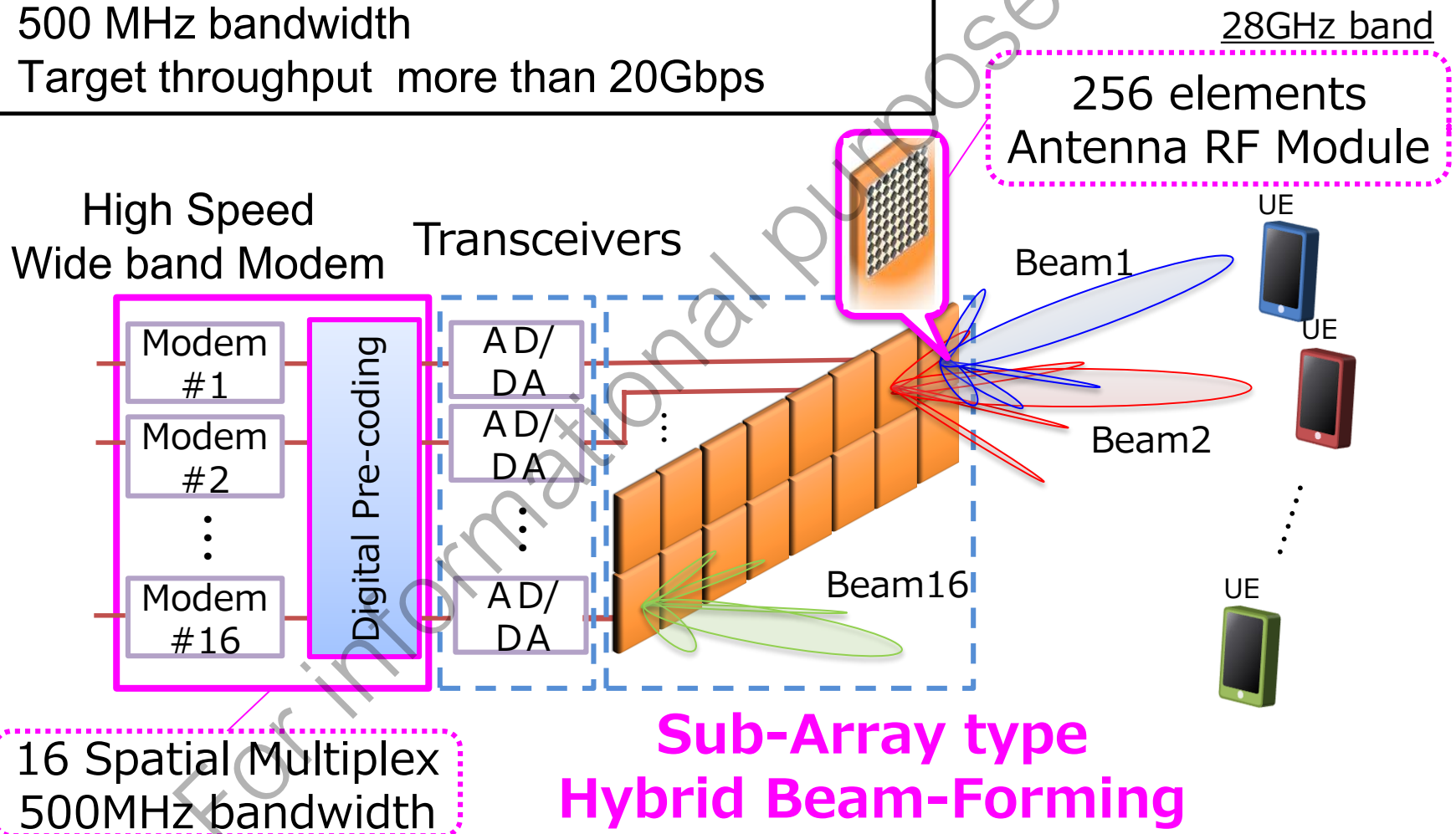
Use Cases in 3GPP (around 30 GHz)

Items	indoor	dense urban	urban macro
inter cell distance	20m	50m ～200m	500m
antenna height	3m	10m ～25m	25m
mobility	3km/h	3～30 km/h	3～30 km/h
antenna element	BS: up to 256 / UE: up to 32		
bandwidth	up to 1GHz		

IEICE vol. 117, no. 246, RCS2017-196 (Oct. 2017)

28GHz Wide Band Massive MIMO System for 5G trial (by Mitsubishi Electric) : Overview

