The testing technology of 5G base station

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Course Objectives

Upon completion of this course, you will be able to

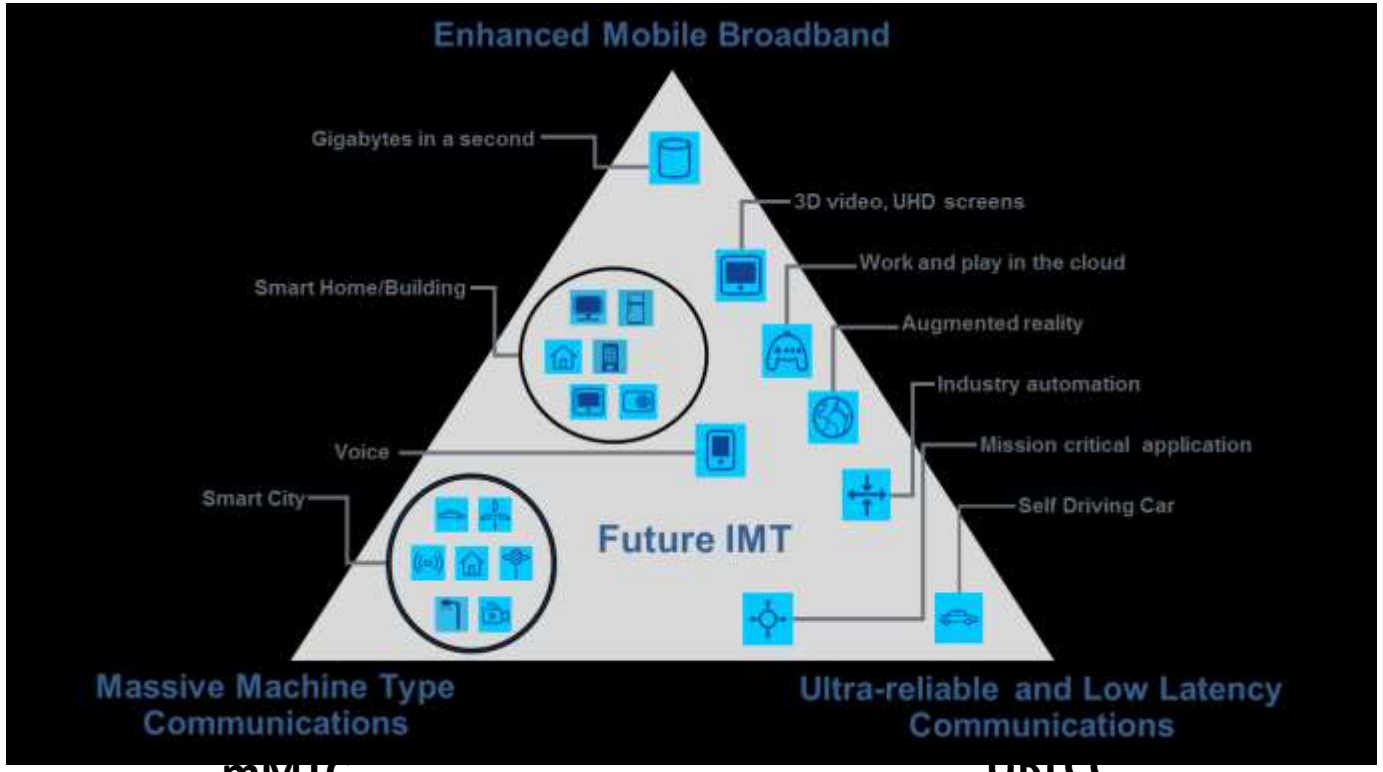
- Know the main form of the 5G base station
- Know the main challenge of 5G base station product testing
- Know the standardization status of 5G base station testing
- Know the basic method of 5G base station testing

Agenda

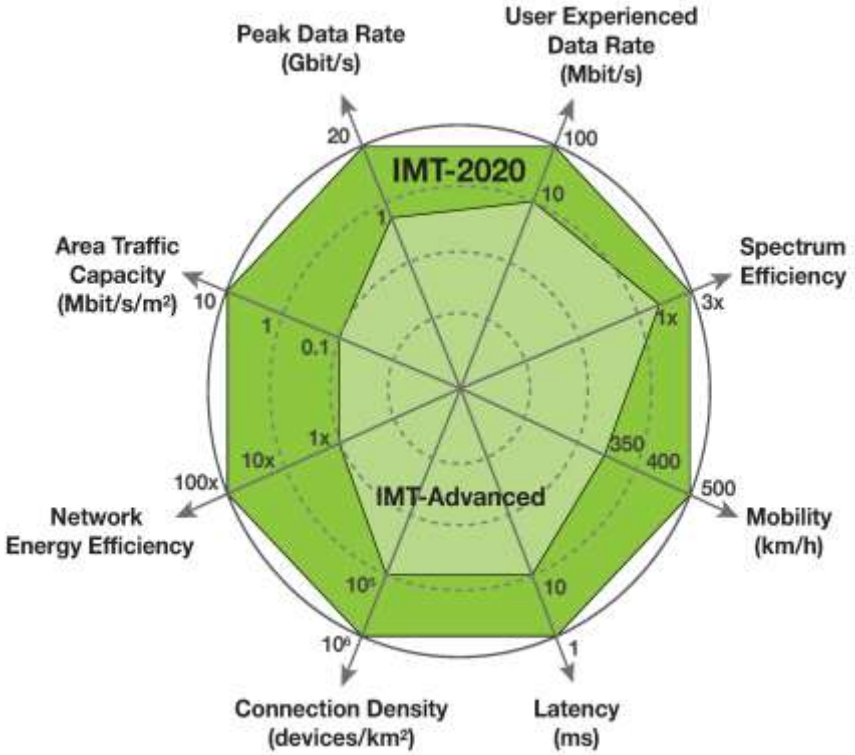
1. The development of 5G base station product
2. The main challenge of 5G base station product testing
3. The standardization status of 5G base station testing
4. Thinking of test method of 5G base station

