Application Note

5G NEW RADIO OVER-THE-AIR BASE STATION TRANSMITTER TESTS

Radiated conformance testing according to TS 38.141-2, Rel. 16

Products:

- R&S®TS8991 with WPTC
- R&S®ATS1800C
- R&S®PWC200
- R&S®FSW
- R&S®FSV(A)3000
- R&S®FSV(A)
- R&S®SMW200A
- R&S®SMBV100B

Christian Wicke, Fabian Bette | GFM324 | Version 1e | 06.2020

https://www.rohde-schwarz.com/appnote/GFM324

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Contents

1 Introduction

The 5th generation (5G) of mobile networks introduces a paradigm shift towards a user and application centric technology framework.

The goal of 5G New Radio (NR) is to flexibly support three main service families:

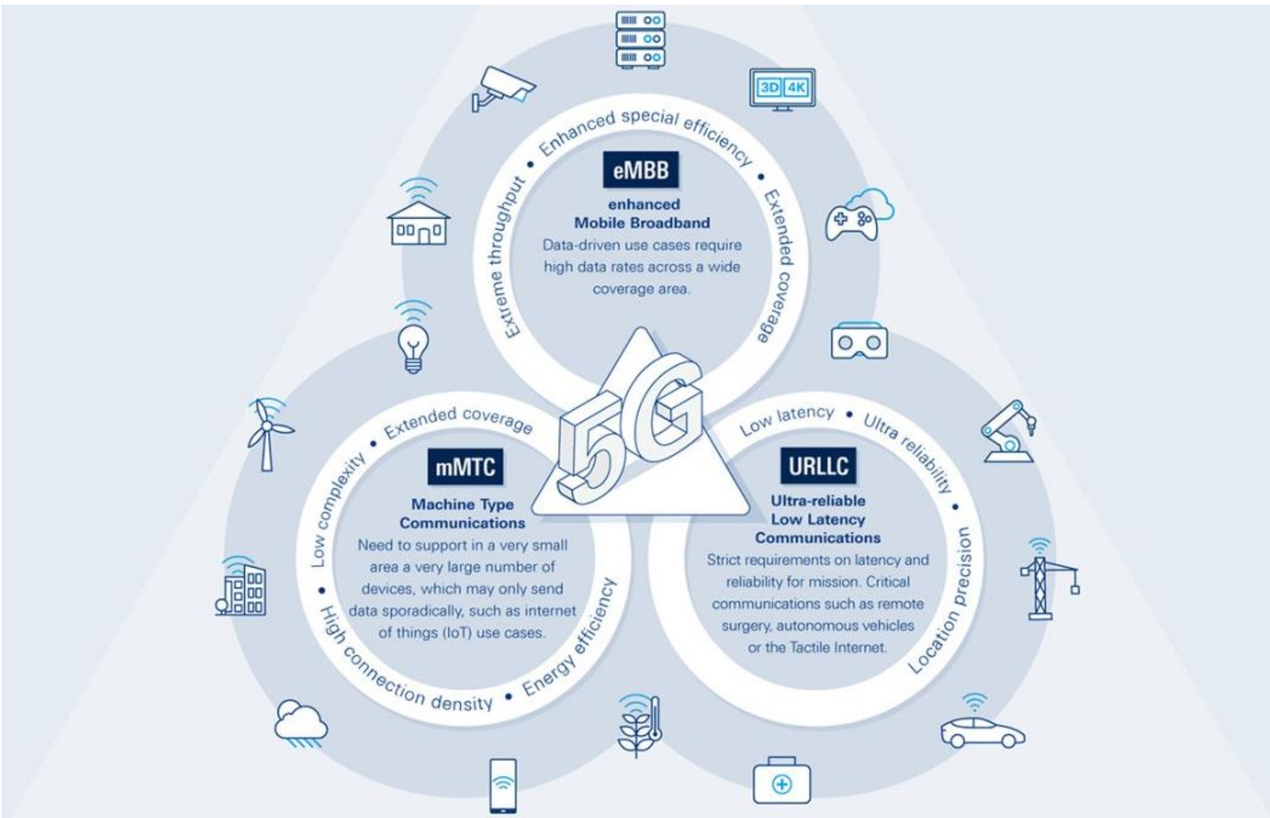


Figure 1: 5G New Radio main service families

► Enhanced mobile broadband (eMBB) for higher end-user data rates

► Massive machine type communications (mMTC) targets cost-efficient and robust D2X connections

► Ultra-reliable, low latency communications (URLLC) supporting new requirements from vertical industries such as autonomous driving, remote surgery or cloud robotics

3GPP, the responsible standardization body, defines the Radio Frequency (RF) conformance test methods and requirements for NR Base Stations (BS) in the technical specifications TS 38.141 which covers transmitter (Tx), receiver (Rx) and performance (Px) testing.

The technical specification **TS 38.141** consists of two parts depending on whether the test methodology has conducted or radiated requirements:

► **TS 38.141-1: Part 1** [1]: Conducted conformance testing

► **TS 38.141-2: Part 2** [2]: Radiated conformance testing

This application note describes all mandatory **RF transmitter tests (TS 38.141-2, chapter 6)**, according to Release 16 (V16.3.0). Furthermore, chapter 4 of this document provides a brief introduction about the different R&S OTA antenna test solutions and how they're applicable for base station conformance testing. Rohde & Schwarz offers suitable solutions for any test case that is mentioned in this application note.

Generally, each chapter is structured in three sections:
First, a short introduction at the beginning of a chapter is covering the scope of the individual test case. Next, there comes a step-by-step description of the testing procedure showing the necessary testing parameters and a schematic test setup.

Hereinafter, Table 1 gives an overview of all 5G base station transmitter tests covered individually in this document.

Table 1: OTA transmitter tests

Chapter TS 38.141-2	Test	Single Carrier (SC)	Multi Carrier (MC)
6.2	Radiated transmit power	✓	✗
6.3	OTA base station output power	✓	✗
6.4.2	OTA RE power control dynamic range	✓	✗
6.4.3	OTA total power dynamic range	✓	✗
6.5.1	OTA transmitter OFF power	✓	✗
6.5.2	OTA transmitter transient period	✓	✗
6.6.2	OTA frequency error	✓	✗
6.6.3	OTA modulation quality	✓	✗
6.6.4	OTA time alignment error	✓	✗
6.7.2	OTA occupied bandwidth	✓	✗
6.7.3	OTA Adjacent channel leakage power ratio (ACLR)	✓	✗
6.7.4	OTA operating band unwanted emissions	✓	✗
6.7.5.2	General OTA transmitter spurious emissions	✓	✗
6.7.5.3	OTA transmitter spurious emissions - Protection of the base station receiver of own or different base station	✓	✗
6.7.5.4	OTA transmitter spurious emissions - Additional spurious emissions requirements	✓	✗
6.7.5.5	OTA transmitter spurious emissions - Co-location requirements	✓	✗
6.8	OTA transmitter intermodulation	✓	✗

Note: this document covers single carrier (SC) tests only.

Base station (RF) receiver tests (TS 38.141-2, chapter 7) are described in GFM325

For further reading

Find a more detailed overview of the technology behind 5G New Radio from this Rohde & Schwarz book [3] and www.rohde-schwarz.com/5G.

2 General Test Conditions

2.1 Safety indication

VERY HIGH OUTPUT POWERS CAN OCCUR ON BASE STATIONS. MAKE SURE TO USE SUITABLE ATTENUATORS IN ORDER TO PREVENT DAMAGE TO THE TEST EQUIPMENT.

2.2 Base station classes and configurations

The minimum RF characteristics and performance requirements for 5G NR in-band base stations are generally described in 3GPP document TS 38.104 [4].

2.2.1 Base station reference points

This application note covers radiated measurements only. In [1] and [4] two different base station types are defined for frequency range one (FR1) and two (FR2). Radiated requirements are also referred to as OTA requirements.

2.2.2 BS type 1-O and 2-O (FR1, FR2, radiated)

For base station type 1-O and 2-O the radiated characteristics are defined over the air where the OTA interface is referred to as Radiated Interface Boundary (RIB). Co-location requirements are specified at the conducted interface of the co-location reference antenna.

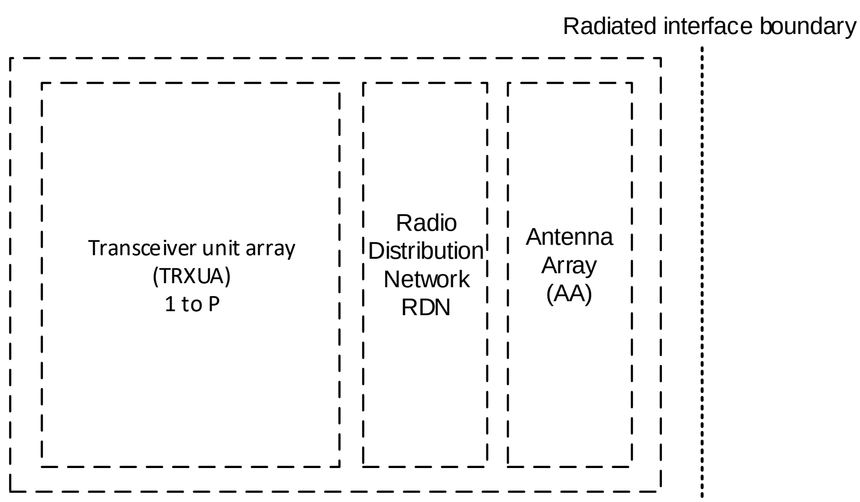


Figure 2: Radiated reference points for BS type 1-O and BS type 2-O [2]

2.2.3 BS type 1-H (FR1, hybrid)

This base station type has two reference points fulfilling both radiated and conducted requirements.

Conducted characteristics are defined at the transceiver array boundary (TAB) which is the conducted interface between the transceiver unit array and the composite antenna equipped with connectors for conducted measurements. The specific requirements and test cases are defined in TS 38.141-1 [1].

Furthermore, the specific conducted measurements are described in extra Rohde & Schwarz application notes [5], [6] and [7].

Radiated characteristics are defined over-the air (OTA) and to be measured at the radiated interface boundary (RIB). The specific requirements and test cases are defined in TS 38.141-2 [2]. This application note applies to radiated measurements only at the RIB.

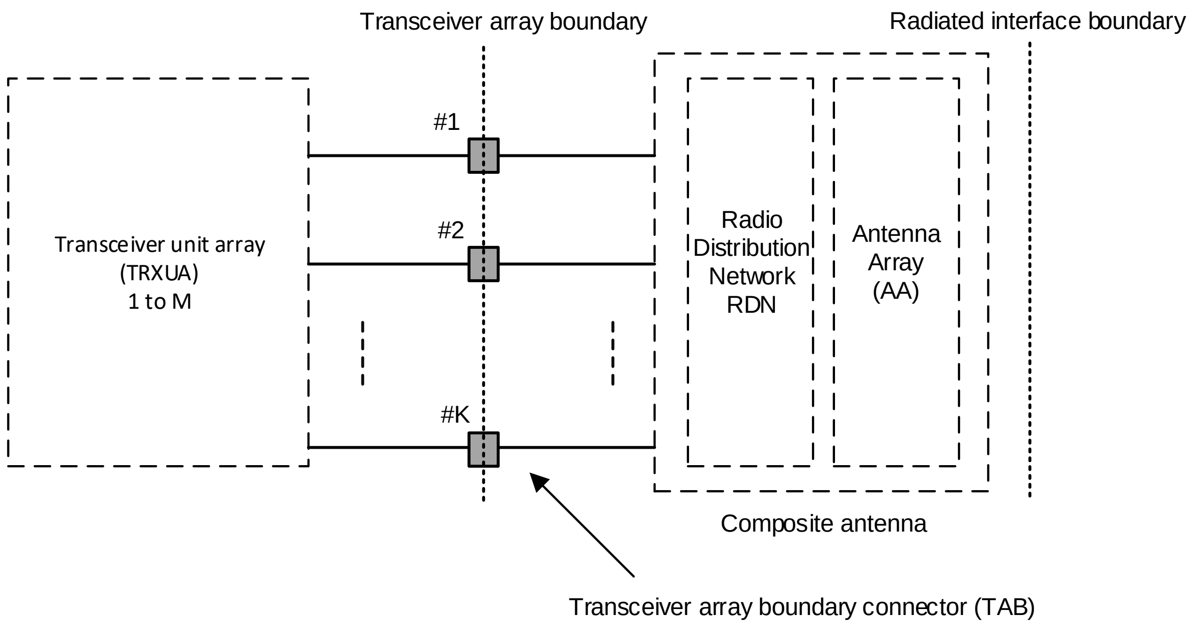


Figure 3: Radiated and conducted reference points for BS type 1-H [2]

2.2.4 BS classes (TS 38.104, chapter 4.4)

The specification distinguishes base station classes by BS type 1-O and 2-O and BS type 1-H.