Sub-Array type Hybrid Beam-Forming
- ✓ 256 elements Antenna RF Module x 16
- ✓ 16 Spatial Multiplex with Digital Pre-coding
- ✓ 500 MHz bandwidth
- ✓ Target throughput more than 20Gbps



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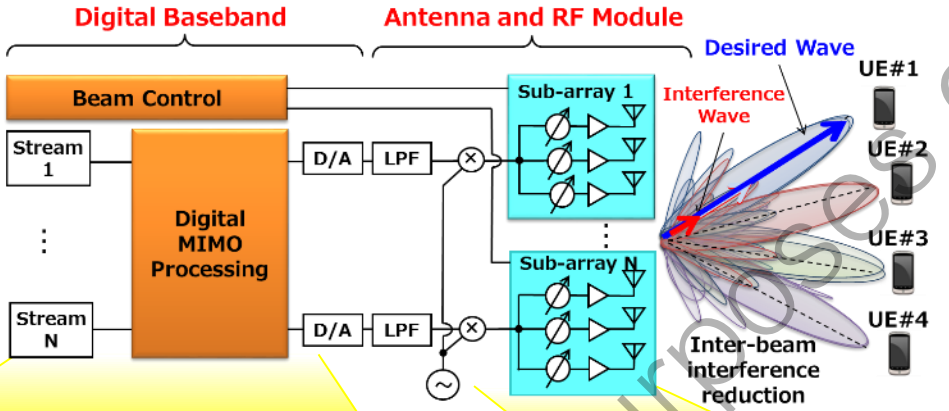
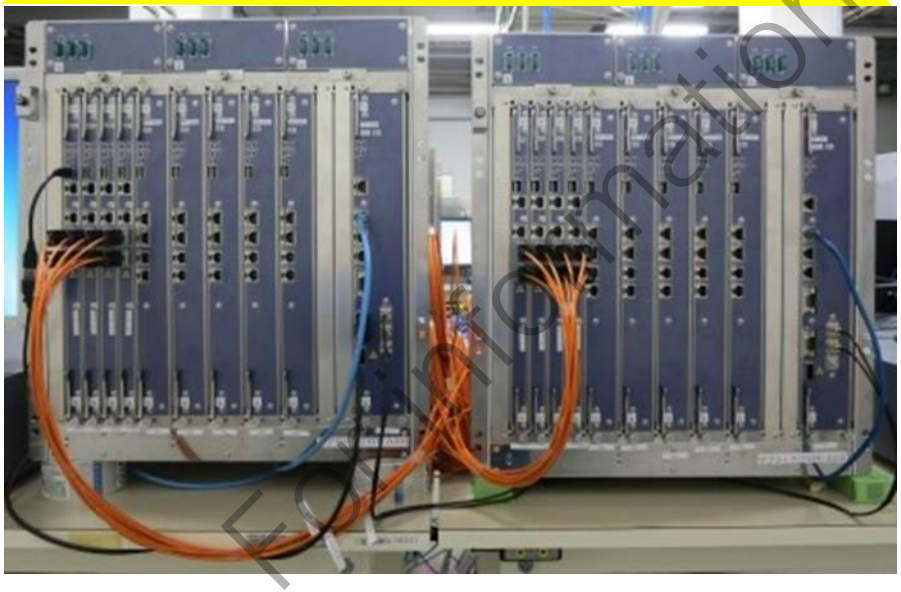
28GHz Wide Band Massive MIMO System for 5G trial (by Mitsubishi Electric) : Equipment and Module



Digital Baseband



28GHz Antenna and RF Module

28GHz Antenna and RF Frontend Module for 5G trial (by Mitsubishi Electric) : Overview