1. 5G base station product

eMBB

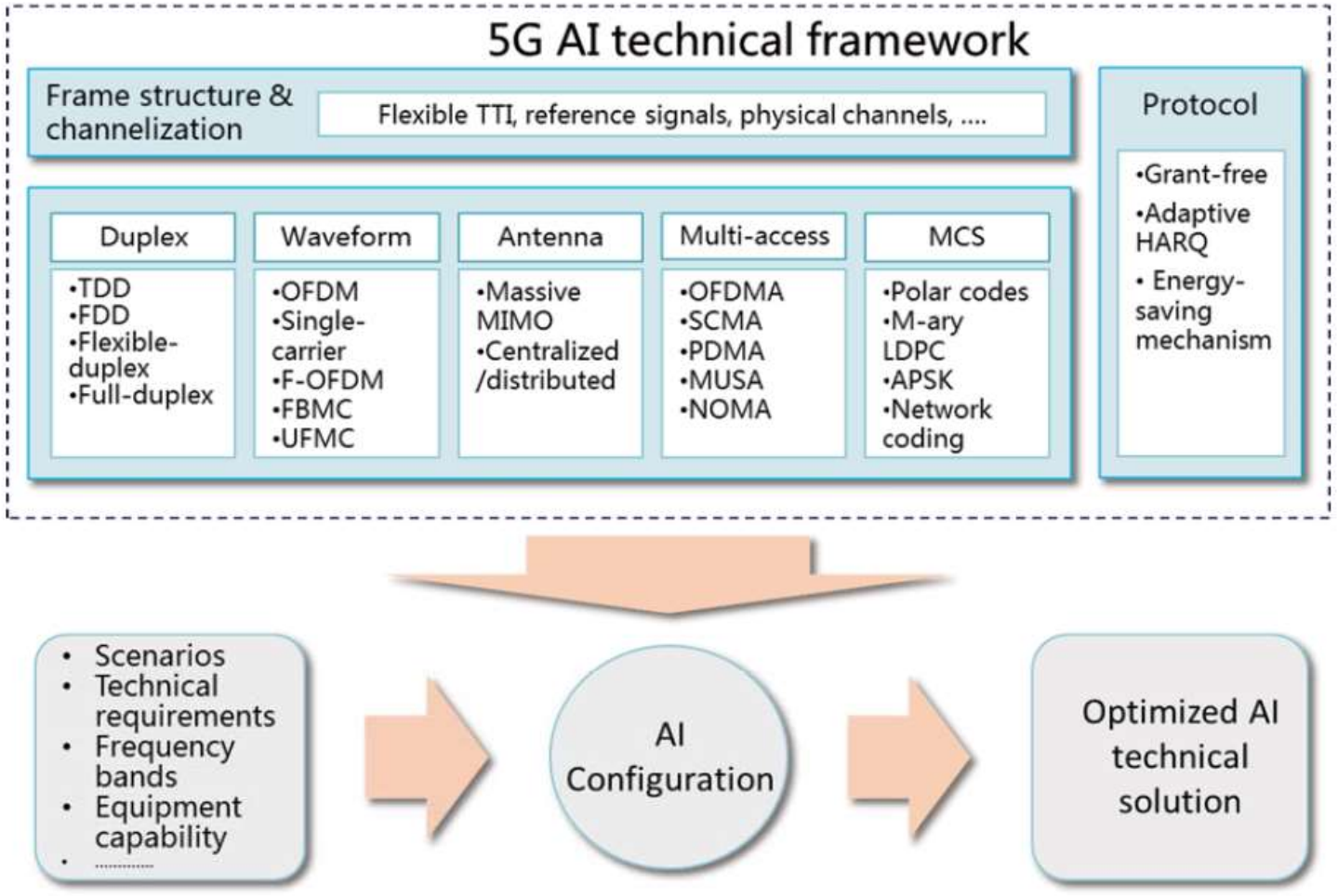


mMTC URLLC



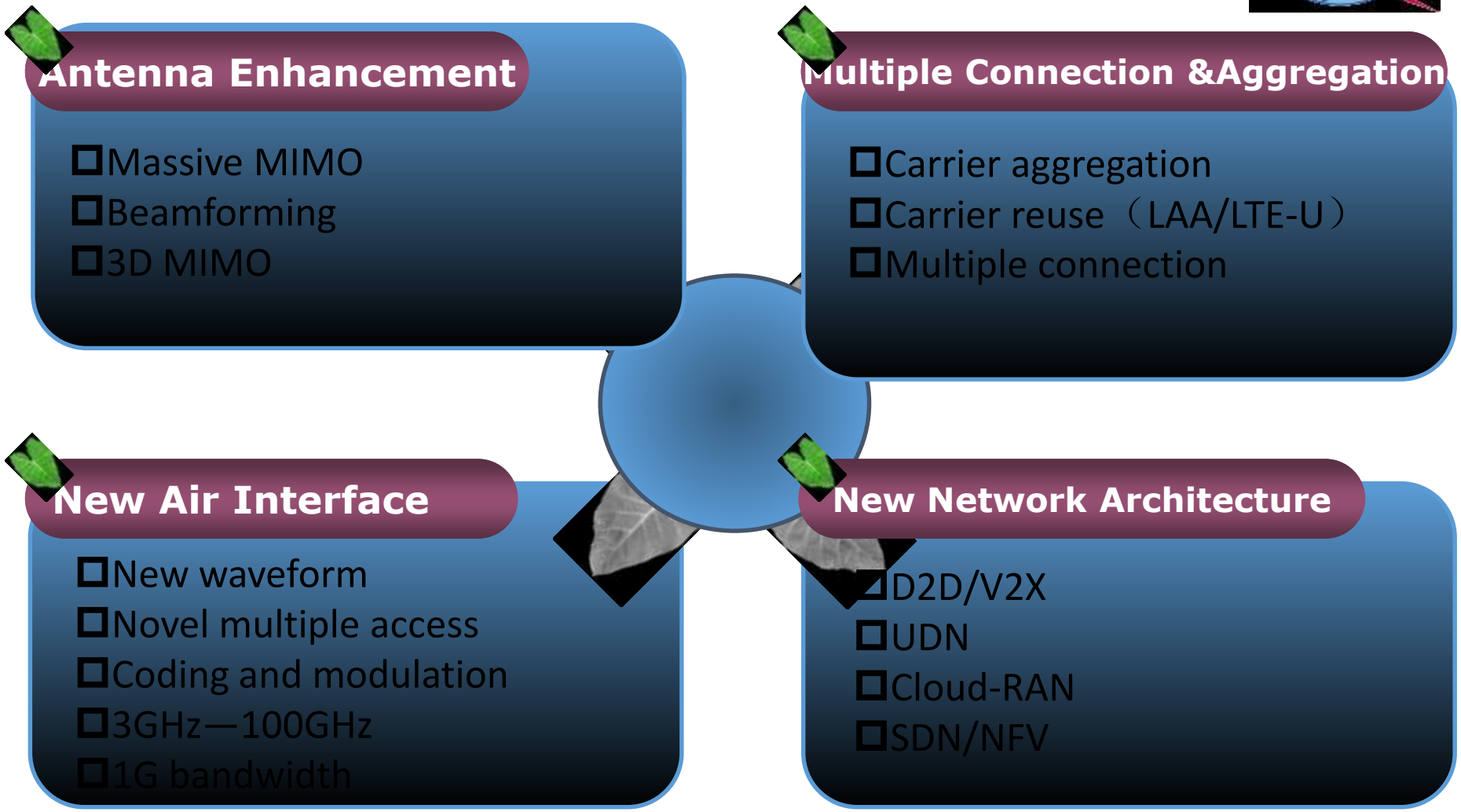
Source:Recommendation ITU-R M.2083-0:IMT Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond

1. 5G base station product



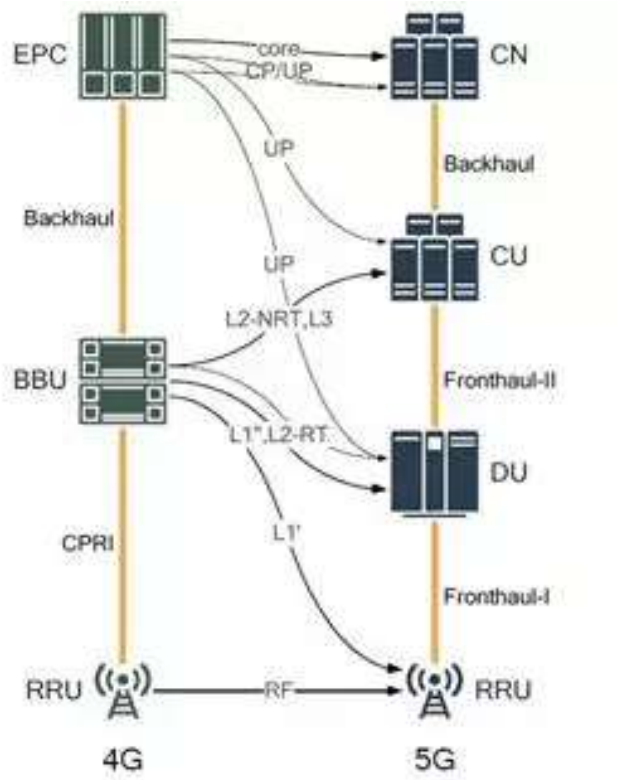
Flexible and confi gurable Air Interfaces technical framework of 5G