Table 2: Base station classes - BS to UE minimum distance along the ground

Base station type	Name	Cell size	Minimum distance along the ground
BS type 1-O and BS type 2-O	Wide area	Macro cell	35 m
	Medium range	Micro cell	5 m
	Local area	Pico cell	2 m

Table 3: Base station classes - BS to UE minimum distance along the ground

Base station type	Name	Cell size	Minimum coupling loss
BS type 1-H	Wide area	Macro cell	70 dB
	Medium range	Micro cell	53 dB
	Local area	Pico cell	45 dB

2.3 5G NR frequency ranges

The frequency ranges in which 5G NR can operate according to Release 16 (V16.3.0) specifications are shown in Table 4.

Table 4: Frequency ranges [4], chapter 5

Frequency range designation	Corresponding frequency range
FR1	410 MHz - 7125 MHz
FR2	24250 MHz - 52600 MHz

2.4 R&S devices and options

For OTA base station transmitter tests the following Rohde & Schwarz antenna test solutions can be used:

- R&S®TS8991 OTA Performance Test System with WPTC test chamber **(FR1, FR2)**
- R&S®ATS1800C CATR based 5G NR mmWave test chamber **(FR2)**
- R&S®PWC200 Plane wave converter (shielded in a WPTC test chamber, opt.) **(FR1)**

Any of the following Rohde & Schwarz signal and spectrum analyzers can be used for the tests described in this document:

- R&S®FSW
- R&S®FSV and R&S®FSVA
- R&S®FSV3000 and R&S®FSVA3000
- R&S®FPS

Furthermore, the **5G NR Downlink Measurements** software option is needed:

- R&S®FSW-/FSV-/FSV3-/FPS-K144

For further information on R&S signal and spectrum analyzers, please see:

https://www.rohde-schwarz.com/signal-spectrum-analyzers

The **OTA Transmitter Intermodulation** test case (6.8) requires an additional interfering signal. This interferer can be generated by any of the following Rohde & Schwarz vector signal generators equipped with **-K144 5G NR software option**:

- R&S®SMW200A
- R&S®SMBV100B

For demonstration purposes any of these signal generators mentioned before can be used to simulate a 5G NR base station as well. However, please keep in mind that the maximum upper frequency of a specific generator model may not be sufficient to providing all NR operating bands in FR2 specified by today. In that case, please also consider applicable frequency up-converters.

For further information on R&S signal generators, please see:

https://www.rohde-schwarz.com/signalgenerators

The following test equipment and abbreviations are used in this application note:

- R&S R&S®TS8991 OTA performance test system is referred to as the **TS8991**
- R&S®ATS1800C CATR based 5G NR mmWave test chamber is referred to as the **ATS1800C**
- R&S®PWC200 Plane wave converter is referred to as the **PWC200**
- R&S®FSW spectrum analyzer is referred to as the **FSW**
- R&S®SMW200A vector signal generator is referred to as the **SMW**

2.5 Reference coordinate system

For radiated test setups a reference coordinate system is required. The reference coordinate system should be associated to an identifiable physical feature on the base station enclosure.

The reference coordinate system is created of a cartesian coordinate system with rectangular axis x,y,z and spherical angles θ, φ as showed in Figure 4.

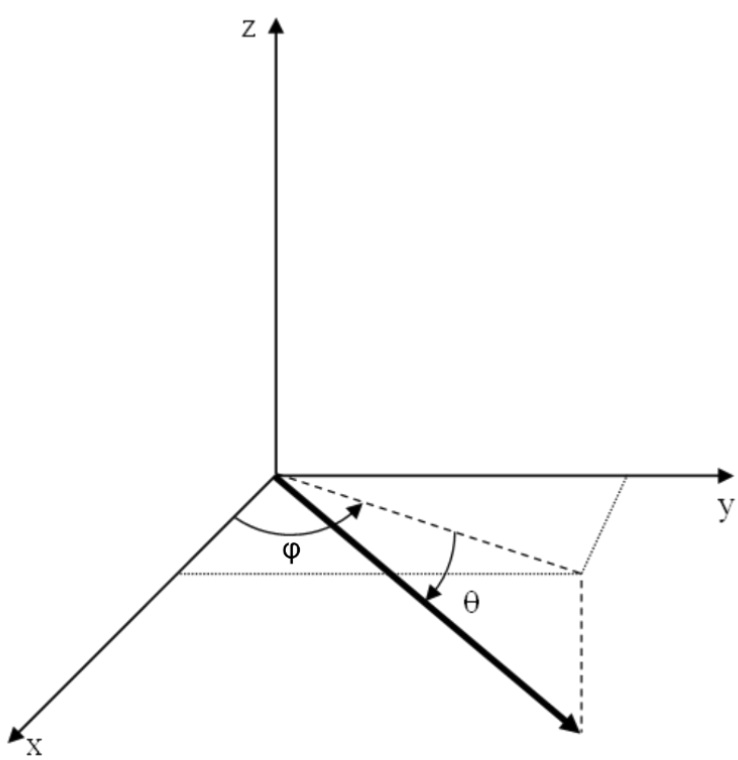


Figure 4: Reference coordinate system [2]

3 Basics about OTA testing

3.1 OTA Calibration

In order to carry out accurate measurements, the OTA system must be calibrated prior to perform the tests. For this purpose, the user defined frequency response correction options SMW-K544 and the FSW-K544 are used. More information about these software options can be found in [8] and [9].

The system loss (cable losses, antennas losses, OTA losses, etc.) is measured with a CW signal, which is swept over the frequency. For every frequency step the received power is measured and an attenuation table is created:

For further reading

► Rohde & Schwarz, Demystifying over-the-air (OTA) testing - White paper, 2019

► Demystifying 5G – System calibration basics for over-the-air (OTA) testing (video content)

► Demystifying 5G – Calibrating OTA test systems using gain transfer method (video content)

3.2 Effective isotropic radiated power (EIRP)

The EIRP denotes the absolute output power in a given direction. If no direction is defined, the direction of maximum radiation intensity is implied. The EIRP is the power an ideal isotropic radiator requires as input power to achieve the same power density in the given direction. EIRP is the power accepted by the antenna multiplied by the antenna gain, or radiated power multiplied by the directivity [10]:

$$EIRP = P_{in} \cdot G$$

$$EIRP_{dBm} = P_{in,dBm} + G_{dBi}$$

The following testcases are performed using EIRP measurement:

► 6.2 Radiated transmit power

► 6.5.1 OTA transmitter OFF power (EIRP in beam peak)

► 6.5.2 OTA transmitter transient period

3.3 Total radiated power (TRP)

3.3.1 Theoretical background

The TRP or the radiated power is simply the total power radiated by a base station. It is defined as the radiation intensity at each angle in watts per steradian $I(\theta,\varphi)$ integrated over the whole sphere around the antenna:

The power radiated by the antenna (P_{rad}) is also called the total radiated power (P_{TRP}). It is defined as the radiant intensity $I(\theta,\varphi)$ integrated over the whole sphere around the antenna:

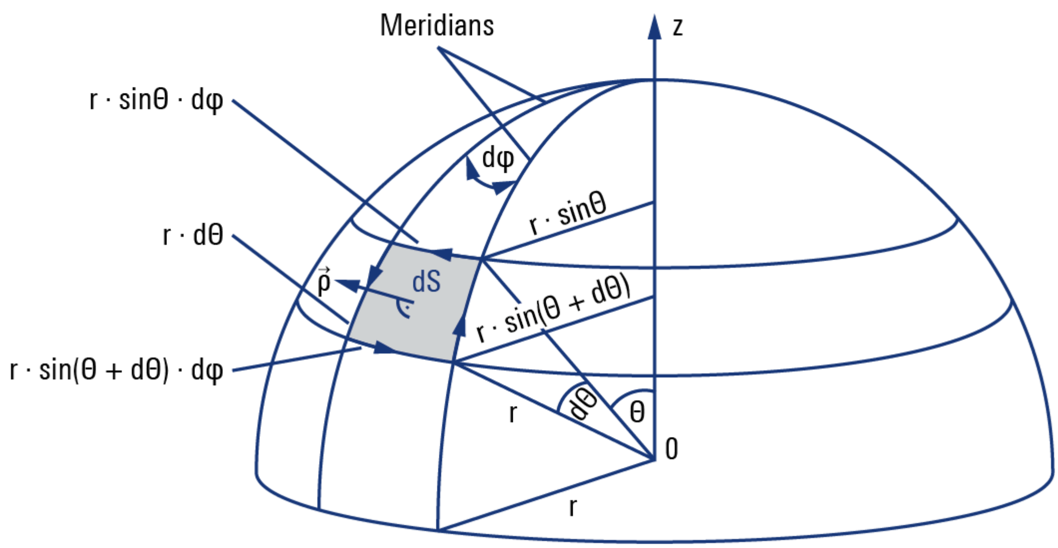


Figure 5: TRP integral

$$P_{TRP} = \int_{\varphi=0}^{2\pi} \int_{\theta=0}^{\pi} I(\theta,\varphi) \cdot \sin\theta \, d\theta d\varphi$$

In the far field the radiation intensity can be defined as:

$$I(\theta,\varphi) = \frac{EIRP(\theta,\varphi)}{4\pi}$$

With this definition of the radiation intensity it is possible to rewrite the TRP integral:

$$P_{TRP} = \frac{1}{4\pi} \int_{\varphi=0}^{2\pi} \int_{\theta=0}^{\pi} EIRP(\theta,\varphi) \cdot \sin\theta \, d\theta d\varphi$$

Even though these above equations are derived under far-field conditions (distance > Fraunhofer distance), they are also valid in closer distances due to energy conservation principle.

Fort further reading

- ► 3GPP TR 37.941 [11]
- ► On the shortest range length to measure the total radiated power
- ► Get ready for over-the-air (OTA) testing! [10]

3.3.2 TRP measurement grids

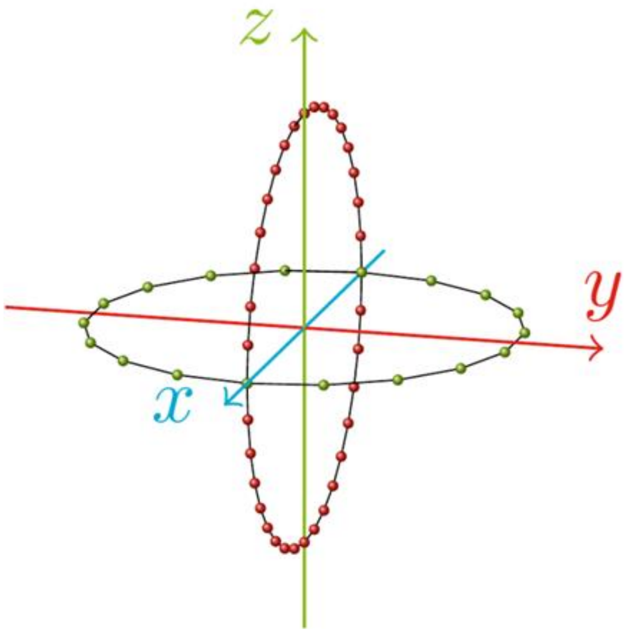


Figure 6: 2-cut grid [11]

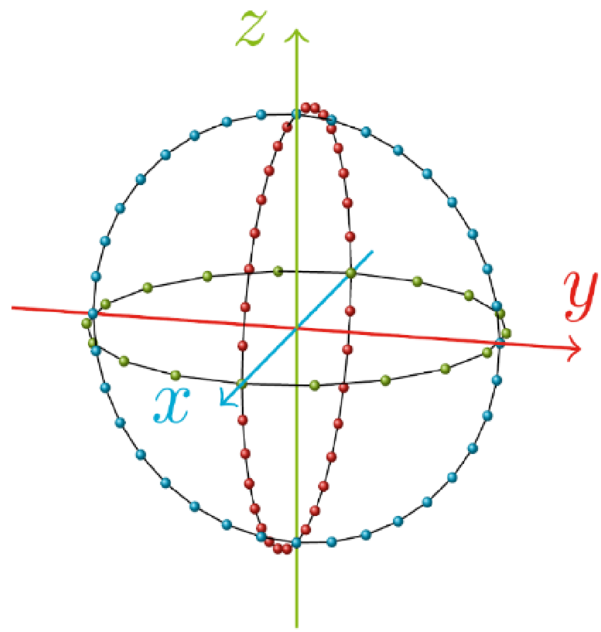


Figure 7: 3-cut grid [11]

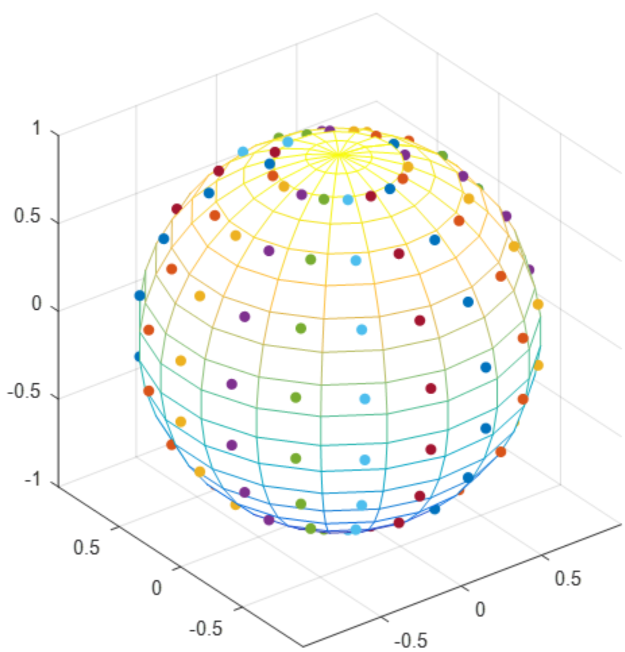


Figure 8: Equal angle grid [11]