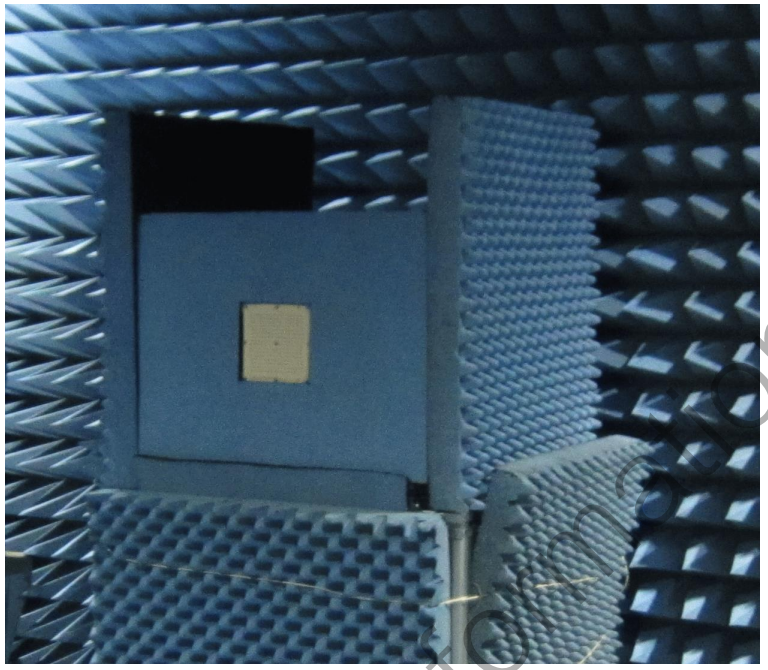
We have developed an Antenna and RF Frontend Module integrating 256-element antenna, high-frequency device (RFIC) and peripheral components, and performed experimental evaluation.

Module Specifications

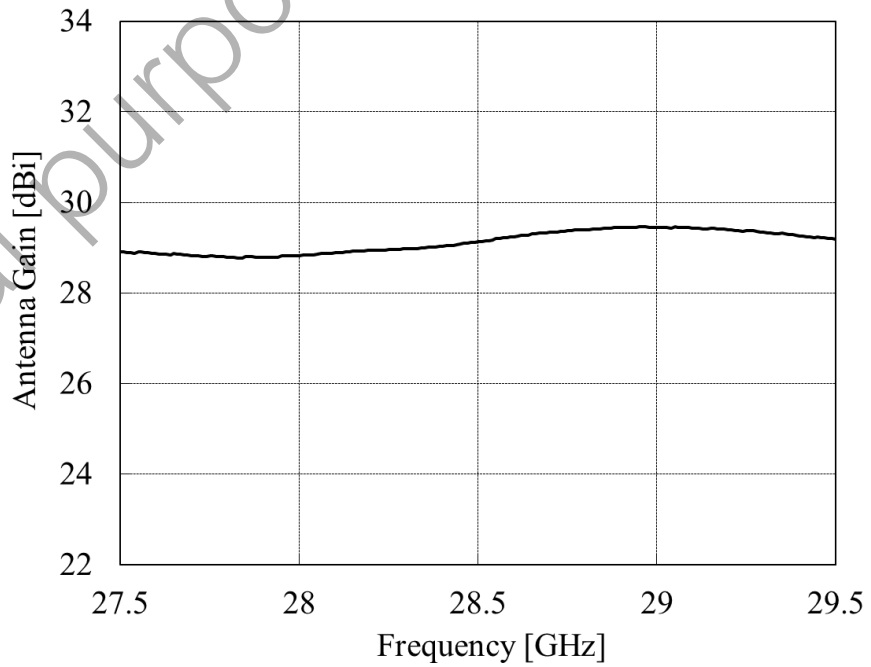
Item	Specification
System frequency range	28GHz band(27.5～29.5GHz)
Bandwidth	800MHz
Antenna system	Printed patch antenna
Antenna elements	256 elements
Array size(NxM)	16x16
Antenna gain	≧28dBi
Polarization	+45/－45degrees
Beam steering adjustment	Vertical : ±12degrees Horizontal : ±45degrees
Module size	120mm×240mm×28mm (without heatsink)

28GHz Antenna and RF Frontend Module for 5G trial (by Mitsubishi Electric) : Antenna part

The developed 256-element antenna has achieved the actual gain of 28.8 dBi or more in wide bandwidth.