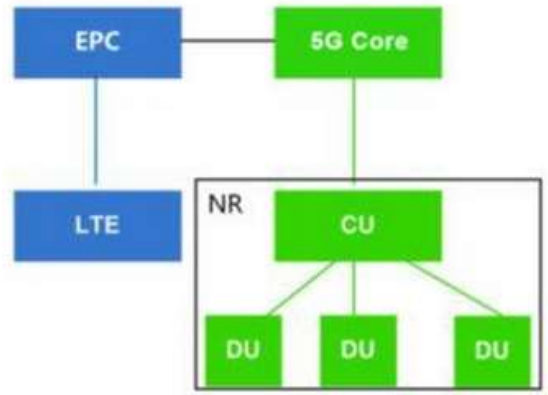
1. 5G base station product



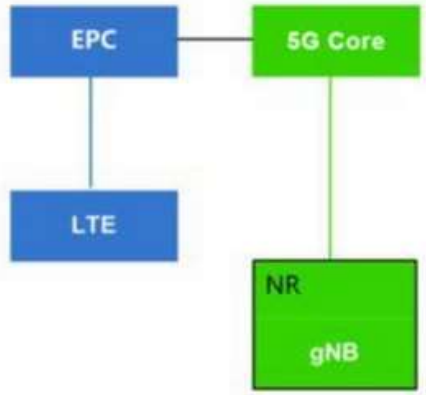
1. 5G base station product

5G RAN functional module reconfiguration





CU-DU distributed architecture



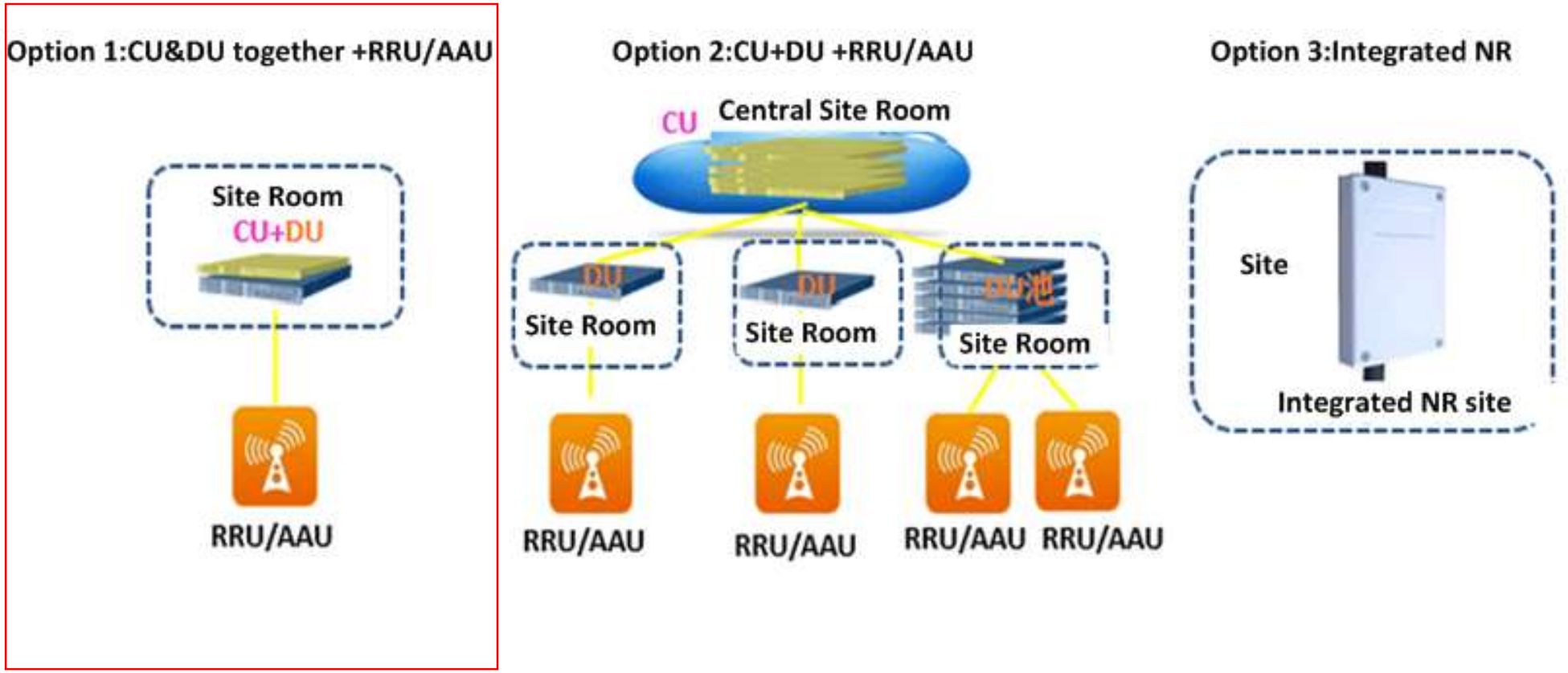
CU-DU integrated architecture

CU Centralized Unit:The non real time part of the original BBU is segmented to deal with non real time protocols and services;

DU Distribute Unit: Handling physical layer protocols and real-time services, and some physical layer functions can be moved up to RRU.

1. 5G base station product

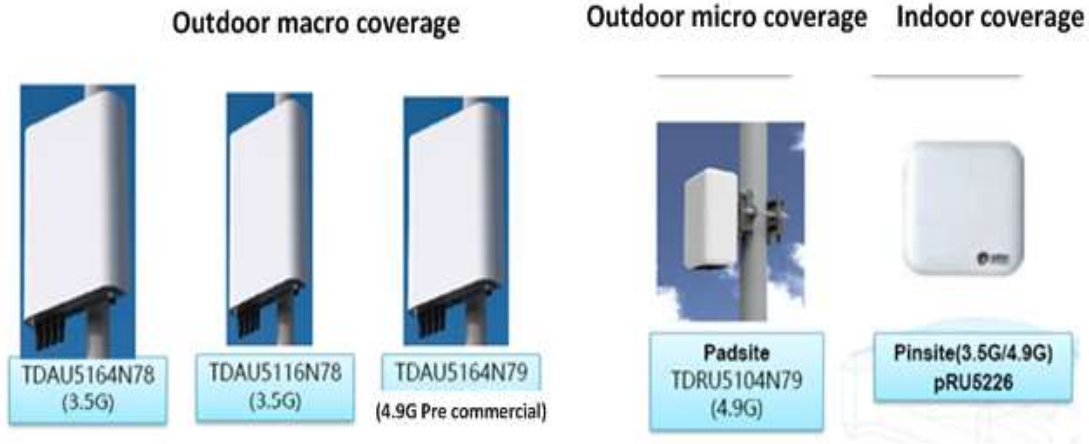
5G Base station deployment scheme have 3 options.



In the early stage of the deployment of 5G network, it will mainly adopt the option1.

