GTI 5G Device OTA Test Specification

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5G Device OTA Test Specification

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1 Scope

This specification targets enhanced Mobile Broadband (eMBB) scenario for 5G Device products testing. It stipulates the 5G device OTA performance test in lab for NSA Mode (Option 3/3a/3x) and SA (Option 2).

This specification provides evaluation criteria for UE OTA performance in the 5G test. Considering various test requirements, specific test cases and methods are designed, together with the basic requirements for each test category, number of test devices, and tailored agreements.

This specification is one of the 5G Sub-6GHz device test specifications which are used in GTI 5G Device Certification.

2 Definitions, Symbols and Abbreviations

Abbreviation	Explanation
3GPP	3rd Generation Partnership Project
AAS	Active Antenna System
RC	Reverberation Chamber
RF	Radio Frequency
RMC	Reference Measurement Channel
SCME	Spatial Channel Model Extension
MIMO	Multiple Input Multiple Output
TDD	Time Division Duplex
FDD	Frequency Division Duplex
PDSCH	Physical Downlink Shared Channel
PUSCH	Physical Uplink Shared Channel
RSRP	Reference Signal Received Power
UDP	User Datagram Protocol
UE	User Equipment

3 Reference

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

[1] 3GPP TR 38.810 V2.0.0, "Technical Specification Group Radio Access Network; Study on test methods for New Radio; (Release 15)", Mar. 2018

[2] 3GPP, TR 38.901, Study on channel model for frequencies from 0.5 to 100 GHz.

[3] 3GPP TR.37.977, "Verification of radiated multi-antenna reception performance of User Equipment (UE)"

[4] 3GPP TR 37.842: "Radio Frequency (RF) requirement background for Active Antenna System (AAS) Base Station (BS)"

[5] K. T. Selvan, R. Janaswamy, "Fraunhofer and Fresnel distances," IEEE Antennas Propagat. Magazine, Aug. 2017.

[6] B. Derat, "5G antenna characterization in the FF," Proc. Int. Symp. EMC & Asia-Pacific Symp. EMC (APEMC), Singpore, May 2018.

[7] S. Singh, F. Ziliotto, U. Madhow, E. M. Belding, and M. Rodwell, "Blockage and directivity in 60 GHz wireless personal area networks:From cross-layer model to multi hop MAC design," IEEE J. Sel. Areas Commun., vol. 27, no. 8, pp. 1400–1413, Oct. 2009.

[8] Michael D. Foegelle. "Antenna Pattern Measurement: Concepts and Techniques."

[9] IEEE 10.1109/ISEMC.2018.8393803

[10] CTIA (2015, May). "Method of Measurement for Radiated RF Power and Receiver Performance", Test Plan for Mobile Station Over the Air performance Rev3.4.2,pp.238-239.Avalible:https://www.ctia.org/docs/default-source/default

[11] The Institute of Electrical and Electronics Engineers. Inc, "IEEE Standard Test Procedures for Antennas", December 19. 1979, pp. 69-75

4 Test Methods

Both Aniecho Chamber (AC) and Reveberation Chamber (RC) can be used for SISO OTA test. Conical Cut Test Method and Great Circle Test Method are typical methods in Anechoic Chamber.

4.1 Anechoic Chamber

4.1.1 Total Radiated Power

Good radiated performance is critical to the effective operation of a wireless device in today's networks. The total radiated power (TRP) test is required to characterize the radiated performance of the device. The TRP requires the spherical effective isotropic radiated power (EIRP) to be measured.

For a complete sphere measured with N theta intervals and M phi intervals, both with even angular spacing, the Total Radiated Power is calculated as follows.

Total Radiated Power:

$$TRP \cong \frac{\pi}{2NM}\sum_{i=1}^{N-1}\sum_{j=0}^{M-1}\left[EiRP_{\theta}(\theta_i,\phi_j)+EiRP_{\phi}(\theta_i,\phi_j)\right]\sin(\theta_i)$$

Typical system schematics for TRP measurement are shown in Figure 4.1.1.1-1. The shown configurations are only representative examples of common measurement systems and do not represent an exhaustive list of allowable configurations. Figure 4.1.1.1-1 also includes illustrations showing conducted power and conducted sensitivity measurement setups.

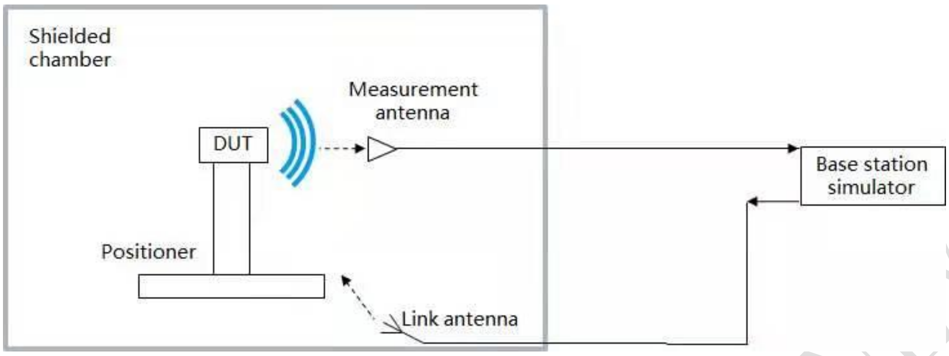

Figure 4.1.1-1: Simplified block diagram showing for a common configuration for the use of a base station simulator for TRP measurements

In Figure 4.1.1.1-1, the forward link communication is transmitted through the communication link antenna and the reverse link is received through the measurement antenna. This configuration supports amplification of both signal paths if necessary.

4.1.2 Total Istropic Sensitivity

Receiver performance, or EIS (Effective Isotropic Sensitivity) is as important to the overall system performance as radiated transmitter performance. This test requires average spherical effective radiated receiver sensitivity (termed Total Isotropic Sensitivity, TIS) to be measured.