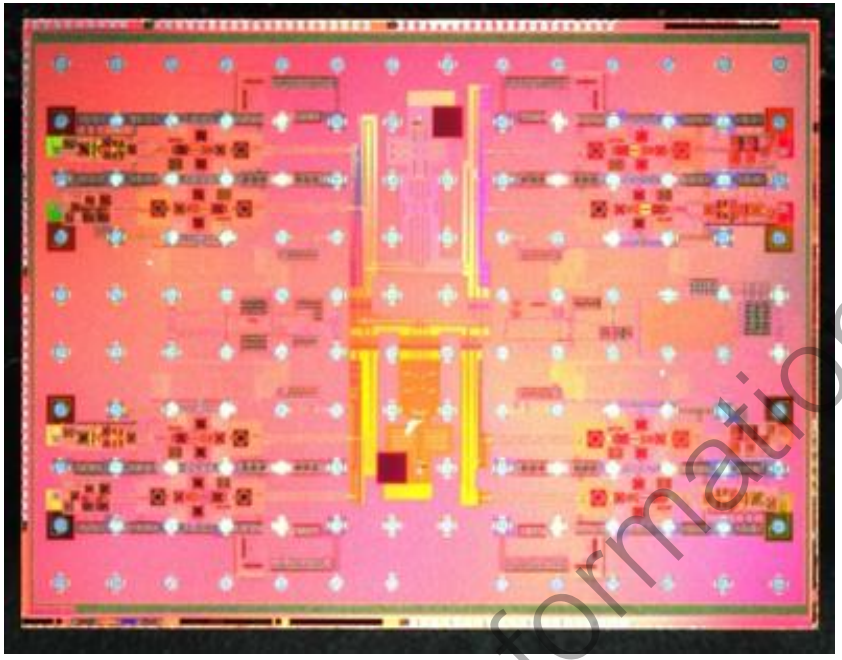
Evaluation Environment for Antenna and RF Frontend Module



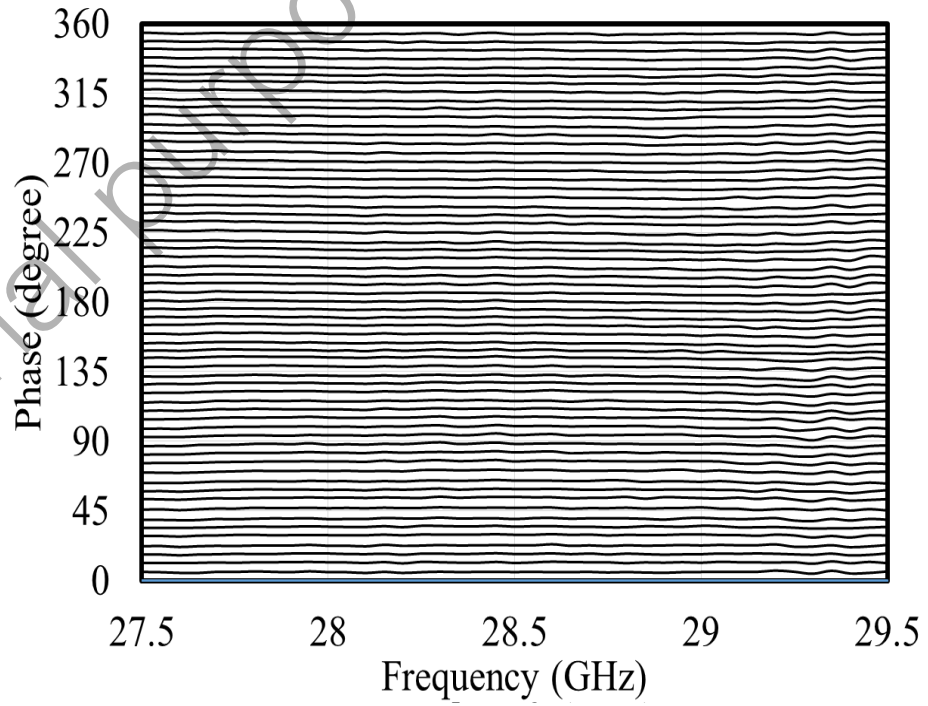
Measured antenna gain frequency characteristics

28GHz Antenna and RF Frontend Module for 5G trial (by Mitsubishi Electric) : RF Circuitry part

In order to realize a compact RF frontened, we have developed an RF-IC integrating 28GHz 6-bit phase shifter with 4 elements and realized low phase difference (1.2 degree rms) in wide bandwidth.