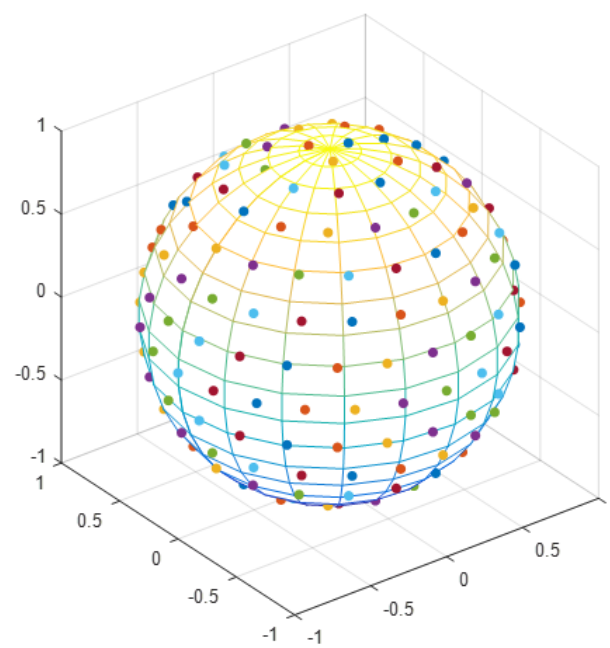


Figure 9: Equal area grid [11]

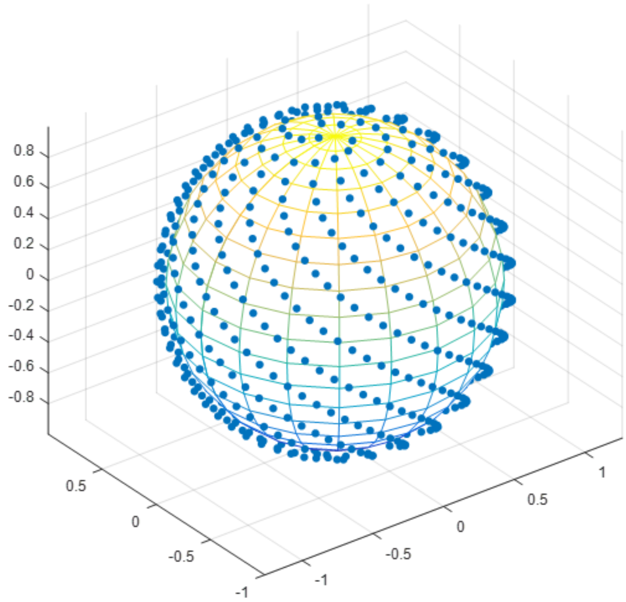


Figure 10: Fibonacci grid [11]

For further reading

► 3GPP TR 37.941 subsection 6.3.4 [11]

3.3.3 TRP measurement procedures

Different procedures can be used to evaluate the TRP estimate. These procedures can provide either an accurate assessment or a controlled overestimate of the TRP. The choice of methods is based also on the available test setup, measurement equipment, and the measurement time. [11]

Table 5 gives an overview about the different TRP measurement procedures and their applicability to the different test cases.

Table 5: TRP measurement procedures

Chapter TS 38.141-2	①	②	③	④	⑤	⑥	⑦	⑧	Comment
6.3	✓		✓		✓				
6.7.3	✓		✓	✓	✓[1)]			✓	Two TRP measurements are needed
6.7.4	✓		✓	✓	✓[1)]	✓	✓	✓	
6.7.5.2	✓	✓[2)]		✓[2)]		✓	✓	✓	Pre-scan is needed to identify the frequencies of interest. Pre-scan can also be applied to ACLR, OBUE and SEM
6.7.5.3	✓	✓[2)]		✓[2)]		✓	✓	✓	
6.7.5.4	✓	✓[2)]		✓[2)]		✓	✓	✓	
6.7.5.5	✓	✓[2)]		✓[2)]		✓	✓	✓	
6.8	✓			✓[2)]				✓	Relies on unwanted emission requirements (i.e. 6.7.3 OTA ACLR, 6.7.4 OTA operating band unwanted emissions and 6.7.5 OTA transmitter spurious emissions)

[1)] Applicable if the directivity of corresponding requirement at the reference direction is equivalent to the directivity at the reference direction when BS emits $P_{rated,c,TRP}$ and $P_{rated,c,EIRP}$
[2)] At harmonic frequencies the use of this method is FFS (for further study) due to risk of high beamforming gain.
Please note: If box is blank the method is not generally excluded.

① Full sphere using reference steps (accurate)
② Full sphere using sparse sampling (overestimate)
③ Two cuts + Pattern multiplication (accurate)
Note: Pattern multiplication is conditional
④ Two/three cuts (overestimate)
⑤ Beam-based directions
⑥ Peak method
⑦ Equal sector with peak average
⑧ Pre-scan

For further reading

► 3GPP TR 37.941 [11]

4 OTA antenna test solutions from R&S

It is important to know, that not all OTA base station conformance tests can be performed with all available OTA antenna test solutions. In OTA testing different types of test systems are distinguished. The following brief introduction provides an overview of the different R&S OTA antenna test solutions and how they can used for base station conformance tests in accordance with 3GPP TS 38.141-2 [2]. Rohde & Schwarz offers a suitable solution for any test case that is mentioned in [2].

Table 6 gives an overview which OTA antenna test solution is applicable to the specific 3GPP test case.

Table 6: Overview antenna test solutions

Chapter	Test	FR1		FR2	
		PWC200	WPTC	ATS1800C	WPTC
6.2	Radiated transmit power	✓	✓	✓	✓
6.3	OTA base station output power	✓	✓	✓	✓
6.4.2	OTA RE power control dynamic range	✓	✓	✓	✓
6.4.3	OTA total power dynamic range	✓	✓	✓	✓
6.5.1	OTA transmitter OFF power	✓	✓	✓	✓
6.5.2	OTA transmitter transient period	✓	×	✓	✓
6.6.2	OTA frequency error	✓	✓	✓	✓
6.6.3	OTA modulation quality	✓	✓	✓	✓
6.6.4	OTA time alignment error	✓	✓	✓	✓
6.7.2	OTA occupied bandwidth	✓	✓	✓	✓
6.7.3	OTA Adjacent channel leakage power ratio (ACLR)	✓	✓	✓	✓
6.7.4	OTA operating band unwanted emissions	TBC	✓	✓	✓
6.7.5.2	General OTA transmitter spurious emissions	×	✓	✓	✓
6.7.5.3	OTA transmitter spurious emissions - Protection of the BS receiver of own or different BS	✓	✓	planned	✓
6.7.5.4	OTA transmitter spurious emissions - Additional spurious emissions requirements	×	✓	✓	✓
6.7.5.5	OTA transmitter spurious emissions - Co-location requirements	✓	✓	×	✓
6.8	OTA transmitter intermodulation	partly	✓	×	✓

✓: Applicable ×: Not applicable

4.1 WPTC indoor anechoic chambers (as part of R&S TS8991)

Rohde & Schwarz offers a turnkey over the air solution for antenna, cellular and non-cellular testing. In cooperation with Albatross Projects GmbH a broad range of standardized Wireless Performance Test Chambers (WPTC) in various dimensions are available. These offered test chambers belong to the category of indoor anechoic chambers or general chambers. When configuring a TS8991 OTA-Performance test system, the configurator gives the choice of different test chamber sizes.

The anechoic chamber for models XS to M have absorber linings to cover frequencies down to approx. 600 MHz while the larger L and XL models have larger absorbers that cover frequencies down to approximately 400 MHz. By default, the upper frequency of the WPTC-series is approximately 18 GHz, but could be increased if needed. For base station tests in FR2 this is mandatory.

It is possible to figure out static measurements as well as 3D pattern measurements with the conical cut positioner.

Table 7 and Figure 11 gives an overview about the different WPTC models. Due to the rather large dimensions of a base station antenna, the larger models are more suitable for the base station conformance tests. The Rohde & Schwarz sales engineers will assist with the selection of a suitable model:

► https://www.rohde-schwarz.com/service-sales-locator

Table 7: WPTC model overview

Model	Outer dimensions [m]	Typical range length [m]
WPTC-XS	2.43 x 2.40 x 2.43	> 0.65
WPTC-S	3.70 x 3.00 x 3.10	> 1.02
WPTC-M	4.60 x 3.45 x 3.70	> 1.30
WPTC-L	5.20 x 4.05 x 4.30	> 1.38
WPTC-XL	5.80 x 5.10 x 5.20	> 1.83

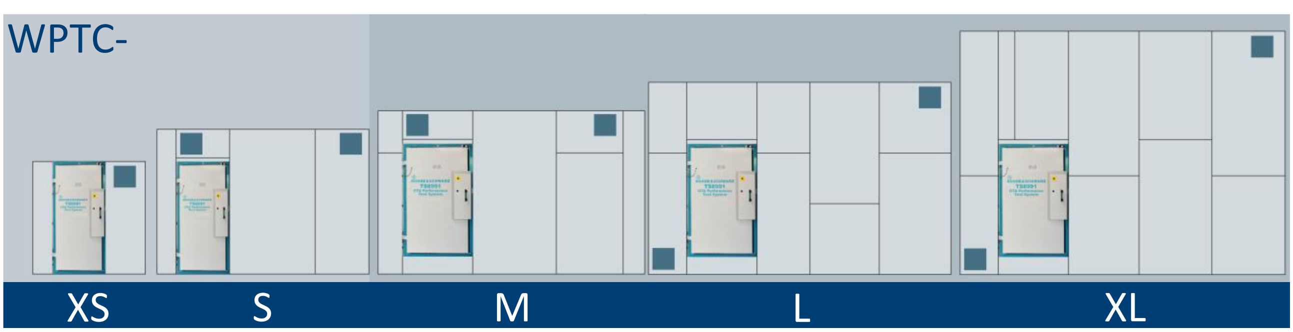


Figure 11: WPTC models

For further reading

► https://rohde-schwarz.com/product/ts8991

► https://www.rohde-schwarz.com/brochure-datasheet/ts8991/

4.2 R&S ATS1800C (CATR)

The R&S ATS1800C is a compact antenna test range (CATR) test system which was designed for 5G NR antennas, modules and devices (user equipment, UE) characterization throughout the entire development lifecycle, from R&D to conformance tests for both active and passive measurements (3D antenna gain patterns, ACLR, EVM, EiRP, TRP, EiS, etc.). The ATS1800C covers an in-band frequency range from 23.5 GHz to 44 GHz and an out-of-band frequency range from 6 GHz to 110 GHz. Therefore, this test chamber is perfectly suited for base station conformance tests in FR2.

The coordinate system used is as follows:

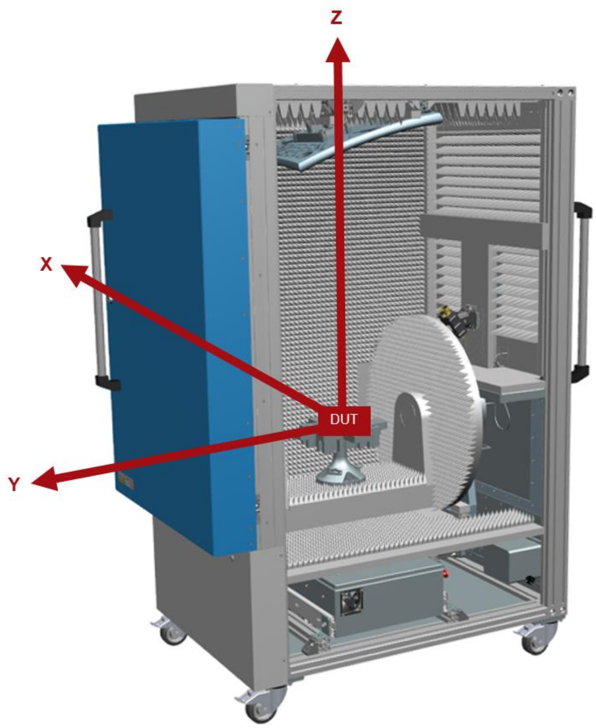


Figure 12: Coordinate system R&S®ATS1800C

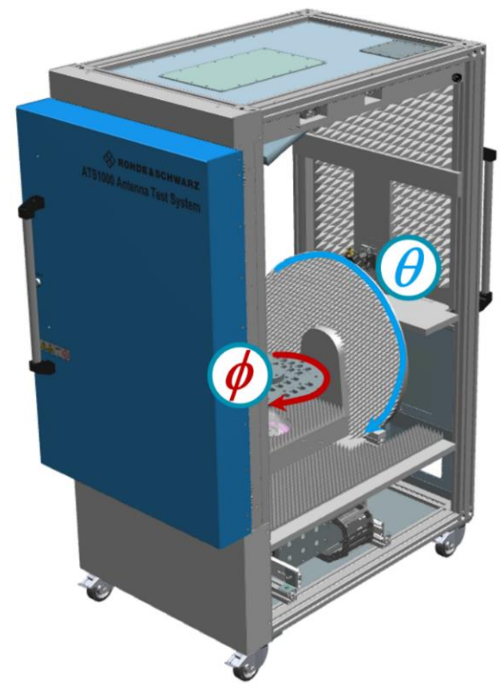


Figure 13: Coordinate system R&S®ATS1800C [12]

The ATS1800C provides RF feedthroughs (CATR-CSRF1: 1.85 mm (f), CATR-FEED2: 2 x 2.4 mm) for connecting the measurement devices that are located at the rear side of the chamber (see Figure 14).