For a complete sphere measured with N theta intervals and M phi intervals, both with even angular spacing, the Total Isotropic Sensitivity is calculated as follows.

$$TIS \cong \frac{2NM}{\pi \sum_{i=1}^{N-1} \sum_{j=0}^{M-1} \left[\frac{1}{EIS_{\theta}(\theta_i, \phi_j)} + \frac{1}{EIS_{\phi}(\theta_i, \phi_j)} \right] \sin(\theta_i)}$$

where EIS is the radiated effective isotropic sensitivity measured at each direction and polarization.

Typical system schematics for TIS measurement are shown in Figure 4.1.1.2-1. The shown configurations are only representative examples of common measurement systems and do not represent an exhaustive list of allowable configurations. Figure 4.1.1.2-1 also includes illustrations showing conducted power and conducted sensitivity measurement setups.

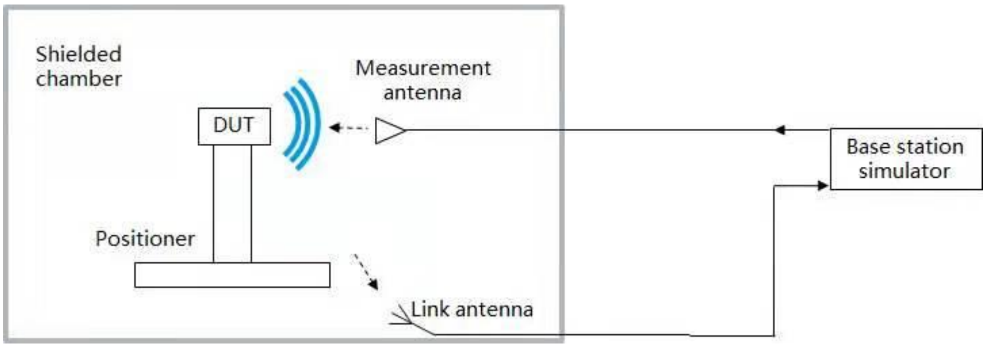

Figure 4.1.1.2-1: Simplified block diagram showing for a common configuration for TIS measurements

In Figure 4.1.2-1, the forward link communication is transmitted through the measurement antenna and the reverse link is received through the communication link antenna. This configuration supports amplification of both signal paths if necessary.

4.2 Reverberation Chamber

4.2.1 Reverberation chamber field distribution

In a well-designed RC there are very many modes excited at the frequency of operation.

Almost every mode can be factorized into 8 plane waves. During a stirring sequence, the modes change, thus the plane waves change amplitude and direction. If the RC operates well, over a stirring sequence incident the DUT will have experiences plane waves from an even distribution of angles on the sphere. This is illustrated in figure

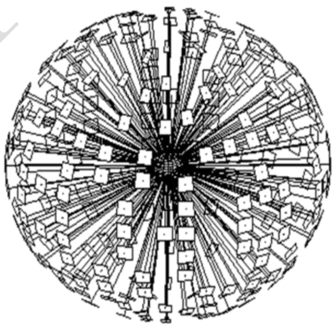

Figure 4.2.1-1 Plane wave distribution in an RC over a stirring sequence

Receives amplitude on an antenna port in an RC is Rayleigh faded over frequency and time (on the time scale of the stirring) and in space. This is illustrated in figure

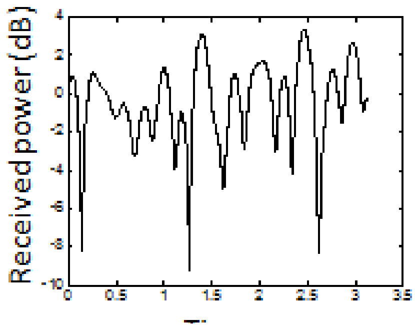

Figure 4.2.1-2 Rayleigh faded signal in reverberation chamber

Polarization balance in another important parameter in the RC. In a properly designed RC, there is polarization balance over a stirring sequence, with a distribution for different stirrer positions. This is illustrated in figure

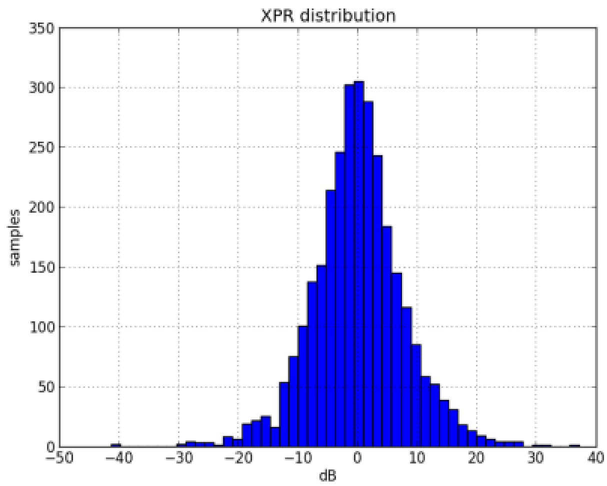

Figure 4.2.1-3 Polarization distribution inside reverberation chamber

Correlation between the fixed antennas in the RC can be controlled by design. The correlation should be set to as low a value as possible to be able to test low correlated antennas (DUTs). In a well-designed RC, there should be a very low correlation between the fixed antennas in the RC.

4.2.1.1 Positioning and mode stirring facilities

The reverberation chamber shall be equipped with mode-stirring facilities in such a way that enough number of independent power samples can be achieved for the accuracy requirement stated in this standard to be fulfilled. Possible mode-stirring methods include platform stirring, polarization stirring and mechanical stirring with fan-type stirrers, irregular shaped rotational stirrers, or plate-type stirrers. Also frequency stirring is possible if the type of measurement allows for a frequency-averaged value, but this is not necessary if the chamber is sufficiently large and well stirred.