1. 5G base station product

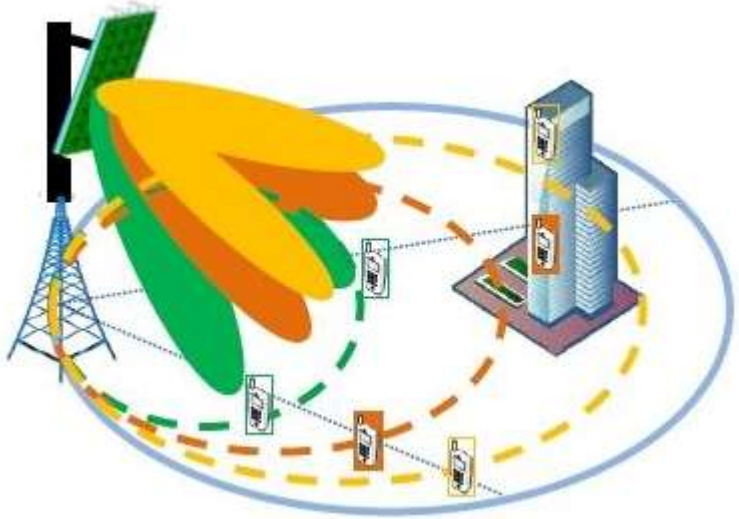
5G Product planning of Samsung



5G Product planning of Datang

5G Product planning of Ericsson

2.The challenge of 5G base station testing

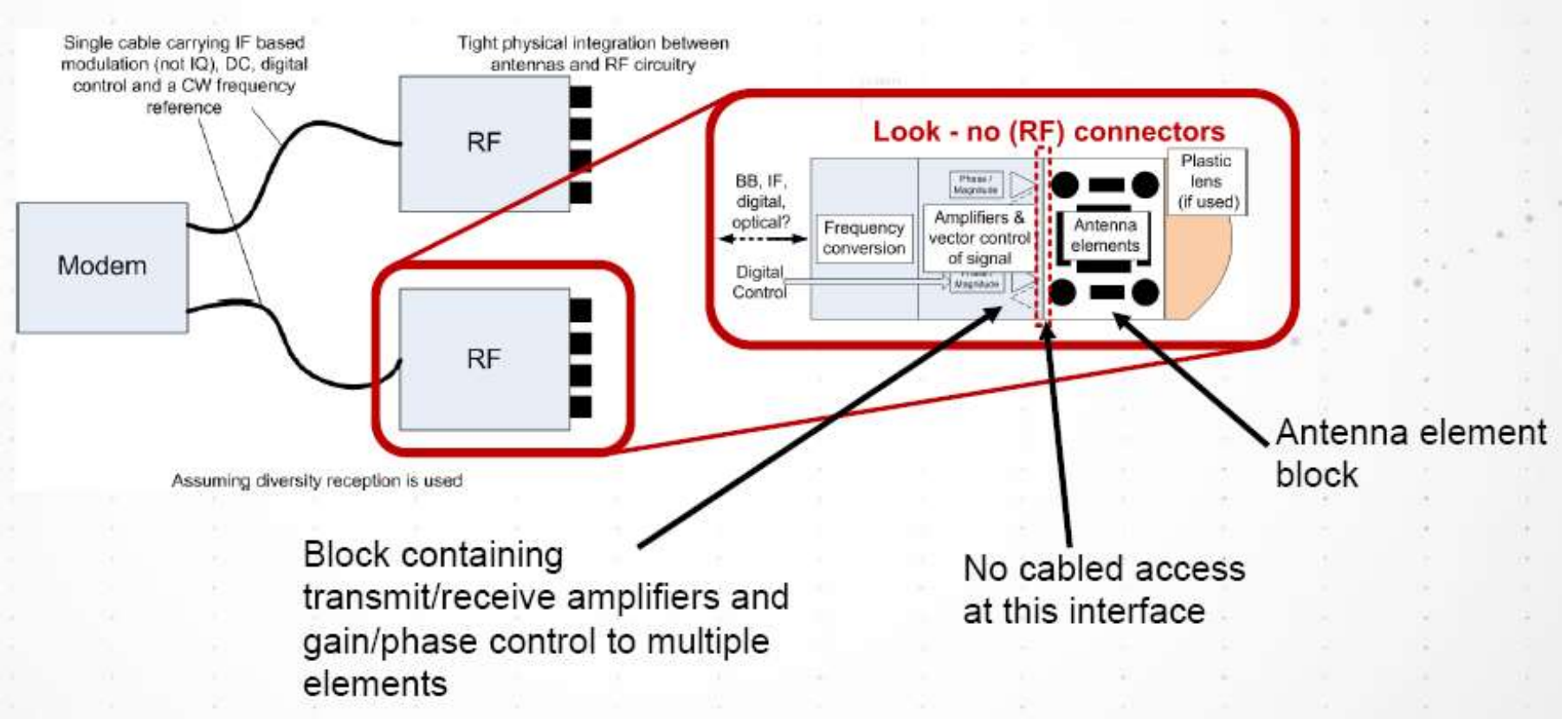


The main challenge of 5G base station testing

a) Large antennas arrays, more than 64
b) Integration of antenna, radio frequency and baseband
c) Radio frequency ports can not be tested independently
d) The antenna array unit does not work alone
e) Dynamic adjustment of antenna beam
f) Millimeter wave equipment meets higher requirements for test instruments and cables
g) ----------

2.The challenge of 5G base station testing

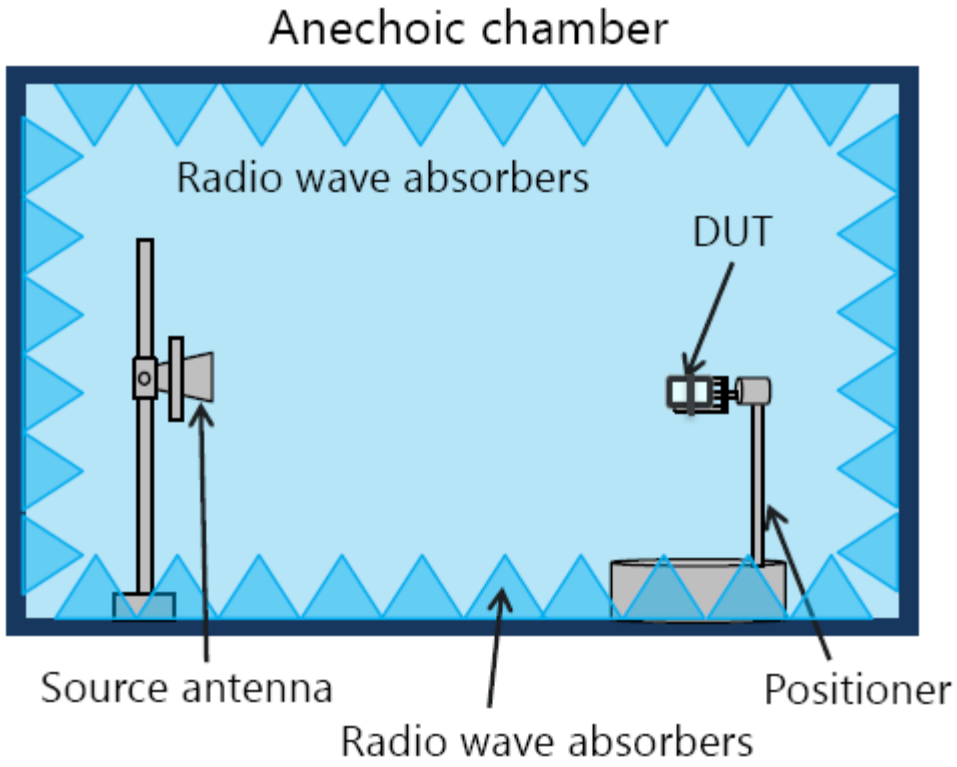
One example: Without RF connectors between the RF and antenna of a MMW radio system； in this case, we couldn’t test with cables.



2.The challenge of 5G base station testing

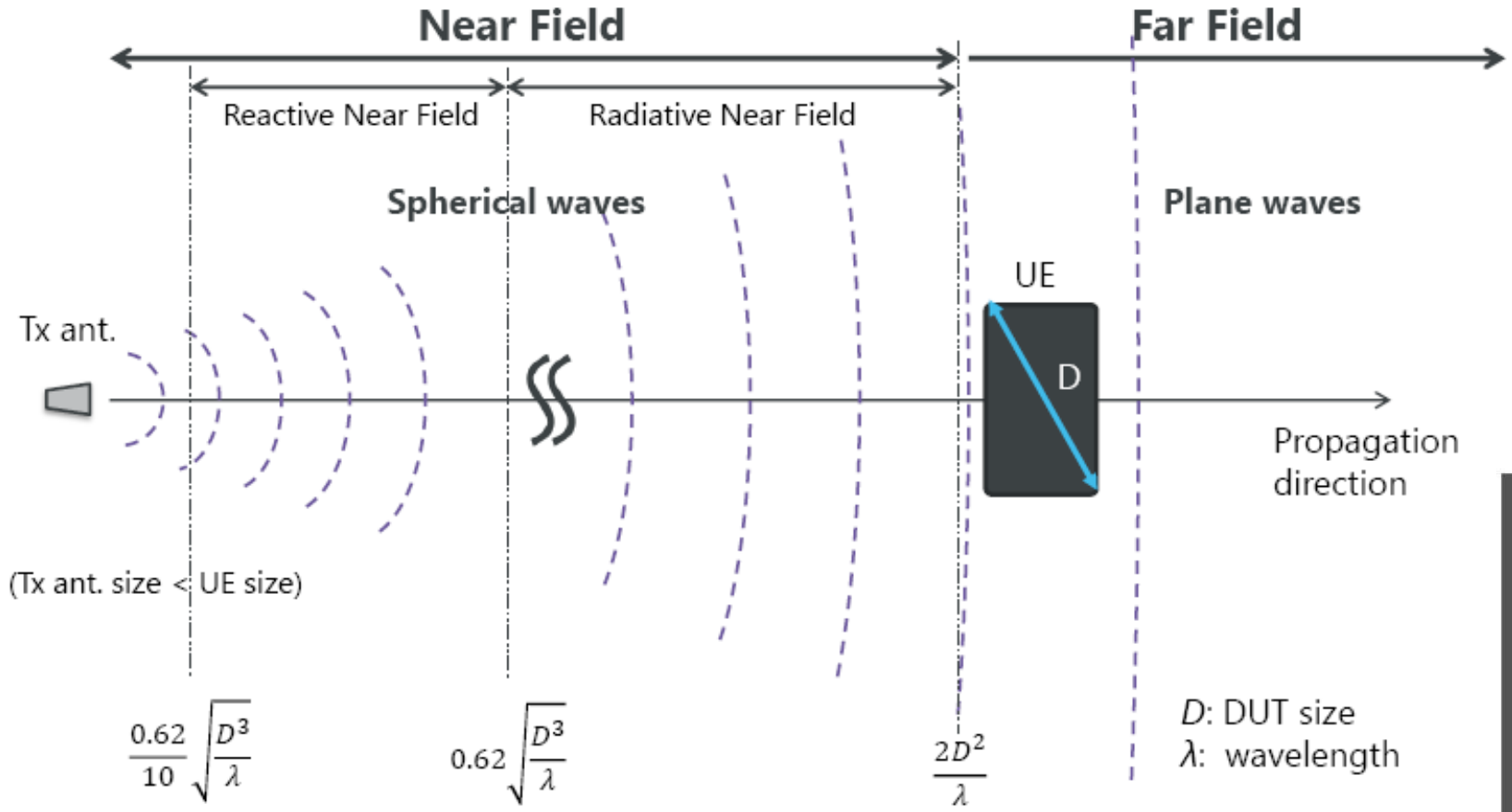
In order to deal with the challenges bring by the change of 5G product form and the introduction of new technologies, we need to use the OTA testing methods.