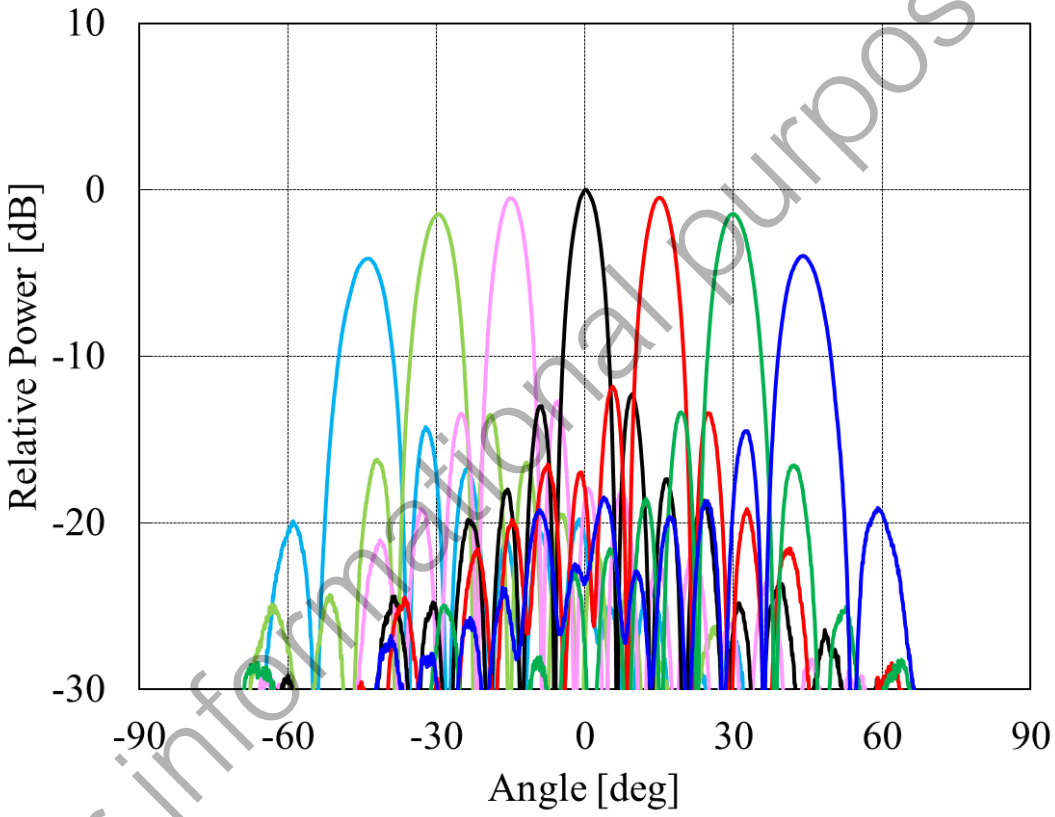
RF-IC integrating
4-element phase shifter
(chip size: 7.2mm×5.3mm)



Evaluation Results on the Phase Control Characteristics of Module

28GHz Antenna and RF Frontend Module for 5G trial (by Mitsubishi Electric) : Experimental Results

Beam scanning with high accuracy of ±45 degrees was realized to reduce the error of the main beam direction against the indicated angle to 0.6 degree rms or less. We have confirmed that highly accurate beamforming over wide angle is feasible in 28GHz.



Radiation pattern of Antenna and RF Frontend Module
(displayed in 15-degree increments from -45 degrees to + 45 degrees)

Digital Baseband for 5G trial (by Mitsubishi Electric)

Appearance

Specifications of the digital baseband

Item	Specification
Band Width	500MHz
Component Carrier	5(100MHz x 5CC)
Multiplexing	TDD
Radio sub-frame	0.20ms
Radio Access	OFDM (Sub-Carrier Space 75kHz)
Modulation	QPSK、16QAM、 64QAM、256QAM
Channel Coding	PDSCH : LDPC (R=3/4,5/6,11/12) PDCCH : Convolution
Max. MIMO Multiplex	16

News Release on February 14, 2018

http://www.mitsubishielectric.com/news/2018/0214-e.html

Mitsubishi Electric Demonstrates 16-beam Spatial-multiplexing Technology and Achieves 25.5Gbps Throughput in 5G Base Station

Expected to contribute to ubiquitous connection of devices via broadband transmission

TOKYO, February 14, 2018 – Mitsubishi Electric Corporation (TOKYO: 6503) announced today that it has developed a 16-beam spatial-multiplexing technology operating at 28GHz for fifth-generation (5G) mobile base stations and that it has demonstrated what is believed to be the world's first[1] 5G system to achieve 25.5Gbps for one user device at 28GHz with 500MHz bandwidth. Mitsubishi Electric expects its new mobile system to help realize a society in which mobile devices are connected ubiquitously via broadband transmission. The details of the system will be announced at the IEICE Technical Committee on Radio Communication Systems conference on February 28. Outdoor trials are planned in fiscal 2018.

[1] According to Mitsubishi Electric research as of February 14, 2018

16-beam Spatial-multiplexing Transmission Trial

User equipment
(16 antennas)

Base station
(2-beam massive element RF unit x 8)

2-beam antenna RF unit with massive antenna elements
(512 antenna elements)

This presentation includes a part of results of "The research and development project for realization of the fifth-generation mobile communications system" commissioned by The Ministry of Internal Affairs and Communications, Japan.