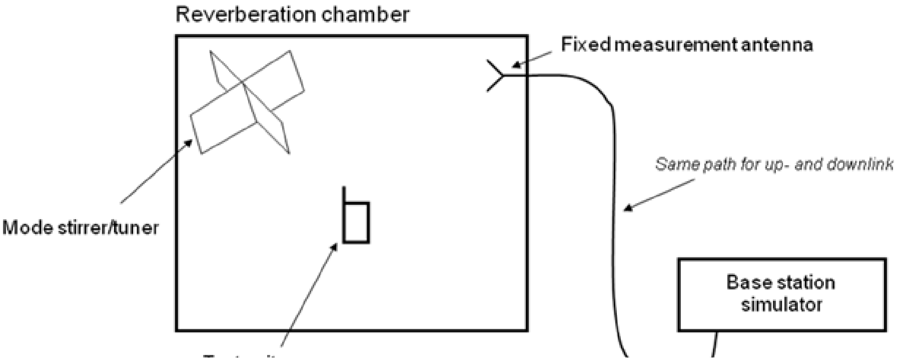

Figure 4.2.1.1-1 Reverberation chamber measurement setup

4.2.1.2 Chamber size and characteristics

The reverberation chamber shall have a volume large enough to support the number of modes needed for the stated accuracy at the lowest operating frequency. If the UE/MS is moved around in the chamber during the measurement, the volume of the reverberation chamber can be reduced. Also, frequency stirring can be used to improve the accuracy, however, this will reduce the resolution of the results correspondingly.

The reverberation chamber can be loaded with lossy objects in order to control the power delay profile in the chamber to some extent. However the reverberation chamber should not be loaded to such an extent that the mode statistics in the chamber are destroyed. It is important to keep the same amount of lossy objects in the chamber during calibration measurement and test measurement, in order not to change the average power transfer function between these two cases. Examples of lossy object are head and hand phantoms.

Furthermore, the DUT must not be closer than 0.5 wavelengths to other electromagnetic reflective objects inside the chamber and 0.7 wavelengths to absorbing objects.

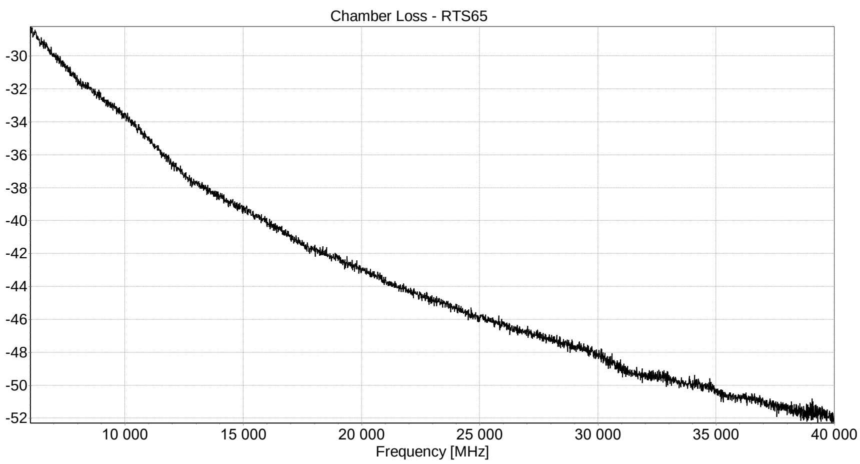

Figure 4.2.1-1 Chamber loss

4.2.2 General Test Methods

The following list of equipment is required to perform related measurements.

- Reverberation chamber
- Radio communication tester
- RF cables (1 cable connecting the radio communication tester to the reverberation chamber for SISO measurements and some cables for 2x2/4x4 MIMO measurements)
- Applicable DUT holder
- Applicable phantoms (e.g. SAM head phantom, hand phantom or laptop phantom)

The UL/DL port of the radio communication tester is connected to the fixed measurement antennas of the RC. Other equipment inside the RC, such as the reference antenna and cables, should be terminated with 50 ohm terminations.

4.2.2.1 Total Radiated Power

Initial Condition:

During the TRP measurement, the mode stirrers/Turntable/measurement will rotate/switch to form a statistically uniform isotropic Rayleigh fading channel environment in a certain space in the reflecting cavity. The turntable carries the object to be rotated and performs multi-point testing in the above space. At least 100 statistically independent power measurement samples are guaranteed.

As in the radiation efficiency measurement, the TRP of the test unit is proportional to the average transferred power in the chamber. Through the calibration measurement, the average power transmission in the chamber is known, and therefore the TRP can be calculated with the following equation:

$$\mathbf{TRP=1/N^*}\sum_{n=1}^{n} P(n) G_{ref} R_{fix} T_{cable}$$

where

P(n) is the power samples in stirrer position n;

N is the total number of stirrer positions;

T_{cable} is the transmission in the cable connecting the power meter to the fixed measurement antenna and G_{ref} and R_{fix} are as defined in the calibration section before. Note that the summation is done on decimal power values, even though the results are normally presented in decibels of measured power (dBm) units.

NOTE： The measurement procedure is based on the measurement of the total power radiated from the DUT to a full 3 dimensional isotropic environment with uniform elevation and azimuth field distribution. The power transmitted by the DUT is undergoing Rayleigh fading and is sampled by the fixed measurement antennas. Moreover, it is important that the samples collected are independent, in order to get sufficient accuracy of the estimated TRP value.

4.2.2.2 Total Istropic Sensitivity

During the TIS measurement, the mode stirrers/Turntable/measurement will rotate/switch to form a statistically uniform isotropic Rayleigh fading channel environment in a certain space in the reflecting cavity. The turntable carries the object to be rotated, and performs multi-point testing in the above space. At least 100 independent sampling points should be tested to ensure the accuracy of the test results. At each sampling point, the receiver performance of the EUT is measured by measuring the minimum forward link power of the EUT at a certain bit error rate, frame error rate or block error rate.

The TIS parameter is calculated by the following equation:

$$\text{TIS}=\left(\frac{1}{N}\sum_{n=1}^{N}\frac{1}{P_{BSS(n)}}\right)^{-1}/G_{ref}R_{fix}T_{cable}$$

where

P(n) is the power samples in stirrer position n;

N is the total number of stirrer positions;

T_{cable} is the transmission in the cable connecting the power meter to the fixed measurement antenna and G_{ref} and R_{fix} are as defined in the calibration section before. Note that the summation is done on decimal power values, even though the results are normally presented in decibels of measured power (dBm) units.