Figure 14: Feedthroughs R&S®ATS1800C

In order to reduce path loss, keeping the measurement devices near to the feedthroughs by using short cables is highly recommended. Chapter 7 provides recommendations for suitable RF cables.

However, the quiet zone of this chamber measures around 30 cm x 30 cm and the DUT load capacity of the positioner is limited to 8 kg. In case of base station modules that exceed these restrictions please contact Rohde & Schwarz for a customized solution.

4.2.1 CATR principles in general

Inside the fully shielded chamber is the compact antenna test range (CATR) consisting of a feed antenna, a bidirectional parabolic reflector and a 3D positioner. The reflector has an extremely high precision surface roughness, which minimizes the errors introduced by the reflection. This allows the reflector to be used in a very wide frequency range for accurate measurement results. [13]

Figure 15: R&S®ATS1800C CATR [13]

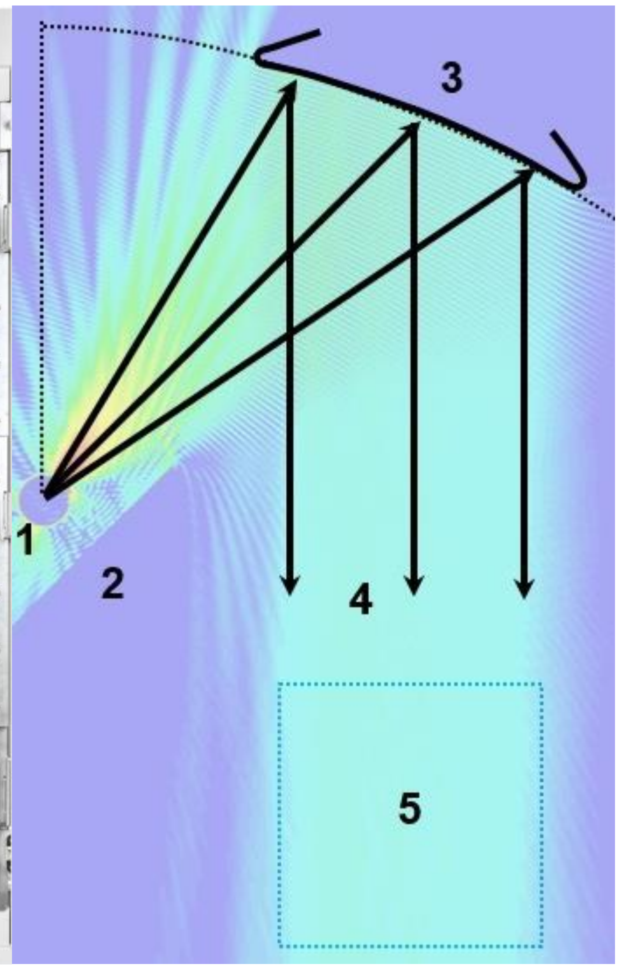


Figure 16: Wave propagation in the CATR setup [12]

1 = Feed antenna at focus of reflector
2 = Blocker to decouple feed from direct path to DUT
3 = Parabolic reflector with blended rolled edges
4 = Reflected plane wave
5 = Quiet zone for DUT

For further reading

► https://rohde-schwarz.com/product/ats1800c

► https://www.rohde-schwarz.com/brochure-datasheet/ats1800c/

4.3 R&S PWC200 Plane Wave Converter (PWC)

The R&S®PWC200, designed for 5G massive MIMO base station testing, offers instantaneous measurements of far-field characteristics at a tremendously reduced distance from the phased antenna array to the DUT. Among other things, this makes it perfectly suited for OTA base station conformance tests in FR1.

The PWC200 plane wave converter is a bidirectional array of 156 wideband Vivaldi antennas placed in the radiating near field of the device under test (DUT). The phased antenna array can form planar waves inside a specified quiet zone (e.g. 1m Ø) within the radiating near field of the 5G massive MIMO base station module for real-time radiated power and transceiver measurements (EVM, ACLR, SEM, etc.).

Each antenna includes a phase shifter and attenuator path, allowing arbitrary synthesis of the electromagnetic field directly in front of the array at the spherical quiet zone enclosing the DUT. All signal paths are combined to a single port that can be connected to measurement equipment (e.g. spectrum analyzer). [14]

The R&S®PWC200 generates a 3D spherical quiet zone within a 1 m diameter sphere at a distance of 1.50 meters at a frequency of 3.5 GHz. In comparison, a direct far field measurement already requires a distance of 23.5 m.

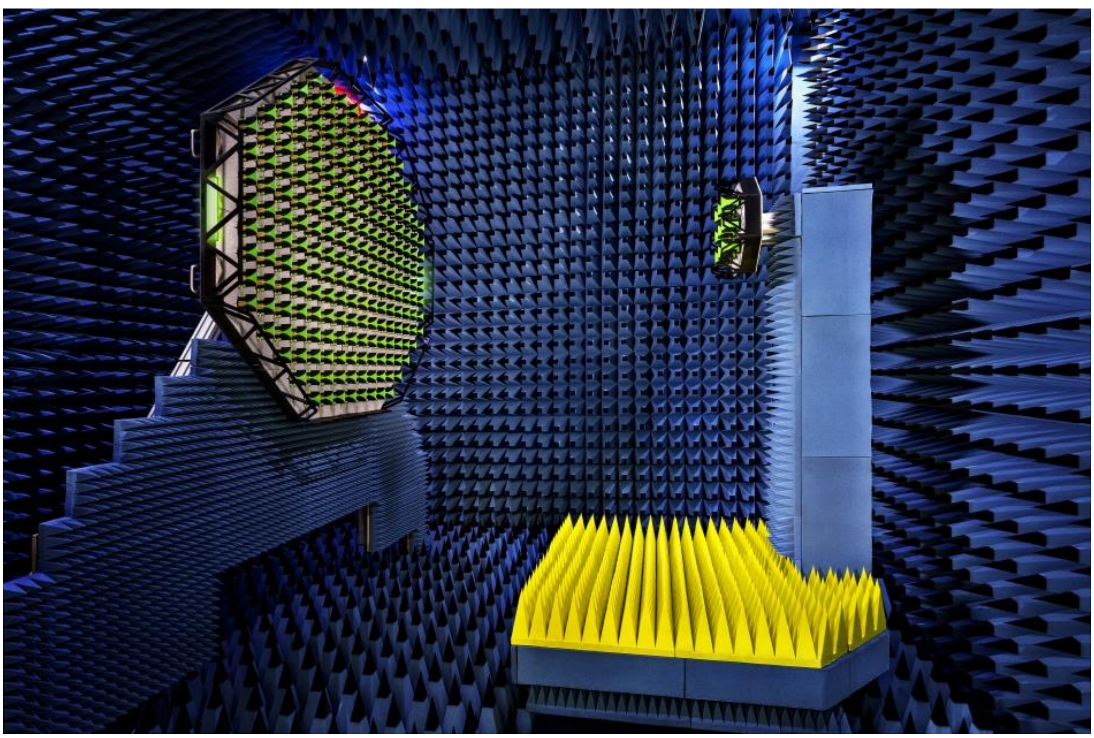


Figure 17: R&S® PWC200 equipped in anechoic test chamber

The R&S®PWC200 has to be shielded in a suitable wireless performance test chamber (e.g. WPTC, offered by Rohde & Schwarz).

For more details on this technology, refer to the EuCAP 2018 publication "Plane Wave Converter for 5G Massive MIMO Basestation Measurements".

For further reading

- https://rohde-schwarz.com/product/pwc200
- https://www.rohde-schwarz.com/brochure-datasheet/pwc200/
- EuCAP 2018 publication "Plane Wave Converter for 5G Massive MIMO Basestation Measurements"

5 Transmitter Tests (Chapter 6)

Specification TS 38.141-2 [2] defines the tests required in the various frequency ranges and positions (**B**ottom, **M**iddle, **T**op) in the operating band. In instruments from Rohde & Schwarz, the frequency range can be set to any frequency within the supported range independently of the operating bands.

Please note that this version of the application note describes single carrier (SC) tests under normal test environment (TE) only.

In order to allow comparisons between tests, test models (TMs) standardize the resource block (RB) allocations. For NR, these are called enhanced NR TMs with the frequency range (e.g. NR-FR2-TM1.1). The NR FR2 test models needed for BS type 2-O are described in TS 38.141-2 [2]. The NR FR1 test models are described in TS 38.141-1 [1]. Both of them are stored as predefined settings in instruments from Rohde & Schwarz.

Table 8 provides an overview of the basic parameters for the individual tests numbered by the chapters of TS 38.141-2 and linked to the corresponding chapters in this application note. Both, the required test models (TM) for BS type 2-O and the frequency positions (B, M, T) to be measured are shown.

Table 8: Tx basic parameters overview

Chapter	Test	TE	RF channels to be tested	FR2 test models (BS type 2-O)
6.2	Radiated transmit power	N, E[1]	B, M, T	NR-FR2-TM1.1
6.3	OTA base station output power	N	B, M, T	NR-FR2-TM1.1
6.4.2	OTA RE power control dynamic range	N	B, T	NR-FR2-TM2 NR-FR2-TM3.1
6.4.3	OTA total power dynamic range	N	M	NR-FR2-TM2
6.5.1	OTA transmitter OFF power	N	M	NR-FR2-TM1.1
6.5.2	OTA transmitter transient period	N	M	
6.6.2	OTA frequency error	N	B, T	NR-FR2-TM2 NR-FR2-TM3.1
6.6.3	OTA modulation quality	N	B, T	
6.6.4	OTA time alignment error	N	M	NR-FR2-TM1.1
6.7.2	OTA occupied bandwidth	N	M	NR-FR2-TM1.1
6.7.3	OTA Adjacent channel leakage power ratio (ACLR)	N	B, T	
6.7.4	OTA operating band unwanted emissions	N	B, M, T	
6.7.5.2	General OTA transmitter spurious emissions	N	B, T	NR-FR2-TM1.1
6.7.5.3	OTA transmitter spurious emissions - Protection of the base station receiver of own or different base station	N	M	
6.7.5.4	OTA transmitter spurious emissions - Additional spurious emissions requirements	N	B, T	
6.7.5.5	OTA transmitter spurious emissions - Co-location requirements	N	M	
6.8	OTA transmitter intermodulation	N	M	Test not applicable for BS type 2-O

[1] Please note that this application note covers normal test environment conditions only

As of now, there are still several requirements not available or finalized in TS 38.141-2 (V16.3.0) yet, especially for base station type 1-H. Table 9 shows the requirements as officially published:

Table 9: Available requirements (TS 38.141-2, version 16.3.0)

Requirement	Requirement set		
	BS type 1-H	**BS type 1-O**	**BS type 2-O**
Radiated transmit power	6.2	6.2	6.2
OTA base station output power	N/A	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	N/A

5.1 Requirements classification

Table 10: Classification of radiated transmitter requirements [11]

TX requirement	Description	Classification
Radiated transmit power	The minimum requirements for radiated transmit power, are placed on one or more manufacturer declared beams over a declared OTA peak direction set. OTA requirements for BS output power are defined for directional EIRP requirements as radiated transmit power requirements. This requirement originates from the Rel-13 AAS BS requirement for the EIRP accuracy.	Directional
OTA BS output power	TRP metric is used for BS output power limit requirement.	TRP
OTA output power dynamics	OTA output power dynamics consists of the Total power dynamic range, as well as the RE power control dynamic range requirements. For E-UTRA specification, the RE power control dynamic range requirement has no specific test and is tested together with the EVM. Furthermore, verification of the output power dynamics is not impacted by the spatial aspects around the BS. Therefore, the OTA output power dynamics requirements are considered as directional requirements.	Directional

OTA transmit OFF power	The OTA transmit OFF power is a co-location requirement in FR1, defined at the co-location reference antenna conductive output side, subject to scaling. For FR2, it is defined as TRP requirement.	FR1: Co-location FR2: TRP
OTA transient period	Same as OTA transmit OFF power, the OTA transient period is a co-location requirement in FR1, defined at the co-location reference antenna conductive output side, subject to scaling. For FR2, it is defined as directional requirement.	FR1: Co-location FR2: directional
OTA transmitted signal quality	EVM: The range of directions where the EVM requirement must be met is declared by the manufacturer as OTA coverage range, while the requirement itself is considered directional. Frequency error: The frequency error is coherent and will have a ‘flat’ response in the spatial domain, i.e. OTA frequency error will not depend on the selection of the measurement point within beam’s compliance directions set. Therefore, single directional requirement can be applied. TAE: In terms of testing effort it is beneficial, to coordinate testing of OTA TAE with testing of other transmitter parameters such as OTA frequency error and radiated transmit power.	Directional
OTA occupied bandwidth	For occupied bandwidth, the beam characteristics are not important. The requirement should however cover the fact that all transmitter is active and the system is operating at the maximum declared rated total radiated power. Occupied bandwidth is specified as a directional requirement valid over the OTA coverage range.	Directional
OTA ACLR	ACLR requirement is the ratio of two TRP measures: the total radiated filtered mean power centred on the assigned channel frequency to the total radiated filtered mean power centred on an adjacent channel frequency.	TRP
OTA operating band unwanted emission	The OBUE unwanted emissions requirement in the OTA domain must capture all emissions around the BS by application of the TRP metric.	TRP
OTA transmitter spurious emission	Similar to other Unwanted emissions requirements, the metric used to capture transmitter spurious emissions OTA is TRP.	TRP except for co-location requirements applicable in FR1
OTA transmitter intermodulation	OTA transmitter intermodulation requirement relies on Unwanted emission requirements (i.e. operating band unwanted emission, transmitter spurious emission, and ACLR; all defined as TRP) in the presence of a wanted signal and an interfering signal. No requirement for FR2 is defined.	Co-location

5.2 Complete Tx test setup overview

Figure 18 shows the general test setup for transmitter tests. A spectrum analyzer (FSW) is used to perform the tests. Some tests require special setups which are described in the respective sections.