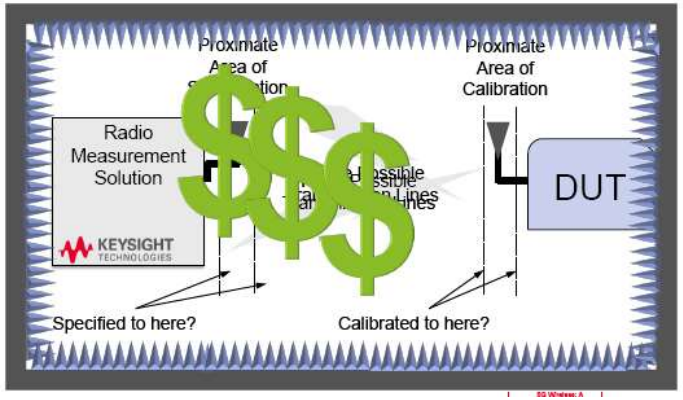
- Test the multi beam stereoscopic direction map of 5G base station
- Test the radio frequency index by the air interface
- Test the base station throughput under multi user access



2.The challenge of 5G base station testing

Near Field&Far Field





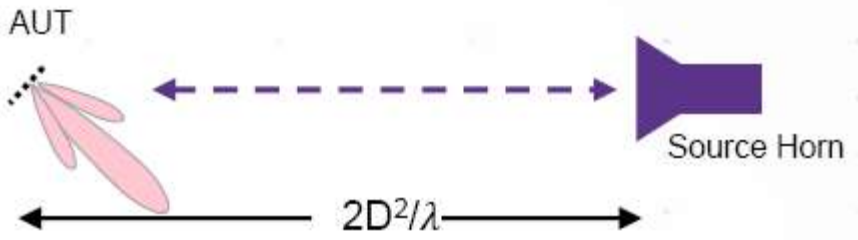
Far Field

A field where a radio wave radiated from the wave source propagates and can be regarded as a plane wave.

2.The challenge of 5G base station testing

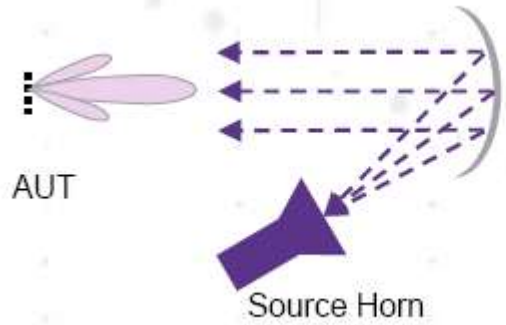
OTA Chamber Types

Direct Far Field(DFF) test system is based on combination of the antenna aperture(D) and the operating frequency/wavelength(λ) to measure a true far field distance defined as $FF=2D^2/\lambda$.



Near-field test system measures the energy in the radiating near-field regionand converts those measurements by a Fourier transform into the far-field result.

Indirect Far Field(IFF) Compact Test Range(CATR) uses reflectors to focus the RF energy into a plane wave within a much shorter distance than would normally berequired to achieve radiated far field measurements.



2.The challenge of 5G base station testing

Comparison of Measurement Methods

Far Field Setup	CATR Setup	Near Field Setup
Very large dimensions due to black box approach	Measurements in farfield conditions in a compact footprint	Most compact setup
Both Antenna & RF parametric measurements can be done	Both Antenna & RF parametric measurements can be done	Suitable only for antenna measurements. Question for RF parametric measurements
Large path loss -> low measurement dynamic range	Path loss only dependent on focal length. -> Good dynamic range	Verylow path loss ->Best dynamic range
3GPP compliant	3GPP compliance work ongoing. Awaiting Beamlock mechanism definition to be standardized in Rel15.	3GPP compliant in V.2.1.0
High measurement uncertainty in case of making measurements of "offset DUT placement from phase center of Quiet Zone"	Low measurement uncertainty if the device can be placed within the Quiet Zone. Search algorithm can help identify the location of the radiating region to reposition the DUT	High measurement uncertainty in case of making measurements of "offset DUT placement from phase center of Quiet Zone"

3.The standardization of 5G base station testing

3GPP 38.104—Base Station (BS) radio transmission and reception

3GPP TS 38.104 V15.2.0 (2018-06)


3GPP TS 38.104 V15.2.0 (2018-06)

Technical Specification

3rd Generation Partnership Project;
Technical Specification Group Radio Access Network;
NR;
Base Station (BS) radio transmission and reception
(Release 15)

5G

3GPP

A GLOBAL INITIATIVE

The present document establishes the minimum RF characteristics and minimum performance requirements of NR Base Station (BS).

Table 5.2-1: NR *operating bands* in FR1

NR *operating band*	Uplink (UL) *operating band* BS receive / UE transmit F_{UL_low} – F_{UL_high}	Downlink (DL) *operating band* BS transmit / UE receive F_{DL_low} – F_{DL_high}	Duplex Mode
n1	1920 MHz – 1980 MHz	2110 MHz – 2170 MHz	FDD
n2	1850 MHz – 1910 MHz	1930 MHz – 1990 MHz	FDD
n3	1710 MHz – 1785 MHz	1805 MHz – 1880 MHz	FDD
n5	824 MHz – 849 MHz	869 MHz – 894 MHz	FDD
n7	2500 MHz – 2570 MHz	2620 MHz – 2690 MHz	FDD
n8	880 MHz – 915 MHz	925 MHz – 960 MHz	FDD
n12	699 MHz – 716 MHz	729 MHz – 746 MHz	FDD
n20	832 MHz – 862 MHz	791 MHz – 821 MHz	FDD
n25	1850 MHz – 1915 MHz	1930 MHz – 1995 MHz	FDD
n28	703 MHz – 748 MHz	758 MHz – 803 MHz	FDD
n34	2010 MHz – 2025 MHz	2010 MHz – 2025 MHz	TDD
n38	2570 MHz – 2620 MHz	2570 MHz – 2620 MHz	TDD
n39	1880 MHz – 1920 MHz	1880 MHz – 1920 MHz	TDD
n40	2300 MHz – 2400 MHz	2300 MHz – 2400 MHz	TDD
n41	2496 MHz – 2690 MHz	2496 MHz – 2690 MHz	TDD
n51	1427 MHz – 1432 MHz	1427 MHz – 1432 MHz	TDD
n66	1710 MHz – 1780 MHz	2110 MHz – 2200 MHz	FDD
n70	1695 MHz – 1710 MHz	1995 MHz – 2020 MHz	FDD
n71	663 MHz – 698 MHz	617 MHz – 652 MHz	FDD
n75	N/A	1432 MHz – 1517 MHz	SDL
n76	N/A	1427 MHz – 1432 MHz	SDL
n77	3300 MHz – 4200 MHz	3300 MHz – 4200 MHz	TDD
n78	3300 MHz – 3800 MHz	3300 MHz – 3800 MHz	TDD
n79	4400 MHz – 5000 MHz	4400 MHz – 5000 MHz	TDD
n80	1710 MHz – 1785 MHz	N/A	SUL
n81	880 MHz – 915 MHz	N/A	SUL
n82	832 MHz – 862 MHz	N/A	SUL
n83	703 MHz – 748 MHz	N/A	SUL
n84	1920 MHz – 1980 MHz	N/A	SUL
n86	1710 MHz – 1780 MHz	N/A	SUL

Table 5.2-2: NR *operating bands* in FR2

NR *operating band*	Uplink (UL) and Downlink (DL) *operating band* BS transmit/receive UE transmit/receive F_{UL_low} – F_{UL_high} F_{DL_low} – F_{DL_high}	Duplex Mode
n257	26500 MHz – 29500 MHz	TDD
n258	24250 MHz – 27500 MHz	TDD
n260	37000 MHz – 40000 MHz	TDD
n261	27500 MHz – 28350 MHz	TDD