Note: The measurement procedure is based on samples of the received signal power at the DUT from a full 3 dimensional isotropic environment with uniform elevation and azimuth field distribution. The power received by the DUT is undergoing Rayleigh fading and is transmitted by the fixed measurement antennas. Moreover, it is important that the samples collected are independent, in order to get sufficient accuracy of the estimated TIS value.

5 Transmit Performance

5.1 Total Radiated Power

5.1.1 Total Radiated Power for SA UE within FR1

5.1.1.1 Test Configurations

The NR base station simulator is configured in accordance with the parameters defined in 3GPP TS 38.521-1, section 6.2, regarding the maximum output power measurement, and a loopback test mode is established between the EUT and the base station simulator. During the measurement process, the base station simulator transmits a power control command to the EUT as defined in 3GPP TS 38.521-1, section 6.2 to ensure that the EUT transmits at maximum power throughout the measurement process.

5.1.1.2 Test Procedures

The corresponding channel is selected for testing in the frequency band supported by the EUT. Table 5.1.1.2-1 gives an example of the selection of channels on the NR FR1 band. Place the UE into test chamber with appropriate position.

1) Configure NR SS in accordance with the parameters defined in 3GPP TS 38.521-1, section 6.2, regarding to the maximum output power measurement, and the P-max is set to be NULL. Set up the loopback test mode between the EUT and the base station simulator.

2) UE initial cell selection process. UE attach to NR cell. Ensure the UE is in state RRC_CONNECTED without release.

3) SS sends uplink scheduling information for each UL HARQ process via PDCCH DCI format 0_1 for C_RNTI to schedule the UL RMC according to table 5.1.1.2-1 on NR CC. Since the UL has no payload and no loopback data to send the UE sends uplink MAC padding bits on the UL RMC.

4) Send continuously uplink power control "up" commands in uplink scheduling information to the UE; allow at least 200ms starting from the first TPC command in this step for the UE to reach PUMAX level corresponding to the supported Power Class.

5) Measure the TRP according to chapter 4, the measurement period of each test point shall be at least the continuous duration of one active sub-frame.

Note:

1. Above procedures apply when the conditions meets: UE support 1 UL transmission only when transmitting 1 stream data and its power class 2.

2. UE support 2 UL transmission in diversity mode and can be configured as 1Tx by the codebook as $\frac{1}{\sqrt{2}}\begin{bmatrix}1\\0\end{bmatrix}$and $\frac{1}{\sqrt{2}}\begin{bmatrix}0\\1\end{bmatrix}$, and don't support power class 2 during the 1 UL transmission. With this approach, the transmit antenna switch function should be disabled which can guarantee DUT would use different antennas for the following step 4) and 5). The following procedures apply:

   1) Configure NR SS in accordance with the parameters defined in 3GPP TS 38.521-1, section 6.2, regarding to the maximum output power measurement, and the P-max is set to be NULL. Set up the loopback test mode between the EUT and the base station simulator.

   2) UE initial cell selection process. UE attach to NR cell. Ensure the UE is in state RRC_CONNECTED without release.

   3) SS sends uplink scheduling information for each UL HARQ process via PDCCH DCI format 0_1 for C_RNTI to schedule the UL RMC according to table 5.1.1.2-1 on NR CC. Since the UL has no payload and no loopback data to send the UE sends uplink MAC padding bits on the UL RMC.

   4) SS configure the UL codebook as $\frac{1}{\sqrt{2}}\begin{bmatrix}1\\0\end{bmatrix}$ and Send continuously uplink power control "up" commands in uplink scheduling information to the UE; allow at least

200ms starting from the first TPC command in this step for the UE to reach PUMAX level corresponding to the supported Power Class. Measure the TRP according to chapter 4, the measurement period of each test point shall be at least the continuous duration of one active sub-frame.

5) SS configure the UL codebook as $\frac{1}{\sqrt{2}}\begin{bmatrix}0\\1\end{bmatrix}$ and Send continuously uplink power control "up" commands in uplink scheduling information to the UE; allow at least 200ms starting from the first TPC command in this step for the UE to reach PUMAX level corresponding to the supported Power Class. Measure the TRP according to chapter 4, the measurement period of each test point shall be at least the continuous duration of one active sub-frame.

6) Sum up the measurement results in step (4) and (5) as the TRP.

Alternatively, UE support 2 UL transmission in diversity mode and can be configured as 2Tx by the codebook as $\frac{1}{\sqrt{2}}\begin{bmatrix}1 & 0\\0 & 1\end{bmatrix}$. The following procedures apply:Configure NR SS in accordance with the parameters defined in 3GPP TS 38.521-1, section 6.2, regarding to the maximum output power measurement, and the P-max is set to be NULL. Set up the loopback test mode between the EUT and the base station simulator.

1) UE initial cell selection process. UE attach to NR cell. Ensure the UE is in state RRC_CONNECTED without release.

2) SS sends uplink scheduling information for each UL HARQ process via PDCCH DCI format 0_1 for C_RNTI to schedule the UL RMC according to table 5.1.1.2-1 on NR CC. Since the UL has no payload and no loopback data to send the UE sends uplink MAC padding bits on the UL RMC.

3) SS configure the UL codebook as $\frac{1}{\sqrt{2}}\begin{bmatrix}1 & 0\\0 & 1\end{bmatrix}$: and Send continuously uplink power control "up" commands in uplink scheduling information to the UE; allow at least 200ms starting from the first TPC command in this step for the UE to reach PUMAX level corresponding to the supported Power Class. Measure the TRP according to chapter 4, the measurement period of each test point shall be at least the continuous duration of one active sub-frame.

4) Measure the TRP according to chapter 4, the measurement period of each test point shall be at least the continuous duration of one active sub-frame.