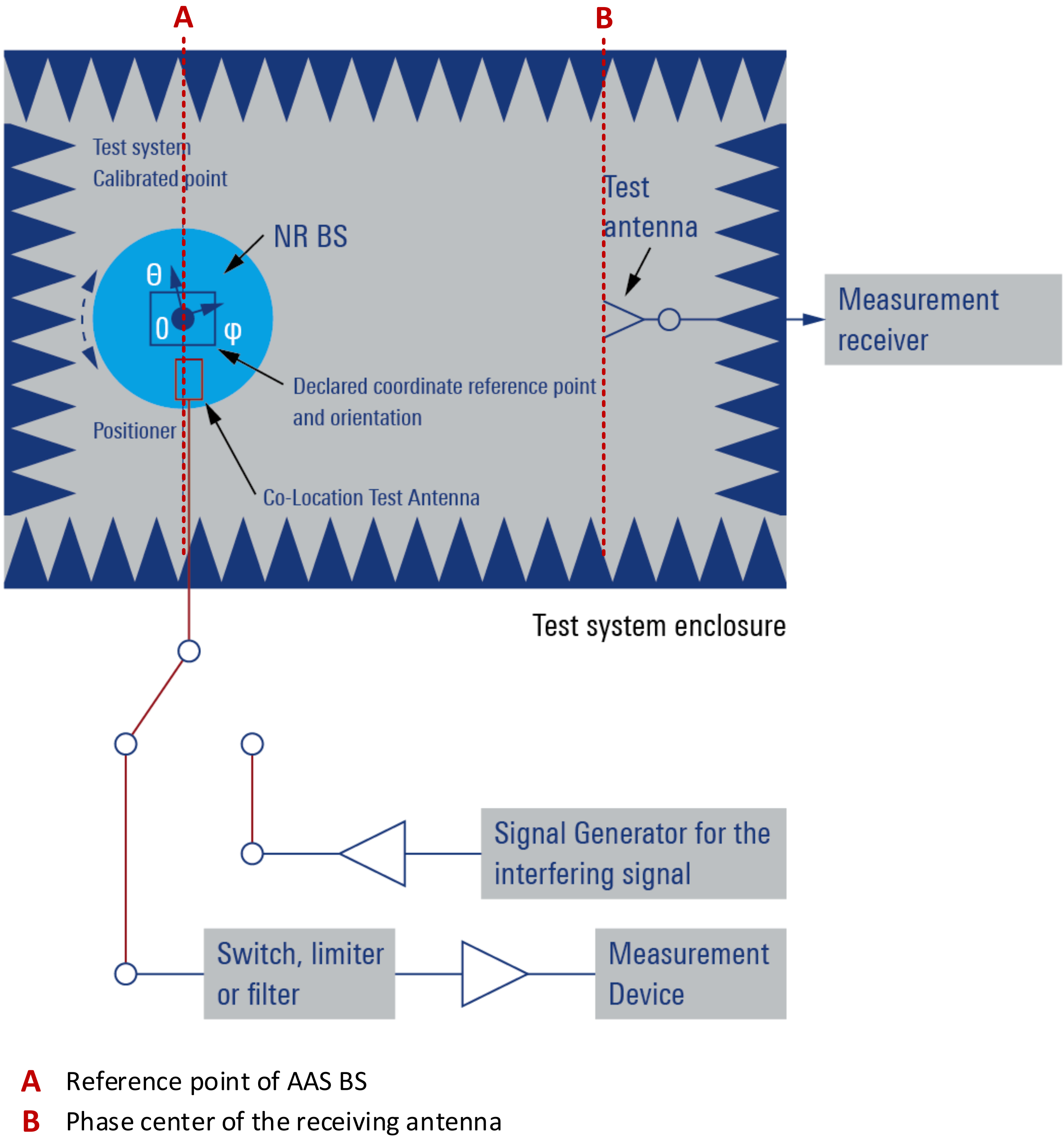


Figure 18: Complete Tx test setup overview

5.3 Radiated transmit power (6.2)

Radiated transmit power is defined as the EIRP (equivalent isotropically radiated power) level for a declared beam at a specific beam peak direction. [2]

The test purpose is to verify the ability to accurately generate and direct radiated power per beam.

For each declared conformance beam direction pair, the EIRP measurement shall remain within the values provided in Table 11 relative to the manufacturers declared rated beam EIRP value:

Table 11: Test requirement for radiated transmit power

BS type	Normal test environment
1-H	f ≤ 3 GHz: ± 3.3 dB
	3 GHz < f ≤ 6 GHz: ± 3.5 dB
1-O	f ≤ 3 GHz: ± 3.3 dB
	3 GHz < f ≤ 6 GHz: ± 3.5 dB
2-O	24.15 GHz < f ≤ 29.5 GHz: ± 5.1 dB
	37 GHz < f ≤ 40 GHz: ± 5.4 dB

Test setup

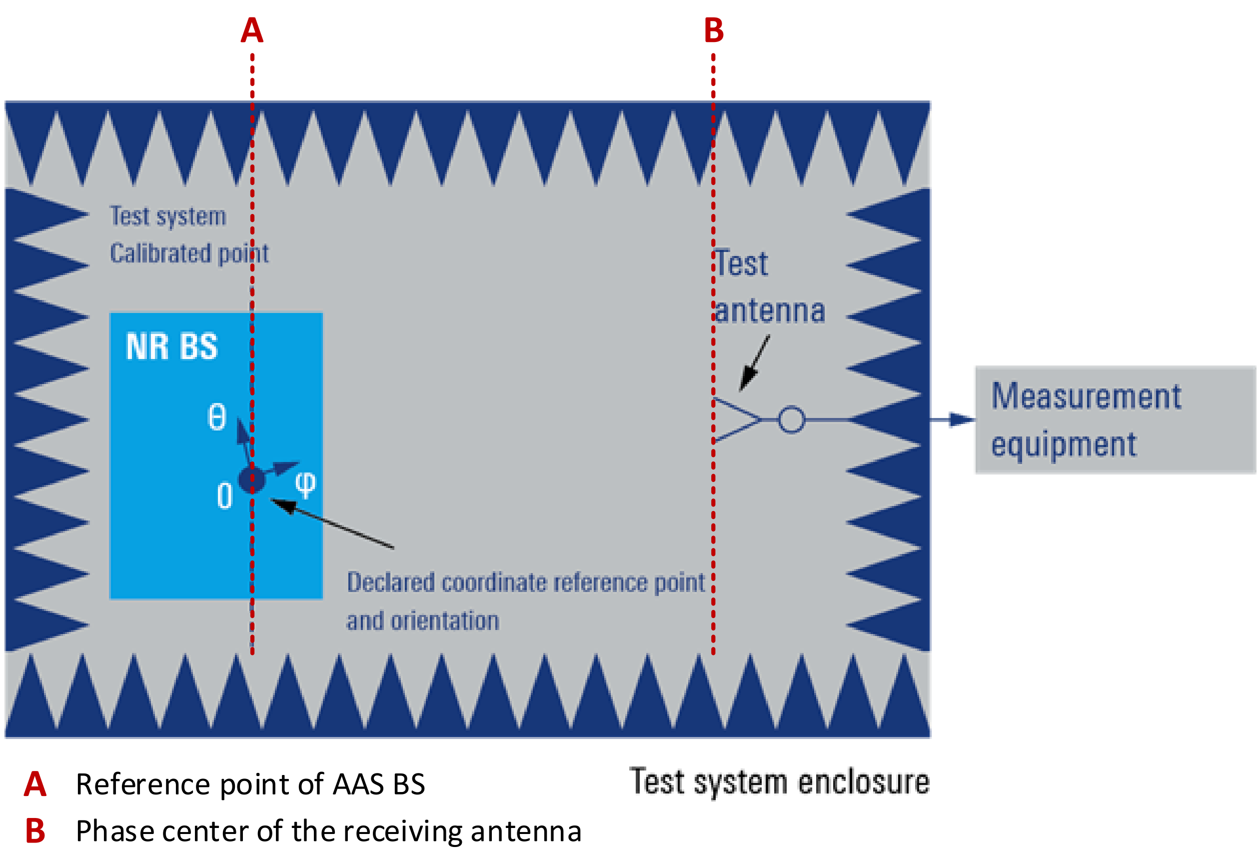


Figure 19: Measurement setup for Radiated transmit power

Test procedure

1. Place the base station at the positioner and align the coordinate system
2. Move the base station in order that the direction to be tested aligns with the test antenna
3. Set the base station to transmit the corresponding test model
   BS type 2-O: NR-FR2-TM1.1
   BS type 1-O: according to TS 38.141-1 [1]
4. Measure the EIRP for any two orthogonal polarizations (p1 and p2) and calculate total radiated transmit power: $EIRP = EIRP_{p1} + EIRP_{p2}$
5. Repeat measurement for all declared beams

5.4 OTA base station output power (6.3)

OTA BS output power is declared as rated carrier TRP, with the output power accuracy requirement defined at the RIB during the transmitter ON period. [2]

The test purpose is to verify the accuracy of the maximum carrier TRP (Total Radiated Power) ($P_{max,c,TRP}$) across the frequency range for all RIBs. OTA BS output power is declared as rated carrier TRP, with the output power accuracy requirement defined at the RIB during the transmitter ON period. [2]

The base station rated carrier TRP for BS type 1-O shall be within the limits as specified in Table 12. For BS type 2-O there is no upper limit for the rated carrier TRP.

Table 12: BS rated carrier TRP limits for BS type 1-O

BS class	$P_{rated,c,TRP}$
Wide Area BS	No upper limit
Medium Range BS	≤ +47 dBm
Local Area BS	≤ +33 dBm

The TRP measurement results shall remain within the values provided in Table 13 relative to the manufacturers declared rated carrier TRP values:

Table 13: Test requirement - TRP difference to the manufacturer´s declared rated carrier TRP

BS type	Frequency range	TRP allowed difference
1-H	N/A	
1-O	f ≤ 3.0 GHz	± 3.4 dB
	3.0 GHz ≤ f ≤ 4.2 GHz	± 3.5 dB
	4.2 GHz ≤ f ≤ 6.0 GHz	± 3.5 dB
2-O	24.25 GHz < f ≤ 29.5 GHz	± 5.1 dB
	37 GHz < f ≤ 40 GHz	± 5.4 dB

Test setup

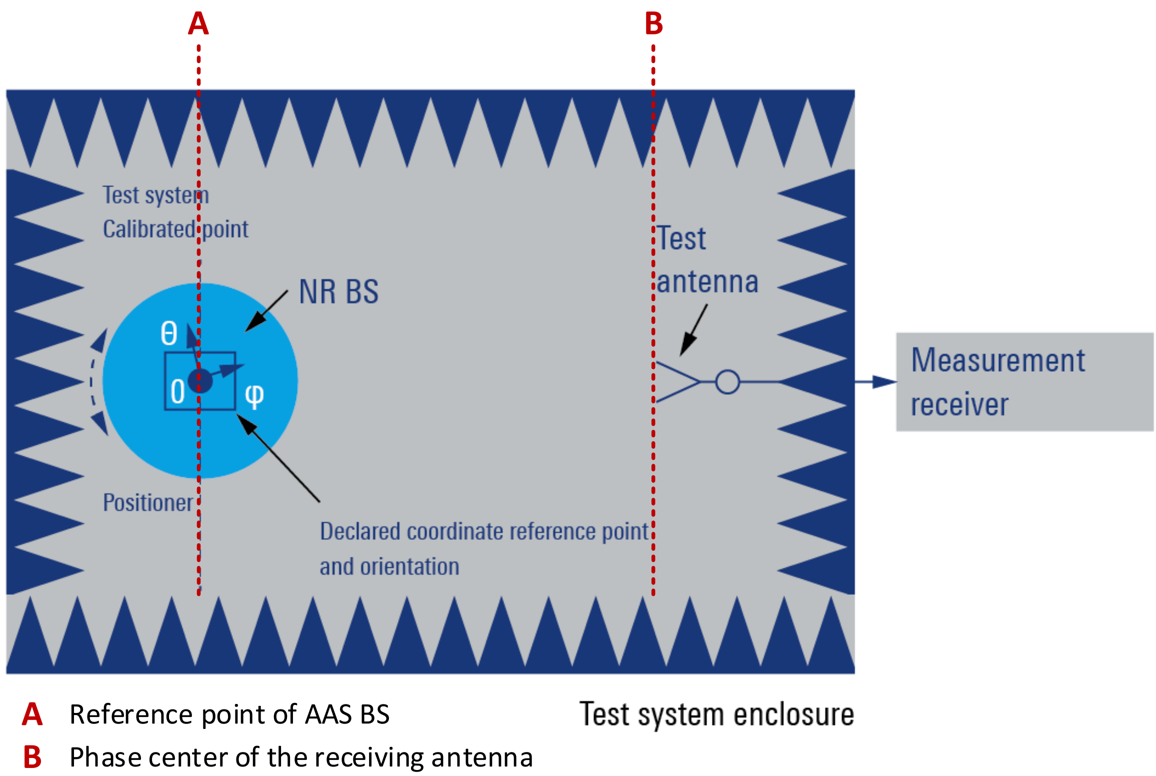


Figure 20: Measurement set up for OTA base station output power

Test procedure

Procedure for measuring TRP is based on the directional power measurements. More information about TRP measurements can be found in chapter 3.3.