3.The standardization of 5G base station testing

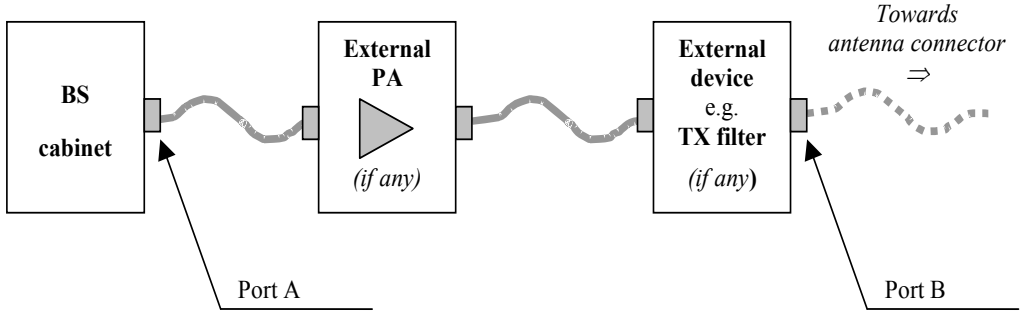


Figure 4.3.1-1: *BS type 1-C* transmitter interface

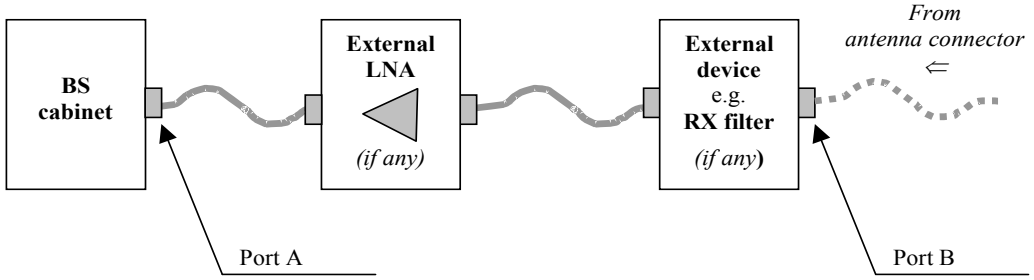


Figure 4.3.1-2: *BS type 1-C* receiver interface

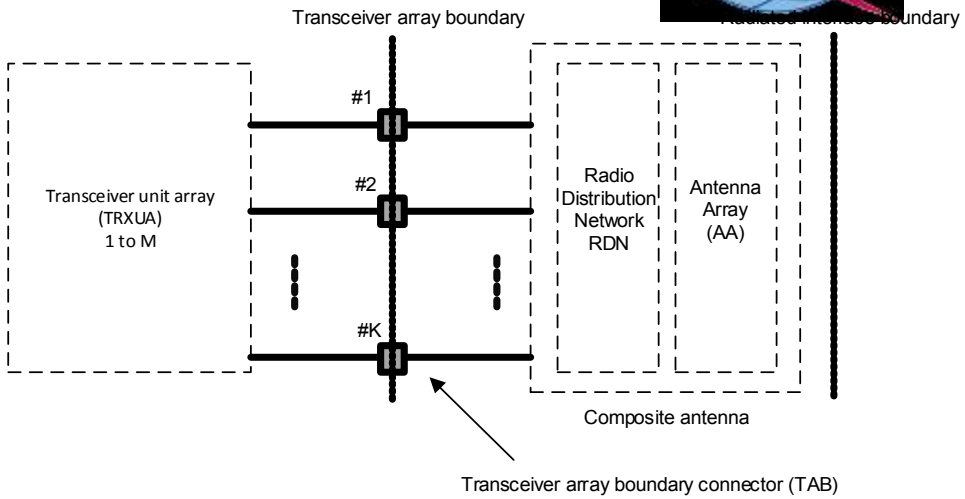


Figure 4.3.2-1: Radiated and conducted reference points for *BS type 1-H*

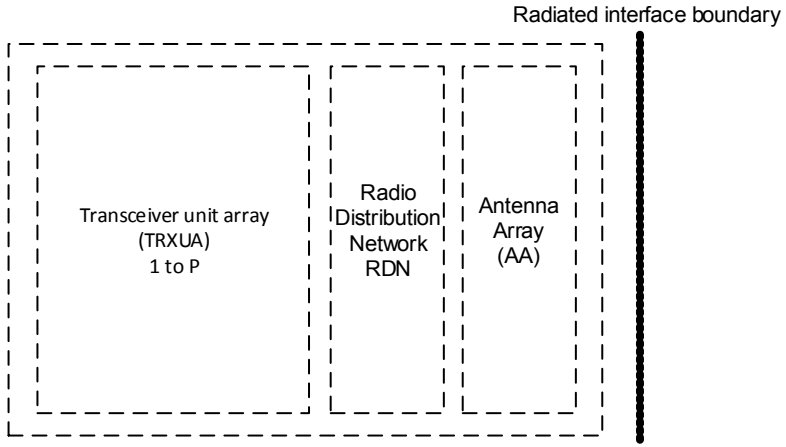


Figure 4.3.3-1: Radiated reference points for *BS type 1-O* and *BS type 2-O*

3.The standardization of 5G base station testing

Requirement	Requirement set			
	BS type 1-C	*BS type 1-H*	*BS type 1-O*	*BS type 2-O*
BS output power	6.2	6.2	NA	NA
Output power dynamics	6.3	6.3		
Transmit ON/OFF power	6.4	6.4		
Transmitted signal quality	6.5	6.5		
Occupied bandwidth	6.6.2	6.6.2		
ACLR	6.6.3	6.6.3		
Operating band unwanted emissions	6.6.4	6.6.4		
Transmitter spurious emissions	6.6.5	6.6.5		
Transmitter intermodulation	6.7	6.7		
Reference sensitivity level	7.2	7.2		
Dynamic range	7.3	7.3		
In-band selectivity and blocking	7.4	7.4		
Out-of-band blocking	7.5	7.5		
Receiver spurious emissions	7.6	7.6		
Receiver intermodulation	7.7	7.7		
In-channel selectivity	7.8	7.8		
Performance requirements	8	8		
Radiated transmit power	NA	9.2	9.2	9.2
OTA base station output power		NA	9.3	9.3
OTA output power dynamics			9.4	9.4
OTA transmit ON/OFF power			9.5	9.5
OTA transmitted signal quality			9.6	9.6
OTA occupied bandwidth			9.7.2	9.7.2
OTA ACLR			9.7.3	9.7.3
OTA out-of-band emission			9.7.4	9.7.4
OTA transmitter spurious emission			9.7.5	9.7.5
OTA transmitter intermodulation			9.8	NA
OTA sensitivity		10.2	10.2	NA
OTA reference sensitivity level		NA	10.3	10.3
OTA dynamic range			10.4	NA
OTA in-band selectivity and blocking			10.5	10.5
OTA out-of-band blocking			10.6	10.6
OTA receiver spurious emission			10.7	10.7
OTA receiver intermodulation			10.8	10.8
OTA in-channel selectivity			10.9	10.9
Radiated performance requirements			11	11

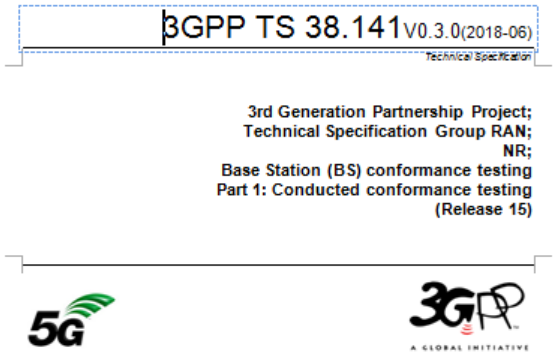
Requirement set applicability

3GPP TS 38.104 V15.2.0 (2018-06)

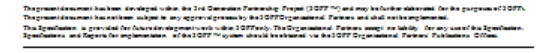
The requirement applicability for each requirement set is defined. For each requirement, the applicable requirement subclause in the specification is identified. Requirements not included in a requirement set is marked not applicable (NA).

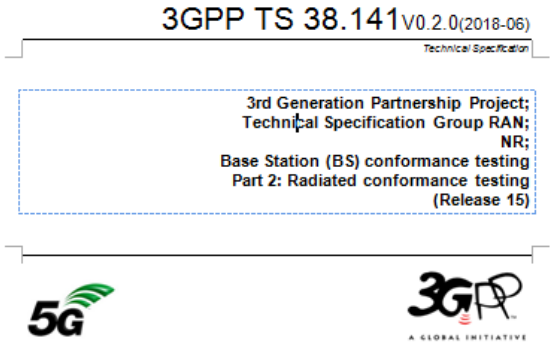
3.The standardization of 5G base station testing

3GPP 38.141-1—Base Station (BS) conformance testing
Part 1: Conducted conformance testing
3GPP TS 38.141V0.3.0(2018-06)

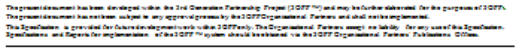

3GPP TS 38.141V0.3.0(2018-06)
Technical Specification

3rd Generation Partnership Project;
Technical Specification Group RAN;
NR;
Base Station (BS) conformance testing
Part 1: Conducted conformance testing
(Release 15)




3GPP TS 38.141V0.2.0(2018-06)
Technical Specification

3rd Generation Partnership Project;
Technical Specification Group RAN;
NR;
Base Station (BS) conformance testing
Part 2: Radiated conformance testing
(Release 15)



3GPP 38.141-2—Base Station (BS) conformance testing
Part 2: Radiated conformance testing
3GPP TS 38.141V0.2.0(2018-06)

3.The standardization of 5G base station testing

3GPP 38.141—Base Station (BS) conformance testing
Part 1: Conducted conformance testing
3GPP TS 38.141V0.3.0(2018-06)

3GPP 38.141-2—Base Station (BS) conformance testing
Part 2: Radiated conformance testing
3GPP TS 38.141V0.2.0(2018-06)

The present document specifies the Radio Frequency (RF) test methods and conformance requirements for NR Base Station (BS). These have been derived from, and are consistent with the NR BS specification defined in 3GPP TS 38.104 [2]. The technical specification 3GPP TS 38.141is in 2 parts:

1. 3GPP TS 38.141-1 (the present document) covers conducted test requirements
2 .3GPP TS 38.141-2 [3] covers radiated requirements.