3. For UE don't apply for any of above condition, the measurement procedures are FFS.

Table 5.1.1.2-1 channel list of NR FR1 SA RF radiated power test

Band	Uplink/	Channel	Subcarrier	Uplink	Carrier	Uplink RB	Down linking

	downlink channel	bandwidth / MHz	spacing (kHz)	modulation format	frequency (MHz)	Configuration	RB configuration
Band n41	513000	100	30	DFT-s-OFDM QPSK	2565	24@12	273@0
	519000				2595	24@125	273@0
	525000				2625	24@237	273@0
Band n79	723334				4850.01	24@12	273@0
						24@125	273@0
						24@ 237	273@0
Note 1: Band n41 and n79 uplink reference channel configurations are referred to Table 5.1.1.2-2.							

Table 5.1.1.2-2 uplink reference channel configuration for n41 and n79 radiated power test

Parameters	Configuration
Channel bandwidth	100MHz
Subcarrier spacing	30KHz
Allocated resource blocks	24
DFT-s-OFDM Symbols per slot	11
Modulation	QPSK
MCS index	2
Target Coding Rate	1/6
Payload size for slots 8, 9, 18 and 19	1192bits
Transport block CRC	16bits
LDPC Base Graph	16
Number of code blocks per slot for slots 8, 9, 18 and 19	1
Total number of bits per slot for slots 8, 9, 18 and 19	6336bits
Total modulated symbols per slot for slots 8, 9, 18 and 19	3168
Note: The PUSCH adopts a mapping type Type-A, and the DMRS adopts a single symbol DMRS configuration Type-1 and two DMRS symbols, and thus the DMRS symbols are located in OFDM symbol bits 2, 7, and 11. The DMRS symbol and the PUSCH data are transmitted in a TDM manner.	

Table 5.1.1.2-3 Downlink reference channel configuration for n41 and n79 radiated power test

Parameter	Unit	
Channel bandwidth	MHz	100
Subcarrier spacing configuration μ		1
Allocated resource blocks		273
Subcarriers per resource block		12
Allocated slots per Frame		13
MCS Index		4
Modulation		QPSK
Target Coding Rate		1/3
Maximum number of HARQ transmissions		1
Information Bit Payload per Slot		
For Slots 0 and Slot i, if mod(i, 10) = {7,8,9} for i from {0,…,19}	Bits	N/A
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,6} for i from {1,…,19}	Bits	17928
Transport block CRC	Bits	24
LDPC base graph		1
Number of Code Blocks per Slot		
For Slots 0 and Slot i, if mod(i, 10) = {7,8,9} for i from {0,…,19}	CBs	N/A
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,6} for i from {1,…,19}	CBs	3
Binary Channel Bits per Slot		
For Slots 0 and Slot i, if mod(i, 10) = {7,8,9} for i from {0,…,19}	Bits	N/A
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,6} for i from {1,…,19}	Bits	58968
Max. Throughput averaged over 1 frame	Mbps	23.306
Note 1:Additional parameters are specified in Table 3GPP TS 38.101-1 A.3.1-1 and Table A.3.3.1-1. Note 2:If more than one Code Block is present, an additional CRC sequence of L = 24 Bits is attached to each Code Block (otherwise L = 0 Bit) Note 3:SS/PBCH block is transmitted in slot #0 of each frame. Note 4:Slot i is slot index per frame.		

5.1.1.3 Test Requirements

The RF radiated power measurement should be included in all possible practical applications of the EUT (such as free space, head and hand phantom) and the main mechanical mode supported by the EUT (such as the expansion or folding of the folding screen phone). See The average and minimum values of the NR FR1 independent network TRP measurements of all test channels of the EUT in the specified frequency band shall not be lower than the corresponding limits in Table 5.1.1.3-1.

Table 5.1.1.3-1 Requirement for the NR FR1 SA TRP test for power class 2 UE

Performance Requirements	**Band n41 TRP / dBm**					
	Free space		**Head and hand phantom**		**Hand phantom only**	
	Avg.	**Min.**	**Avg.**	**Min.**	**Avg.**	**Min.**
Maximum output power for Class A, Class B, Class C (except wearable devices)	[19.5]	[18.5]	[15.5]	[14.5]	[17]	[16]
Maximum output power for Class C (wearable device)	TBD	TBD	TBD	TBD	TBD	TBD
Maximum output power for Class E (tablet)	[19.5]	[18.5]	NA	NA	TBD	TBD
Maximum output power for Class D, Class E (except Tablet)	[19.5]	[18.5]	NA	NA	NA	NA

Performance Requirements	**Band n79 TRP / dBm**					
	Free space		**Head and hand phantom**		**Hand phantom only**	
	Avg.	**Min.**	**Avg.**	**Avg.**	**Min.**	**Avg.**
Maximum output power for Class A, Class B, Class C (except wearable devices)	[19.5]	[18.5]	[15.5]	[14.5]	[17]	[16]
Maximum output power for Class C (wearable device)	TBD	TBD	TBD	TBD	TBD	TBD
Maximum output power for Class E (tablet)	[19.5]	[18.5]	NA	NA	TBD	TBD
Maximum output power for Class D, Class E (except Tablet)	[19.5]	[18.5]	NA	NA	NA	NA

5.1.2 Total Radiated Power for NSA UE within FR1

5.1.2.1 Test Configurations

The test configurations consist of environmental conditions, test frequencies, channel bandwidths and EN-DC operating bands.

Set the E-UTRA system simulator according to TS 36.521-1 and set the NR system simulator according to 3GPP TS 38.521-1, except for the following description:

Table 5.1.2.1-1: PhysicalCellGroupConfig

Derivation Path: 3GPP TS 38.508-1, Table 4.6.3-106			
Information Element	**Value/remark**	**Comment**	**Condition**
PhysicalCellGroupConfig ::= SEQUENCE {			
p-NR-FR1	Not present	Apply if Power Class 3 UE	
}			

Table 5.1.2.1-2: *RRCConnectionReconfiguration:* nr-Config-r15

Derivation Path: 3GPP TS 36.508, Table 4.6.1-8			
Information Element	**Value/remark**	**Comment**	**Condition**
p-MaxEUTRA-r15	Not present	Apply if run test points with E-UTRA UL transmission not overlapping with NR UL transmission in time for PC3 UE	
	20	Apply if run test points with E-UTRA UL transmission overlapping with NR UL transmission in time for PC3 UE	

The band combinations and test channels for EN-DC with 1 LTE band and 1 FR1 NR band are shown as Table 5.1.2.1-3.