1. Place the base station at the positioner and align the coordinate system
2. Set the base station in the direction of the declared beam peak direction
3. Set the BS to transmit the corresponding test model
   BS type 2-O: NR-FR2-TM1.1
   BS type 1-O: according to TS 38.141-1 [1]
4. Orient the positioner (and BS) in order that the direction to be tested aligns with the test antenna such that measurements to determine TRP can be performed
5. Measure the EIRP for any two orthogonal polarizations (p1 and p2) and calculate total radiated transmit power: $EIRP = EIRP_{p1} + EIRP_{p2}$
6. Repeat step 5) for all directions in the appropriated TRP measurement grid needed for full TRP estimation
7. Calculate TRP

$$\mathrm{TRP} = \frac{1}{4\pi}\int_{\varphi=0}^{2\pi}\int_{\theta=0}^{\pi}\mathrm{EIRP}(\theta,\varphi)\sin\theta d\theta d\varphi$$

5.5 OTA output power dynamics (6.4)

The requirements apply during the transmitter ON period.

5.5.1 OTA RE power control dynamic range (6.4.2)

The OTA RE power control dynamic range is the difference between the power of an RE and the average RE power for a BS at maximum output power ($P_{max,c,EIRP}$) for a specified reference condition.

This requirement shall apply at each RIB supporting transmission in the operating band [2].

For this test no specific test or test requirements are defined. Test 6.6.3 OTA modulation quality (5.7.1) test provides sufficient test coverage for this requirement.

5.5.2 OTA total power dynamic range (6.4.3)

The OTA total power dynamic range is the difference between the maximum and the minimum transmit power of an OFDM symbol for a specified reference condition.

This requirement shall apply at each RIB supporting transmission in the operating band [2].

The test purpose is to verify that the total power dynamic range is within the limits specified by the minimum requirement. [2]

For BS type 1-O the downlink (DL) total power dynamic range for each NR carrier shall be larger than or equal to the levels in Table 14.

Table 14: Total power dynamic range for BS type 1-O

BS channel bandwidth (MHz)	Total power dynamic range (dB)		
	15 kHz SCS	**30 kHz SCS**	**60 kHz SCS**
5	13.5	10.0	N/A
10	16.7	13.4	10.0
15	18.5	15.3	12.1
20	19.8	16.6	13.4
25	20.8	17.7	14.5
30	21.6	18.5	15.3
40	22.9	19.8	16.6
50	23.9	20.8	17.7
60	N/A	21.6	18.5
70	N/A	22.3	19.2
80	N/A	22.9	19.8
90	N/A	23.4	20.4
100	N/A	23.9	20.9

OTA total power dynamic range minimum requirement for BS type 2-O is specified such as for each NR carrier. It shall be larger than or equal to the levels specified in Table 15 [2].

Table 15: Minimum requirement for BS type 2-O - total power dynamic range (dB)

SCS (kHz)	50 MHz	100 MHz	200 MHz	400 MHz
60	17.7 dB	20.8 dB	23.8 dB	N/A
120	14.6 dB	17.7 dB	20.8 dB	23.8 dB

Test setup

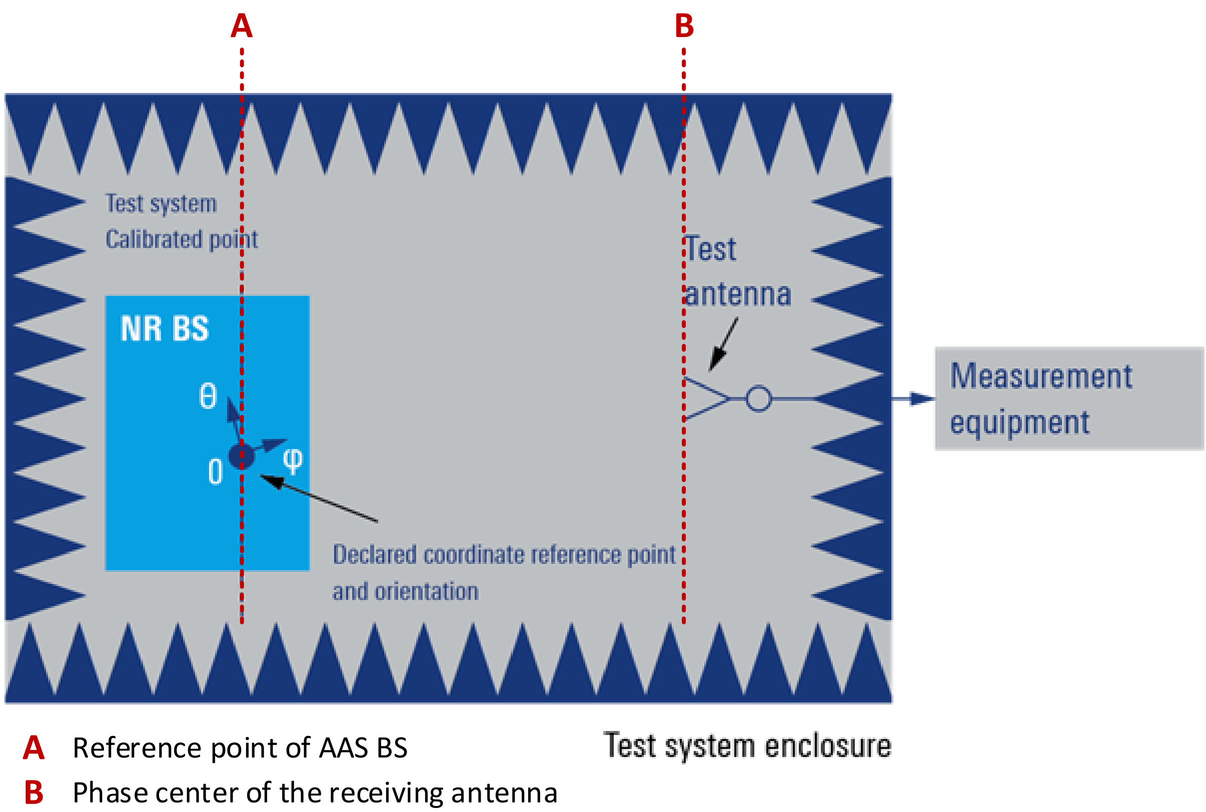
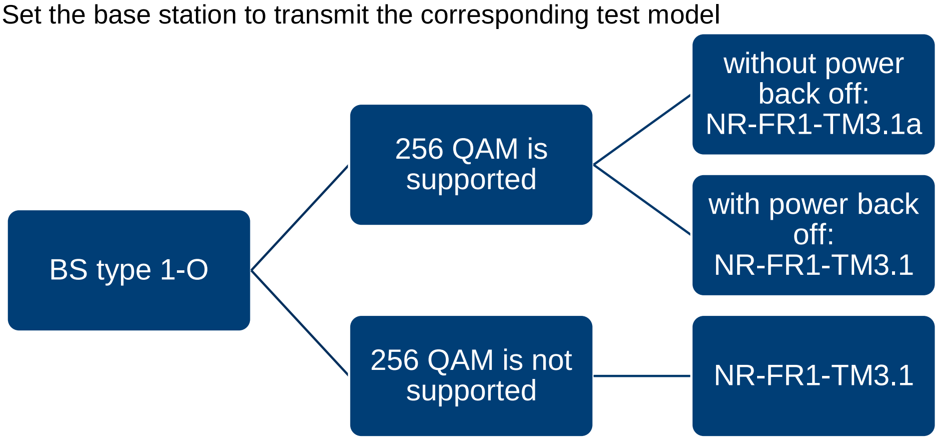
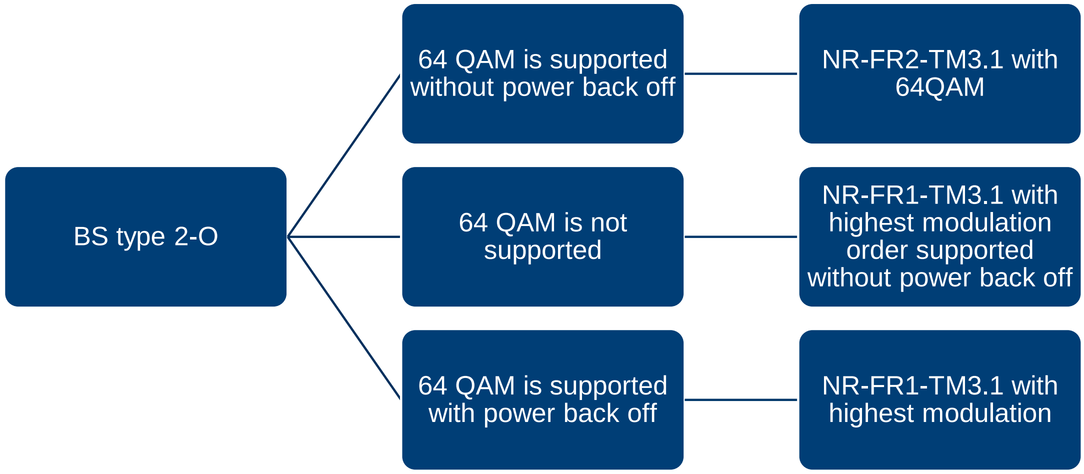


Figure 21: Measurement setup for OTA output power dynamics

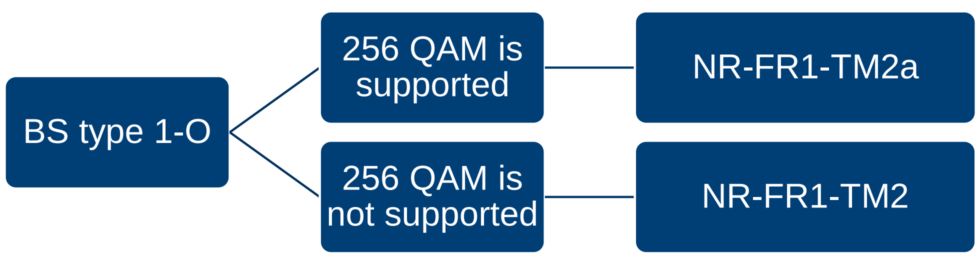
Test procedure

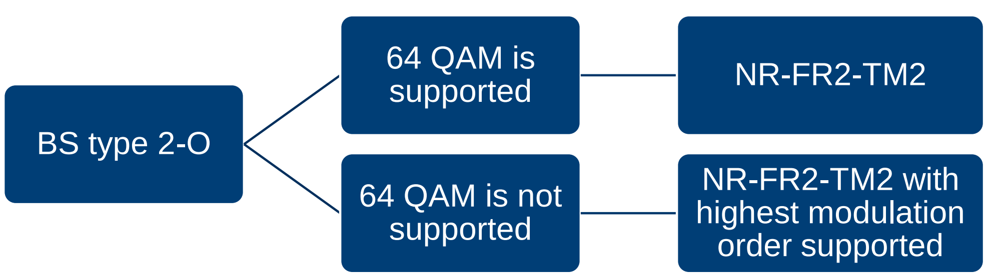
1. Place the base station at the positioner and align the coordinate system
2. Move the base station in order that the direction to be tested aligns with the test antenna
3. Configure the beam peak direction of the BS according to the declared beam direction pair
4. Set the base station to transmit the corresponding test model





5. Measure the OFDM symbol Tx power by measuring the EIRP for any two orthogonal polarizations (p1 and p2)
6. Calculate total radiated transmit power as for particular beam direction pair as $EIRP = EIRP_{p1} + EIRP_{p2}$
7. Set the base station to transmit corresponding test model





8. Measure the OFDM symbol Tx power (OSTP) by measuring the EIRP for any two orthogonal polarizations (p1 and p2) and calculate total radiated transmit power for particular beam direction pair: $EIRP = EIRP_{p1} + EIRP_{p2}$

Note: Measured OFDM symbols shall not contain RS or SSB

5.6 OTA transmit ON/OFF power (6.5)

5.6.1 OTA transmitter OFF power (EIRP in beam peak) (6.5.1)

OTA transmitter OFF power requirements apply only to TDD operation of NR base stations. It´s the mean power measured over 70/N µs filtered with a square filter of bandwidth equal to the transmission bandwidth configuration of the BS (BW_{Config}) centered on the assigned channel frequency during the transmitter OFF period. N = SCS/15, where SCS is Sub Carrier Spacing in kHz. [2]

For BS supporting intra-band contiguous CA, the transmitter OFF power is defined as the mean power measured over 70/N µs filtered with a square filter of bandwidth equal to the aggregated BS channel bandwidth $BW_{Channel\_CA}$ centered on (F_{edge_high}+F_{edge_low})/2 during the transmitter OFF period.