A *BS type 1-C* requires only conducted requirements so requires compliance to part 1 of the specification only.

As *BS type 1-H* has both conducted and radiated requirements so requires compliance to the applicable requirements of part 1 and part 2 of the specification.

BS *type 1-O* and *2-O* have only radiated requirements so require compliance to part 2 of the specification only.

3.The standardization of 5G base station testing

3GPP 38.141—Base Station (BS) conformance testing
Part 1: Conducted conformance testing
3GPP TS 38.141V0.3.0(2018-06)

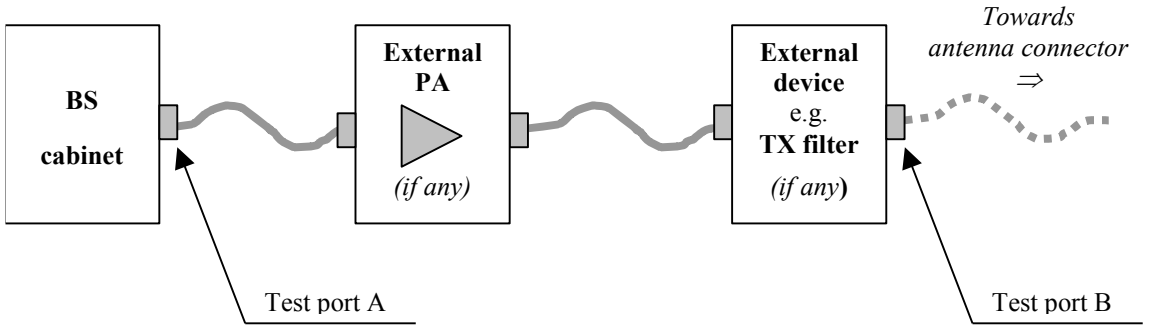


Figure 4.5.1.1.1-1: Transmitter test ports for 1-C

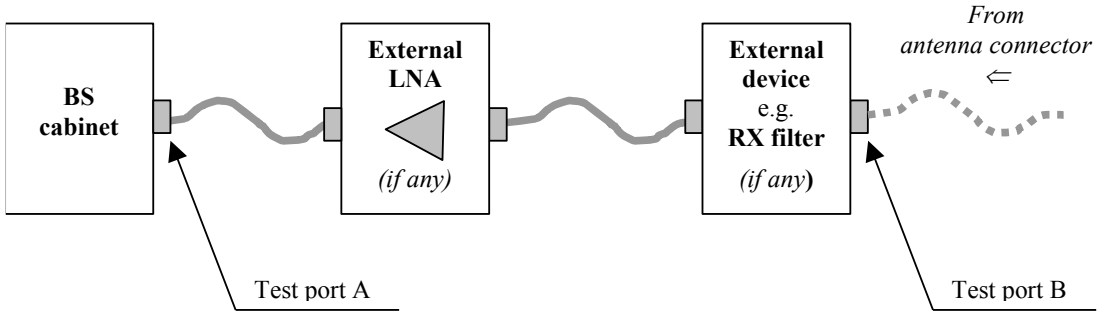


Figure 4.5.1.2.1-1: Receiver test ports for 1-C

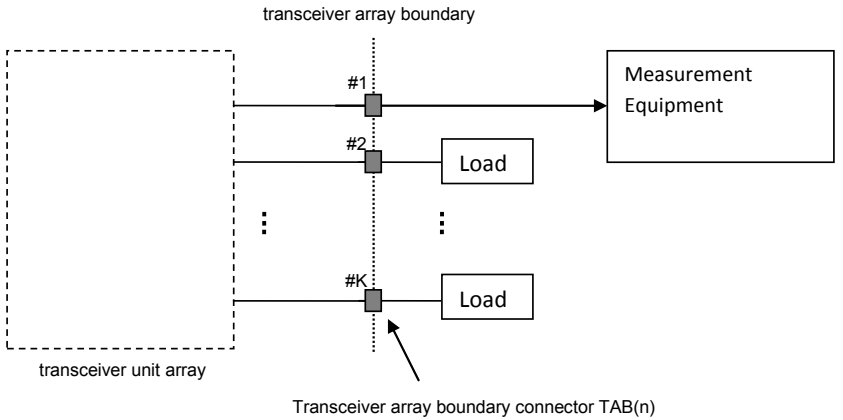


Figure 4.5.2.1-1: Transmitter test ports for 1-H

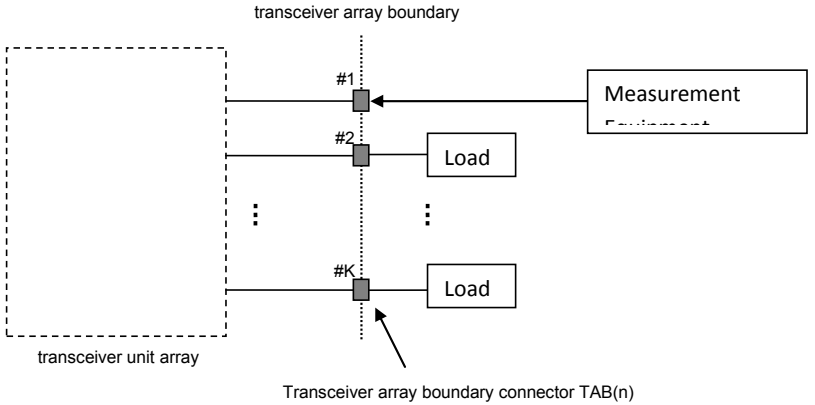


Figure 4.5.2.2-1: Receiver test ports for 1-H

3.The standardization of 5G base station testing

3GPP 38.141-2—Base Station (BS) conformance testing
Part 2: Radiated conformance testing
3GPP TS 38.141V0.2.0(2018-06)

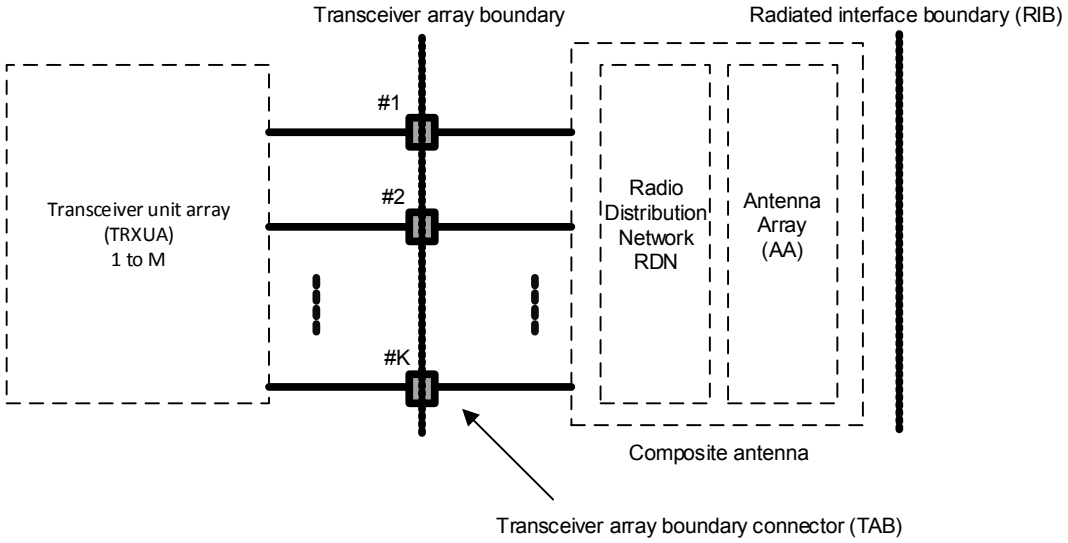


Figure 4.2-1: General architecture of *BS type 1-H*

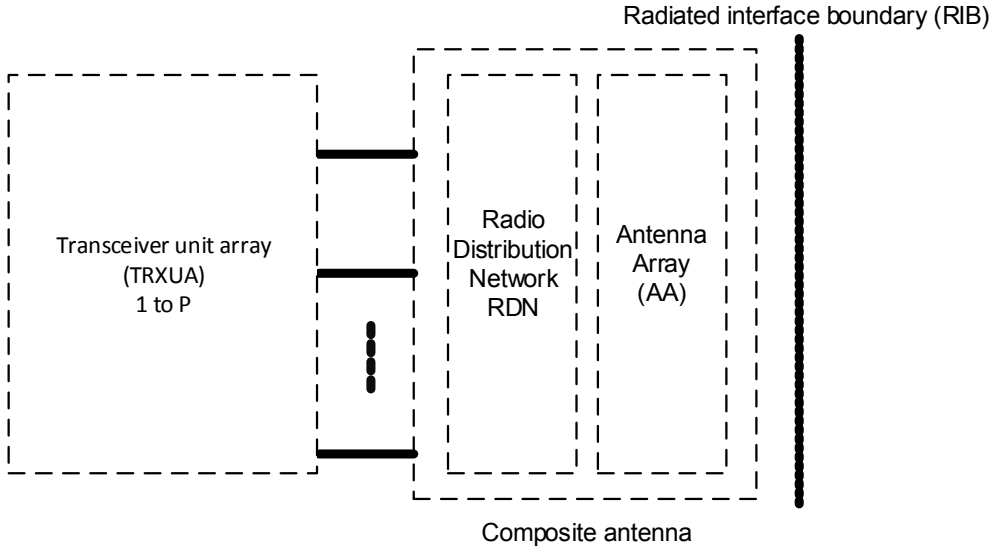


Figure 4.2-2: General architecture of *BS type 1-O* and *BS type 2-O*

3.The standardization of 5G base station testing

3GPP 38.141—Base Station (BS) conformance testing
Part 1: Conducted conformance testing
3GPP TS 38.141V0.3.0(2018-06)