The configurations of NR cell and LTE cell are specified in Table 5.1.2.1-2 and Table 5.1.2.1-3 separately.

Table 5.1.2.1-3 Band combinations and test channels for EN-DC TRP test

EN-DC band combination	**LTE UL Channel**		**NR UL Channel**	
	ARFCN	**Fc**	**NR-ARFCN**	**Fc**
DC_3_n41	19300	1720	513000	2565
	19575	1747.5	519000	2595
	19850	1775	525000	2625
DC_39_n41	38350	1890	513000	2565
	38450	1900	519000	2595
	38550	1910	525000	2625
DC_3_n79	19300	1720	723334	4850.01
	19575	1747.5		
	19850	1775		

DC_39_n79	38350	1890	723334	4850.01
	38450	1900		
	38550	1910		
Note: The detail configurations of E-UTRA and NR cell are specified in Table 5.1.2.1-4 and Table 5.1.2.1-5.				

Table 5.1.2.1-4 Test configurations of NR cell

NR Band	ARFCN	Channel Band width / MHz	SCS (kHz)	Modulation	Fc (MHz)	UL RB	DL RB
Band n41	513000	100	30	DFT-s-OFDM QPSK	2565	24@12	273@0
	519000				2595	24@125	273@0
	525000				2625	24@237	273@0
Band n79	723334				4850.01	24@12	273@0
						24@125	273@0
						24@237	273@0
Note： The Uplink Reference measurement channel refers to Table 5.1.1.1- 4							

Table 5.1.2.1-5 channel list of E-UTRA cell

Band	Uplink channel	Carrier frequency（MHz）	Channel bandwidth (MHz)	Subcarrier spacing（kHz）	Uplink modulation format	Uplink RB Configuration	Down linking RB configuration
Band 3	19300	1720	20	15	QPSK	18@0	100@0
	19575	1747.5					
	19850	1775					
Band 39	38350	1890					
	38450	1900					
	38550	1910					
Note： The Uplink Reference measurement channel refers to 3GPP TS 36.521-1 6.2.							

5.1.2.2 Test Procedures

1) Place the UE into test chamber with appropriate position.

2) Configure E-UTRA and NR system simulator(SS) in accordance with the parameters defined in clause 5.1.2.1. Set up the loopback test mode between the EUT and the base station simulator.

3) UE initial cell selection process. UE attach to E-UTRA cell and then attach to NR cell. Ensure the UE is in state RRC_CONNECTED with generic procedure parameters Connectivity EN-DC, DC bearer MCG and SCG, Connected without release.

4) SS sends uplink scheduling information for each UL HARQ process via PDCCH DCI format 0 and DCI format 0_1 for C_RNTI to schedule the UL RMC according to Table 5.1.2.1-1 on E-UTRA CC and NR CC. Since the UL has no payload and no loopback data to send the UE sends uplink MAC padding bits on the UL RMC.

5) Send continuously uplink power control "up" commands in every uplink scheduling information to the UE; allow at least 200ms starting from the first TPC command in this step for the UE to reach PUMAX level corresponding to the supported Power Class.

6) Measure the TRP over all EN-DC components according to chapter 4, the measurement period of each test point shall be at least the continuous duration of one active sub-frame.

5.1.2.3 Test Requirements

The Total Radiated Power (TRP) for the DC configuration, derived in step 8 shall be within the range prescribed in below tables.

Table 5.1.2.3-1: TRP requirements for EN-DC combinations for power class 3 UE

Performance Requirements	**EN-DC_3_41**					
	Free space		**Head and hand phantom**		**Hand phantom only**	
	Total	**Gap**	**Total**	**Gap**	**Total**	**Gap**
Maximum output power for Class A, Class B, Class C (except wearable devices)	[16.5]	TBD	[12.5]	TBD	[14]	TBD
Maximum output power for Class C (wearable device)	TBD	TBD	TBD	TBD	TBD	TBD
Maximum output power for Class E (tablet)	[16.5]	TBD	NA	NA	TBD	TBD
Maximum output power for Class D, Class E (except Tablet)	[16.5]	TBD	NA	NA	NA	NA
Performance Requirements	**EN-DC_39_41**					
	Free space		**Head and hand phantom**		**Hand phantom only**	
	Total	**Gap**	**Total**	**Gap**	**Total**	**Gap**
Maximum output power for Class A, Class B, Class C (except wearable devices)	[16.5]	TBD	[12.5]	TBD	[14]	TBD
Maximum output power for Class C (wearable device)	TBD	TBD	TBD	TBD	TBD	TBD
Maximum output power for Class E (tablet)	[16.5]	TBD	NA	NA	TBD	TBD

Maximum output power for Class D, Class E (except Tablet)	[16.5]	TBD	NA	NA	NA	NA
Performance Requirements	**EN-DC_3_79**					
	Free space		**Head and hand phantom**		**Hand phantom only**	
	Total	**Gap**	**Total**	**Gap**	**Total**	**Gap**
Maximum output power for Class A, Class B, Class C (except wearable devices)	[16.5]	TBD	[12.5]	TBD	[14]	TBD
Maximum output power for Class C (wearable device)	TBD	TBD	TBD	TBD	TBD	TBD
Maximum output power for Class E (tablet)	[16.5]	TBD	NA	NA	TBD	TBD
Maximum output power for Class D, Class E (except Tablet)	[16.5]	TBD	NA	NA	NA	NA
Performance Requirements	**EN-DC_39_79**					
	Free space		**Head and hand phantom**		**Hand phantom only**	
	Total	**Gap**	**Total**	**Gap**	**Total**	**Gap**
Maximum output power for Class A, Class B, Class C (except wearable devices)	[16.5]	TBD	[12.5]	TBD	[14]	TBD
Maximum output power for Class C (wearable device)	TBD	TBD	TBD	TBD	TBD	TBD
Maximum output power for Class E (tablet)	[16.5]	TBD	NA	NA	TBD	TBD
Maximum output power for Class D, Class E (except Tablet)	[16.5]	TBD	NA	NA	NA	NA