For BS type 1-O, the transmitter OFF power is defined as the output power at the co-location test antenna conducted output(s). For BS type 2-O the transmitter OFF power is defined as TRP. [2]

The purpose of this test is to verify the OTA transmitter OFF power is within the limits of the minimum requirements [2].

This test is tested together with test case 6.5.2. Therefor please see chapter 5.6.2 for the required test setup and the test requirements.

5.6.2 OTA transmitter transient period (6.5.2)

The OTA transmitter transient period requirements apply only to TDD operation of BS. It is the time period during which the transmitter unit is changing from the OFF period to the ON period or vice versa. The OTA transmitter transient period is illustrated in Figure 22.

For BS type 1-O this requirement applies for RIB supporting transmission in the operating band and is measured at the co-location test antenna conducted outputs. For BS type 2-O the requirement applies at each RIB supporting transmission in the operating band. [2]

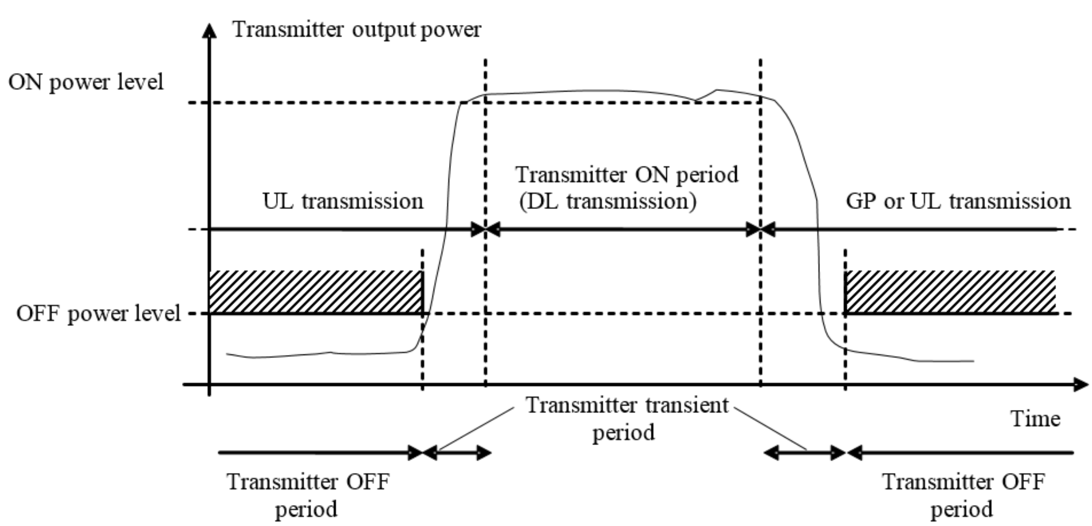


Figure 22: Definition of transmitter ON and OFF periods [2]

The purpose of this test is to verify the OTA transmitter transient periods are within the limits of the minimum requirements.

The mean power spectral density (for BS type 1-O) and the mean EIRP spectral density (for BS type 2-O) measured shall be less than the values specified in Table 16.

Table 16: Test requirements for OTA transmitter transient period (6.5.2)

BS type	Frequency	Mean power spectral density /mean EIRP spectral density
1-O[1)]	f ≤ 3.0 GHz	-102.6 dBm/MHz
	3.0 GHz < f ≤ 6.0 GHz	-102.4 dBm/MHz
2-O	24.15 GHz < f ≤ 29.5 GHz	-33.1 + $P_{rated,c,EIRP}$ - $P_{rated,c,TRP}$ dBm/MHz
	37 GHz < f ≤ 40 GHz	-32.7 + $P_{rated,c,EIRP}$ - $P_{rated,c,TRP}$ dBm/MHz

1) For multi-band RIB, the requirement is only applicable during the transmitter OFF period in all supported operating bands.

$P_{rated,c,TRP}$: value declared for the reference beam direction pair for the beam identifier which provides the highest intended EIRP

Test setup

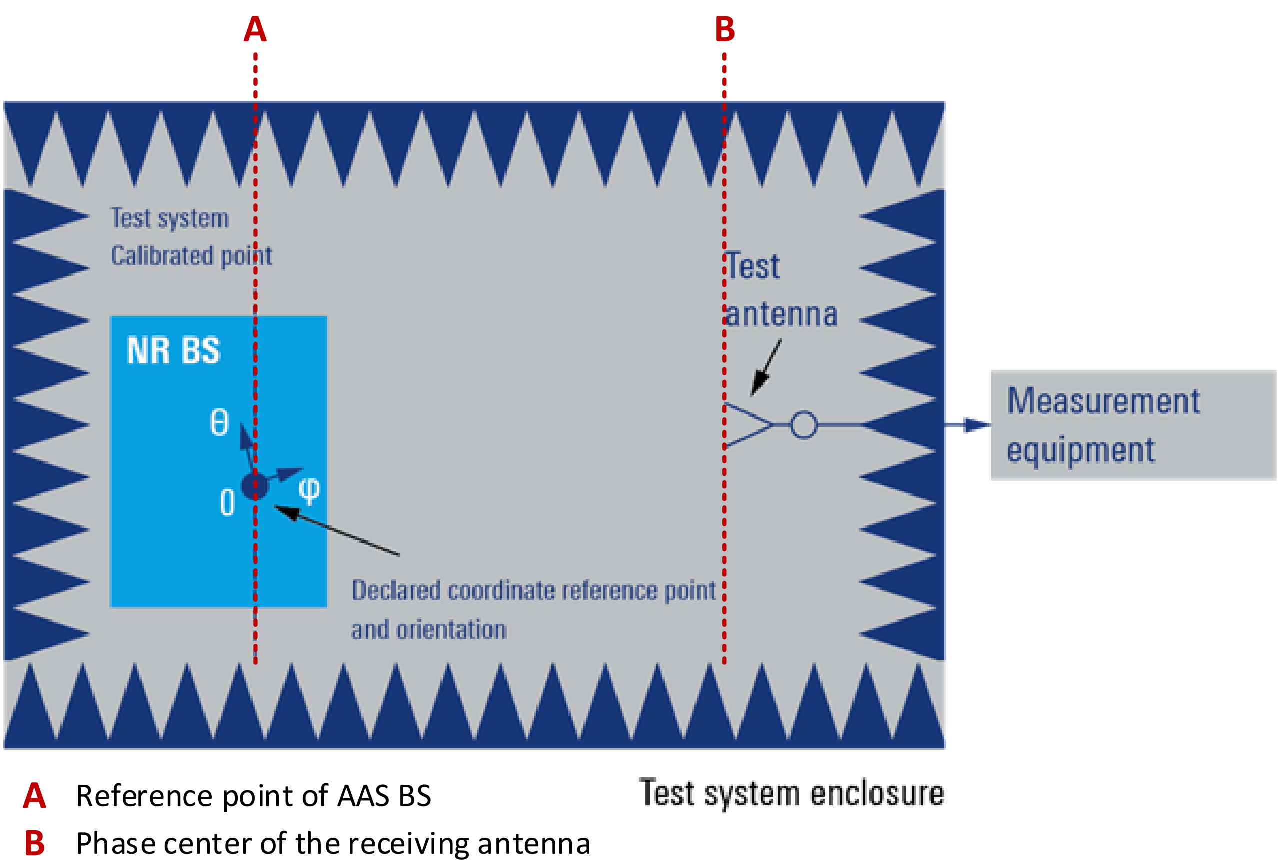


Figure 23: Measurement setup for OTA transmit ON/OFF power (BS type 2-O)

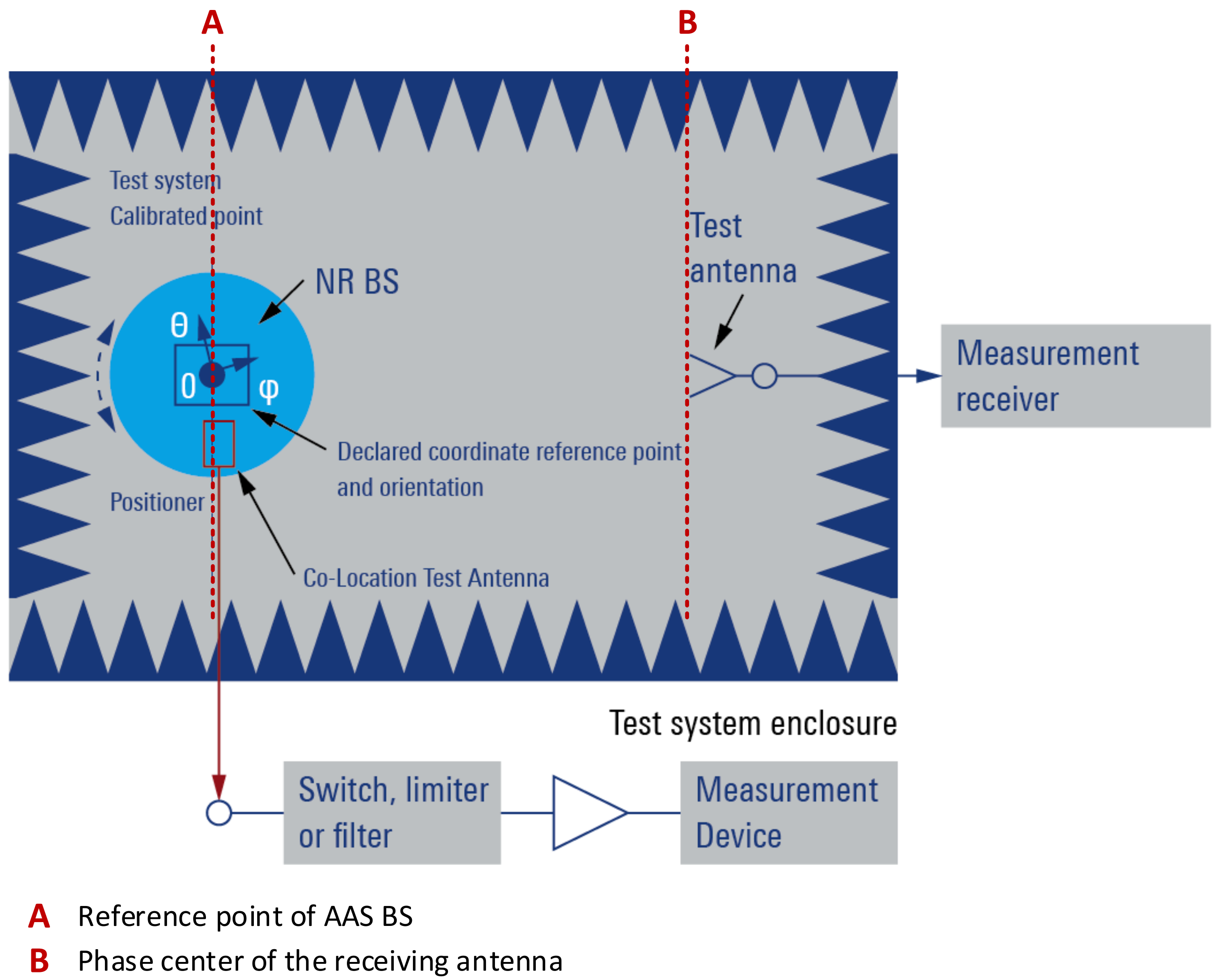


Figure 24: Measurement setup for OTA transmit ON/OFF power (BS type 1-O)

Test procedure

1. Place the base station at the positioner and align the coordinate system
2. Set the BS in the direction of the declared beam peak direction (beam to be tested)
3. BS type 2-O:
   a) Set the base station to transmit NR-FR2-TM1.1 test model
   b) Measure the mean EIRP spectral density as the power sum over two orthogonal polarizations over 70/N µs filtered with a square filter of bandwidth equal to the RF bandwidth of the NR BS centered on the central frequency of the RF bandwidth (x = 3)
4. BS type 1-O
   a) Place the co-location test antenna (more information can be found in [2], subclause 4.12)
   b) Set the base station to transmit the corresponding test model
   c) Measure the mean power spectral density at the output(s) of co-location test antenna as power sum over two orthogonal polarizations over 70/N µs filtered with a square filter of bandwidth equal to the RF bandwidth of the BS centered on the central frequency of the RF bandwidth

Note: 70/N µs average window center is set from 35/N µs after end of one transmitter ON period + 10 µs to 35/N µs before start of next transmitter ON period - 10 µs. N = SCS/15, where SCS is sub carrier spacing in kHz.