Requirement	Requirement set	
	1-C	1-H
BS output power	6.2.2.5.1	6.2.2.5.2
Output power dynamics	6.3	6.3
Transmit ON/OFF power	6.4	6.4
Transmitted signal quality	6.5	6.5
Occupied bandwidth	6.6.2	6.6.2
ACLR	6.6.3.5.3	6.6.3.5.4
Operating band unwanted emissions	6.6.4.5.3	6.6.4.5.4
Transmitter spurious emissions	6.6.5.5.3	6.6.5.5.4
Transmitter intermodulation	6.7.5.1	6.7.5.2
Reference sensitivity level	7.2	7.2
Dynamic range	7.3	7.3
In-band selectivity and blocking	7.4	7.4
Out-of-band blocking	7.5	7.5
Receiver spurious emissions	7.6.5.2	7.6.5.3
Receiver intermodulation	7.7	7.7
In-channel selectivity	7.8	7.8
Performance requirements	8	8

Table 4.8.2-1: Requirement set applicability of conducted testing

3GPP 38.141-2—Base Station (BS) conformance testing
Part 2: Radiated conformance testing
3GPP TS 38.141V0.2.0(2018-06)

Requirement	Requirement set		
	1-H	1-O	2-O
Radiated transmit power	6.2	6.2	6.2
OTA base station output power	NA	6.3	6.3
OTA output power dynamics		6.4	6.4
OTA transmit ON/OFF power		6.5	6.5
OTA transmitted signal quality		6.6	6.6
OTA occupied bandwidth		6.7.2	6.7.2
OTA ACLR		6.7.3	6.7.3
OTA out-of-band emission		6.7.4	6.7.4
OTA transmitter spurious emission		6.7.5	6.7.5
OTA transmitter intermodulation		6.8	NA
OTA sensitivity	7.2	7.2	NA
OTA reference sensitivity level	NA	7.3	7.3
OTA dynamic range		7.4	NA
OTA in-band selectivity and blocking		7.5	7.5
OTA out-of-band blocking		7.6	7.6
OTA receiver spurious emission		7.7	7.7
OTA receiver intermodulation		7.8	7.8
OTA in-channel selectivity		7.9	7.9
Radiated performance requirements		8	8

Table 4.7.2-1: Requirement set applicability of Radiated testing

4.Thinking of test method of 5G base station

In the 5G era, a test system can not completely cover all test items.

Which is the best ways to test 5G base station?

Conducted testing with cables

Radiated testing with Direct Far Field in the OTA chamber

Radiated testing with Near-field in the OTA chamber

Radiated testing with Compact Antenna Test Range in the OTA chamber



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4.Thinking of test method of 5G base station

In which case,we use conducted testing with cables or Radiated testing in the OTA chamber?

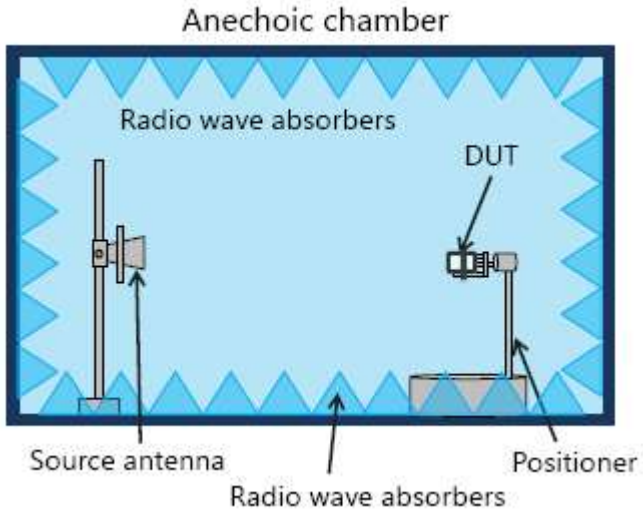
	Chipset, UE R&D				Certification	
Category	Transceiver	RF parametric	Protocol	Antenna	GCF/PTCRB Conformance	CTIA OTA Certification
T&M product	SA / SG	Call Box	Signaling Tester	Call Box	Conformance Test System	Call Box
4G	N/A Conducted	N/A Conducted	N/A Conducted	OTA Test	N/A Conducted	OTA Test
5G Sub-6GHz	N/A Conducted	N/A Conducted	N/A Conducted	OTA Test	N/A Conducted	OTA Test
5G mmWave	OTA Test	OTA Test	OTA Test	OTA Test	OTA Test	OTA Test

Anechoic chamber

Anechoic chamber & Reverberation chamber

4.Thinking of test method of 5G base station

What is the requirements of the OTA chamber for testing 5G base station?

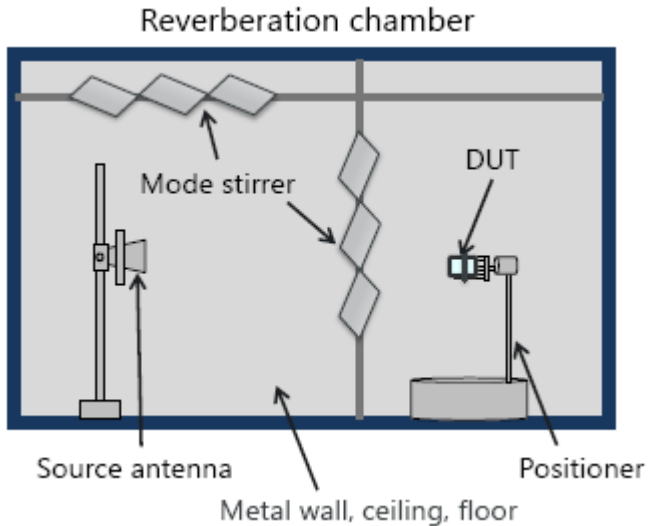


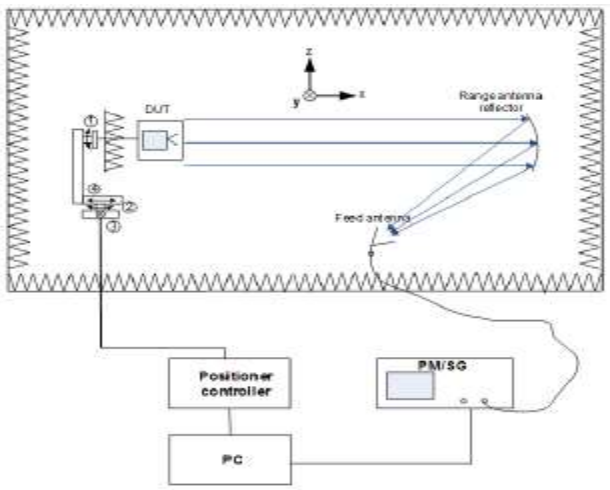
Maybe

Quiet zone >1m

Turntable can bear weight >50kg

Measuring accuracy meet the requirement of 3GPP TS 38.141





Thank You

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About CTTL - SYS

- China Telecommunication Technology Labs
  - Founded in 1981
  - Authoritative test organization
  - Supports the standards and regulation

- Main tasks
  - Information / Communication Technologies research
  - Development of ICT product standards and test methods
  - Products inspection, verification and assessment
  - Testing Instruments metrology and evaluation

- 2G/3G/4G/5G Microwave Equipment
- Antennas / RF Components
- WPAN (Bluetooth, NFC, RFID, Zigbee, etc…)
- Base products (Cables, Op. Fibers, accessories…)
- Signal / Service Driver test
- Power / Battery
- Anti-seismic research and test
- Metrology and calibration