Note 1: Unless otherwise stated, for a specific inter-band EN-DC comb, if a UE indicates support of dynamicPowerSharing in the *UE-MRDC-Capability* IE and Single UL allowed is “NO” according to TS 38.521-3 Clause 5.2B.4, run test points with E-UTRA UL transmission overlapping NR UL transmission in time; ohtherwise, run test points with E-UTRA UL transmission not overlapping with NR UL transmission in time. Actually sometimes UE don’t support dynamic powersharing and TDM-pattern, and it will transmit E-UTRA UL overlapping with NR UL in time, UE behave like this also run test points with E-UTRA UL transmission overlapping NR UL transmission in time.

Note 2: If run test points with E-UTRA UL transmission not overlapping with NR UL transmission in time for PC3 UE, the total TRP requirements applied as the TRP requirement of LTE link and NR link separately, and no Gap requirements.

6 Receive Performance

6.1 Total Isotropic Sensitivity

6.1.1 Total Isotropic Sensitivity for SA UE within FR1

6.1.1.1 Test Configurations

The test channel is listed in Table 6.1.1.1-1 and the detail configuration of the RMC and the SS refers to 3GPP TS 38.521-1 section 7.3.

Table 6.1.1.1- 1 channel list of NR FR1 SA RF TIS test

Band	Uplink/ downlink channel	Channel bandwidth / MHz	Subcarrier spacing (kHz)	Carrier frequency (MHz)	Uplink RB Configuration	Down linking RB configuration
Band n41	513000	100	30	2565	270@0	273@0
	525000			2625		
Band n79	723334			4850.01		

Table 6.1.1.1- 2: Test Configuration Table

Initial Conditions				
Test Parameters				
Test ID	Downlink Configuration		Uplink Configuration	
	Modulation	RB allocation	Modulation	RB allocation
1	CP-OFDM QPSK	273@0	DFT-s-OFDM QPSK	270@0

6.1.1.2 Test Procedures

The corresponding channel is selected for testing in the frequency band supported by the EUT. Table 6.1.1.1-1 gives an example of the selection of channels on the NR FR1 band. Place the UE into test chamber with appropriate position.

1) SS transmits PDSCH via PDCCH DCI format [1_1] for C_RNTI to transmit the DL RMC according to table 6.1.1.1-1 and 6.1.1.1-2.

2) SS sends uplink scheduling information for each UL HARQ process via PDCCH DCI format [0_1] for C_RNTI to schedule the UL RMC according to Table 6.1.1.1-1 and 6.1.1.1-2.

3) Send continuously uplink power control "up" commands in the uplink scheduling information to the UE to ensure the UE transmits PUMAX level for at least the duration of the Throughput measurement.

4) Ensure that the initial BLER of the EUT is zero, while ensuring equal power on each RB. If a test point cannot establish a connection, you can increase the downstream power to establish or maintain a connection. The BLER measurement is initiated and

the amount of data measured should be sufficient to make the BLER test result have a confidence probability higher than 95% and a minimum of 20,000 transport blocks.

5) Reduce the power of NR cell until the EUT throughput drops to 95% of the maximum throughput, and record the minimum value at which the NR carrier throughput no less than 95% as the EIS of this direction. When the current link power is close to the NR sensitivity level, the power down step of the base station simulator should be no more than 0.5 dB.

6.1.1.3 Test Requirements

The receiver sensitivity measurements should be included in all possible practical application scenarios of the EUT (e.g. free space, head phantom, etc.) and in the main mechanical mode supported by the EUT (e.g. expansion or folding of a folding screen phone). All channels were tested with the flip open, slide open state of the slide EUT and antenna pull-out status of the EUT. The average and maximum values of the NR FR1 independent networking TIS measurements for all channels of the EUT over the specified frequency band shall not be higher than the corresponding limits in Table 6.1.1.3- 1.

Table 6.1.1.3- 1 4Rx TIS requirement for the NR FR1 band

Performance Requirements	**Band n41 TIS / dBm**					
	Free space		**Head and hand phantom**		**Hand phantom only**	
	Avg.	**Min.**	**Avg.**	**Min.**	**Avg.**	**Min.**
Maximum output power for Class A, Class B, Class C (except wearable devices)	[-82]	[-81]	[-79]	[-78]	[-80.5]	[-79.5]
Maximum output power for Class C (wearable device)	TBD	TBD	TBD	TBD	TBD	TBD
Maximum output power for Class E (tablet)	[-82]	[-81]	NA	NA	TBD	TBD
Maximum output power for Class D, Class E (except Tablet)	[-82]	[-81]	NA	NA	NA	NA
Performance Requirements	**Band n79 TIS / dBm**					
	Free space		**Head and hand phantom**		**Hand phantom only**	
	Avg.	**Min.**	**Avg.**	**Avg.**	**Min.**	**Avg.**
Maximum output power for Class A, Class B, Class C (except wearable devices)	[-82]	[-81]	[-79]	[-78]	[-80.5]	[-79.5]
Maximum output power for Class C (wearable device)	TBD	TBD	TBD	TBD	TBD	TBD

Maximum output power for Class E (tablet)	[-82]	[-81]	NA	NA	TBD	TBD
Maximum output power for Class D, Class E (except Tablet)	[-82]	[-81]	NA	NA	NA	NA

6.1.2 Total Isotropic Sensitivity for NSA UE within FR1

6.1.2.1 Test Configurations

The test channel is listed in Table 6.1.1.1-1 and the detail configuration of the RMC and the SS refers to 3GPP TS 38.521-3 section 7.3.

Table 6.1.2.1- 1 channel list of FR1 NSA TIS test

EN-DC Combination	LTE ARFCN	LTE DL Carrier/MHz	NR-ARFCN	NR DL Carrier/MHz
DC_3_n41	1300	1815	513000	2565
	1850	1870	525000	2625
DC_3_n79	1300	1815	723334	4850.01
	1575	1842.5		
	1850	1870		
DC_39_n41	38350	1890	513000	2565
	38550	1910	525000	2625
DC_39_n79	38350	1890	723334	4850.01
	38450	1900		
	38550	1910		
Note 1: LTE carrier is configured as Table 6.1.2.1-2, and the reference channel is configured as 3GPP TS 38.523-1 clause 7.3. Note 2: NR carrier is configured as clause 6.1.1.				

Table 6.1.2.1- 2: LTE band Configuration

	Downlink Configuration			Uplink Configuration		
Ch BW	Mod'n	RB allocation		Mod'n	RB allocation	
		FDD	TDD		FDD	TDD
20MHz	QPSK	100	100	QPSK	100	100

6.1.2.2 Test Procedures

The corresponding channel is selected for testing in the frequency band supported by the EUT. Table 6.1.2.1-1 gives an example of the selection of channels on the NR FR1 band. Place the UE into test chamber with appropriate position.

1) Place the UE into test chamber with appropriate position.

2) UE attach to LTE cell. Set up NR cell and UE attach to LTE cell.

3) Ensure the UE is in state RRC_CONNECTED with generic procedure parameters

Connectivity EN-DC, DC bearer MCG and SCG.

4) NR SS sends uplink scheduling information for each UL HARQ process via PDCCH DCI format 0 and DCI format [0_1] for C_RNTI to schedule the UL RMC according to Table 6.1.2.1-1 on both EN-DC component carriers. Since the UL has no payload and no loopback data to send the UE sends uplink MAC padding bits on the UL RMC.

5) E-UTRA SS sends uplink scheduling information for each UL HARQ process via PDCCH DCI format 0 for C_RNTI to schedule the UL RMC according to Table 6.1.2.1-1. Since the UE has no payload data to send, the UE transmits uplink MAC padding bits on the UL RMC.

6) Send continuously uplink power control "up" commands in the uplink scheduling information to both carriers to ensure the UE transmits P_{UMAX} level for at least the duration of the Throughput measurement.

7) Ensure that the initial BLER of the EUT is zero, while ensuring equal power on each RB. If a test point cannot establish a connection, you can increase the downstream power to establish or maintain a connection. The BLER measurement is initiated and the amount of data measured should be sufficient to make the BLER test result have a confidence probability higher than 95% and a minimum of 20,000 transport blocks.

8) Reduce the power of NR cell until the EUT throughput drops to 95% of the maximum throughput, and record the minimum value at which the NR carrier throughput no less than 95% as the EIS of this direction. Reduce the power of LTE cell until the EUT throughput drops to 95% of the maximum throughput, and record the minimum value at which the LTE carrier throughput no less than 95% as the EIS of this direction. Noted that when the current link power is close to the sensitivity level, the power down step of the base station simulator should be no more than 0.5 dB.

9) Rotate the EUT and complete the LTE and NR EIS measurements towards all required directions and calculate the TIS of LTE and NR link separately.

6.1.2.3 Test Requirements

The TIS requirements of NR link refers to Table 6.1.1.3-1 and LTE link are specified in Tables 6.1.2.3-1. Note that

Table 6.1.2.3-1 2Rx TIS requirement of the LTE link forLTE link

Performance Requirements	**Band 3 TIS / dBm**					
	Free space		**Head and hand phantom**		**Hand phantom only**	
	Avg.	**Min.**	**Avg.**	**Avg.**	**Min.**	**Avg.**
Maximum output power for Class A, Class B, Class C (except	[-88]	[-87]	[-85]	[-84]	[-86.5]	[-85.5]

wearable devices)						
Maximum output power for Class C (wearable device)	TBD	TBD	TBD	TBD	TBD	TBD
Maximum output power for Class E (tablet)	[-88]	[-87]	NA	NA	TBD	TBD
Maximum output power for Class D, Class E (except Tablet)	[-88]	[-87]	NA	NA	NA	NA

Performance Requirements	**Band 39 TIS / dBm**					
	Free space		**Head and hand phantom**		**Hand phantom only**	
	Avg.	**Min.**	**Avg.**	**Avg.**	**Min.**	**Avg.**
Maximum output power for Class A, Class B, Class C (except wearable devices)	[-88]	[-87]	[-85]	[-84]	[-86.5]	[-85.5]
Maximum output power for Class C (wearable device)	TBD	TBD	TBD	TBD	TBD	TBD
Maximum output power for Class E (tablet)	[-88]	[-87]	NA	NA	TBD	TBD
Maximum output power for Class D, Class E (except Tablet)	[-88]	[-87]	NA	NA	NA	NA

Appendix A UE Classification

TableA.1 Terminal classification and test status specification list

Equipment type			describe	Test state
Portable wireless terminal	Class A	Handheld portable wireless terminal that only supports voice	The handheld wireless terminal includes a wireless module which only supports voice.	Free space, Head and hand
	Class B	Handheld portable wireless terminal that only supports data	The handheld wireless terminal includes a wireless module which only supports data.	Free space, Hand only
	Class C	Handheld portable wireless terminal supporting voice and data	Its handheld wireless terminal includes wireless modules supporting voice and data.	Free space, head and hand, hand only
Wireless data terminal	Class D	Laptop mounted equipment	The terminal can't work independently, such as plug-in devices like USB dongles	Free space (laptop ground plane model)
	Class E	Laptop embedded equipment	Embedded module card embedded in terminals, such as tablet, and portable broadband wireless device (MiFi).	Free space

Appendix B Measurement Uncertainty

Appendix C Void

Appendix D Document Change Record

Date	Meeting #	Version	Revision Contents
2019-11-18	#26 workshop	1.0	New draft
2020-07-27	#28 workshop	2.0	Typical methods in Anechoic Chamber are added in section 4; Test Procedures are updated in section 5.1.1.2.