5.7 OTA transmitted signal quality (6.6)

5.7.1 OTA frequency error (6.6.2)

OTA frequency error is the measure of the difference between the actual BS transmit frequency and the assigned frequency. The same source shall be used for RF frequency and data clock generation. [2]

The modulated carrier frequency of each NR carrier configured by the BS shall be accurate to within the accuracy range given in Table 17 observed over 1ms.

Table 17: OTA frequency error test requirement for BS type 1-O and BS type 2-O

BS class	Accuracy
Wide Area BS	±(0.05 ppm + 12 Hz)
Medium Range BS	±(0.1 ppm + 12 Hz)
Local Area BS	±(0.1 ppm + 12 Hz)

For this measurement, the FSW (spectrum analyzer) must be synchronized via an external reference to a high precision time reference.

This test case is tested together with test 6.6.3 OTA modulation quality. For test setup and test procedure please see chapter 5.7.2.

5.7.2 OTA modulation quality (6.6.3)

OTA modulation quality is defined by the difference between the measured carrier signal and an ideal signal. Modulation quality can e.g. be expressed as Error Vector Magnitude (EVM). The Error Vector Magnitude is a measure of the difference between the ideal symbols and the measured symbols after the equalization. This difference is called the error vector. [2]

The measured EVM of each NR carrier shall be less than the limits in Table 18.

Table 18: EVM requirements

Base Station type	Modulation scheme for PDSCH	Required EVM (%)
BS type 1-O	QPSK	18.5
	16QAM	13.5
	64QAM	9
	256QAM	4.5
BS type 2-O	QPSK	18.5
	16QAM	13.5
	64QAM	9

For NR, for all bandwidths, the EVM measurement shall be performed for each NR carrier over all allocated resource blocks and downlink slots within 10 ms measurement periods. The boundaries of the EVM measurement periods need not be aligned with radio frame boundaries.

Test setup

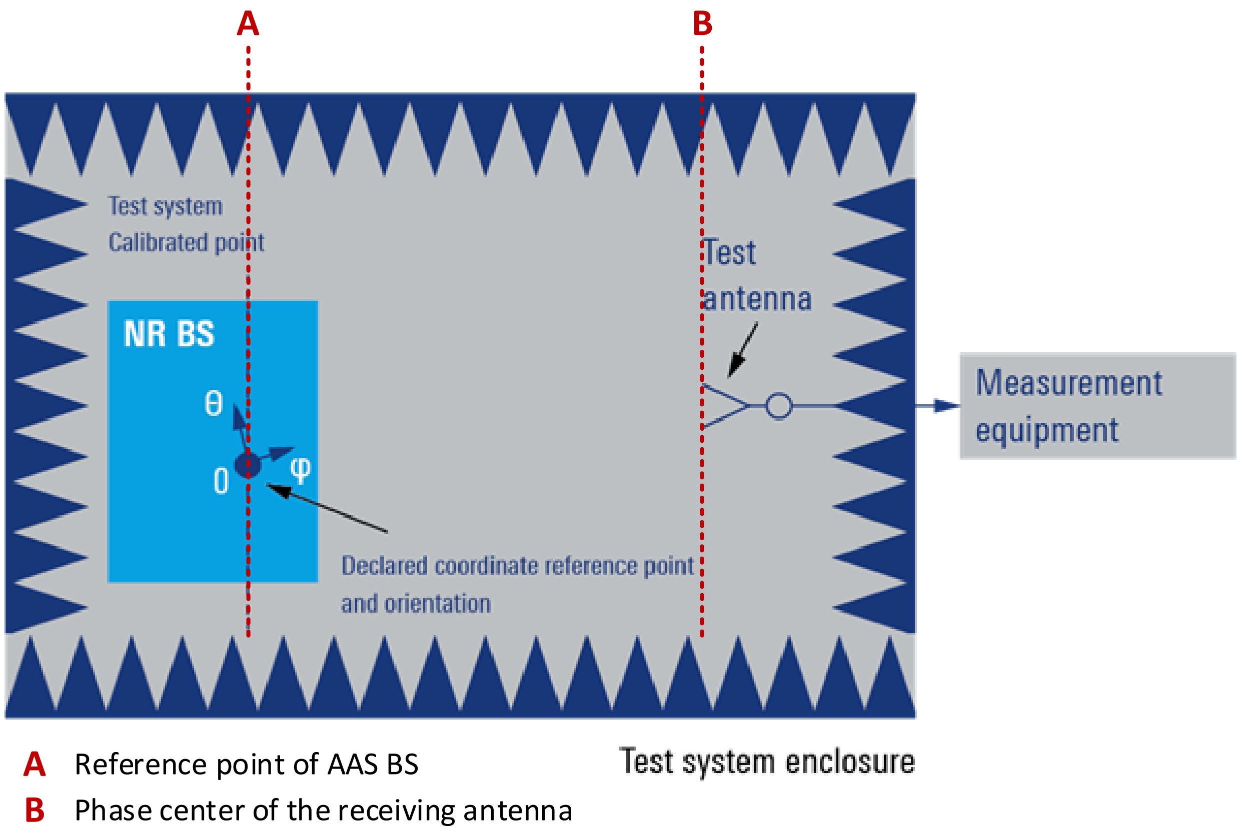
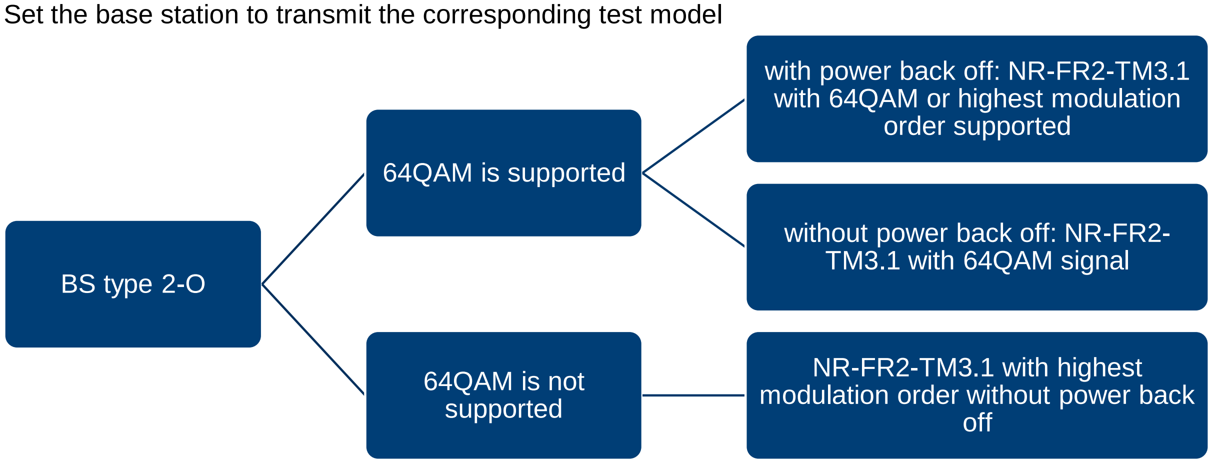
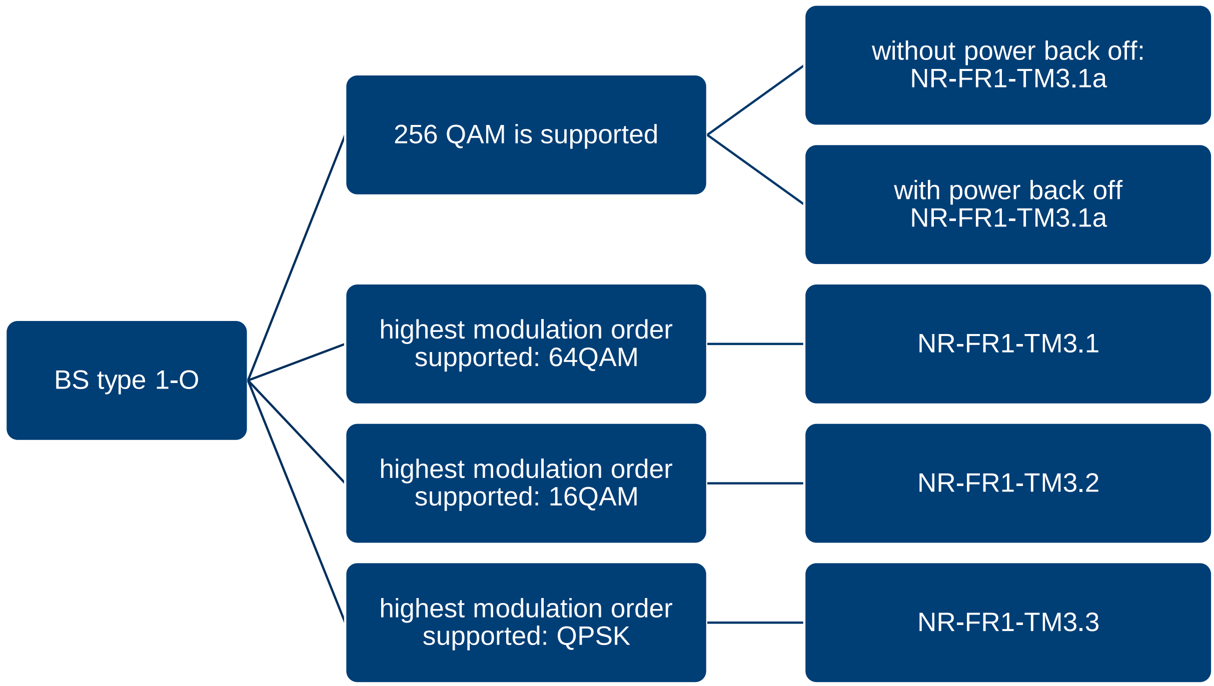


Figure 25: Test setup OTA modulation quality

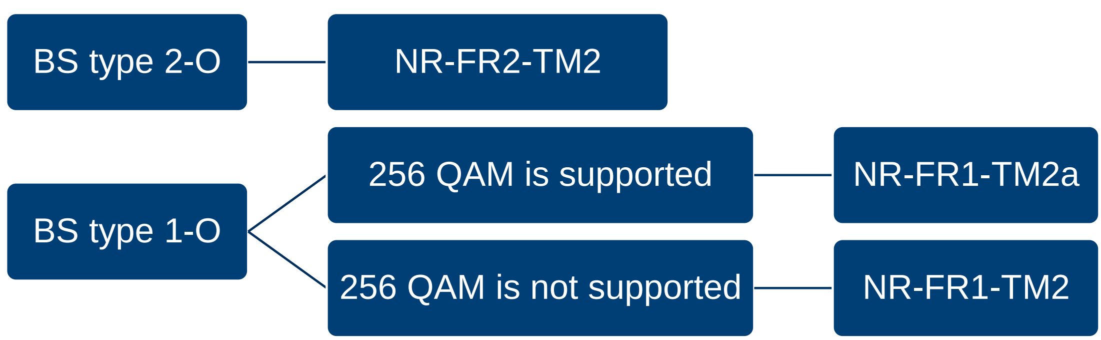
Test procedure

1. Place the base station at the positioner and align the coordinate system
2. Orient the base station in order that the direction to be tested aligns with the test antenna
3. Configure the beamforming settings of the base station to the direction to be tested
4. Set the base station to transmit the corresponding test model





5. Measure the EVM and the frequency error for each carrier
6. Repeat the measurement for the following test models



Note: The OFDM symbol power (in the conformance direction) shall be at the lower limit of the dynamic range according to the test procedure and test requirement in chapter 5.5.2.

5.7.3 OTA time alignment error (6.6.4)

This requirement shall apply to frame timing in MIMO transmission, carrier aggregation and their combinations. Frames of the NR signals present in the radiated domain are not perfectly aligned in time. In relation to each other, the RF signals present in the radiated domain may experience certain timing differences. For a specific set of signals/transmitter configuration/transmission mode, the OTA Time Alignment Error (OTA TAE) is defined as the largest timing difference between any two different NR signals. The OTA time alignment error requirement is defined as a directional requirement at the RIB and shall be met within the OTA coverage range. [2]

Measure the time alignment error between the different reference symbols on different beams on the carrier(s).

Table 19 lists the limits for the OTA TAE values.

Table 19: Test Requirements for OTA TAE

BS type	Combination	OTA TAE (µs)
BS type 1-O	MIMO transmission, at each carrier frequency	≤ 0.090
	intra-band contiguous carrier aggregation, with or without MIMO	≤ 0.285
	intra-band non-contiguous carrier aggregation, with or without MIMO	≤ 3.025
	inter-band carrier aggregation, with or without MIMO	≤ 3.025
BS type 2-O	MIMO transmission, at each carrier frequency	≤ 0.090
	intra-band contiguous carrier aggregation, with or without MIMO	≤ 0.155
	intra-band non-contiguous carrier aggregation, with or without MIMO	≤ 0.285
	inter-band carrier aggregation, with or without MIMO	≤ 3.025

Test setup

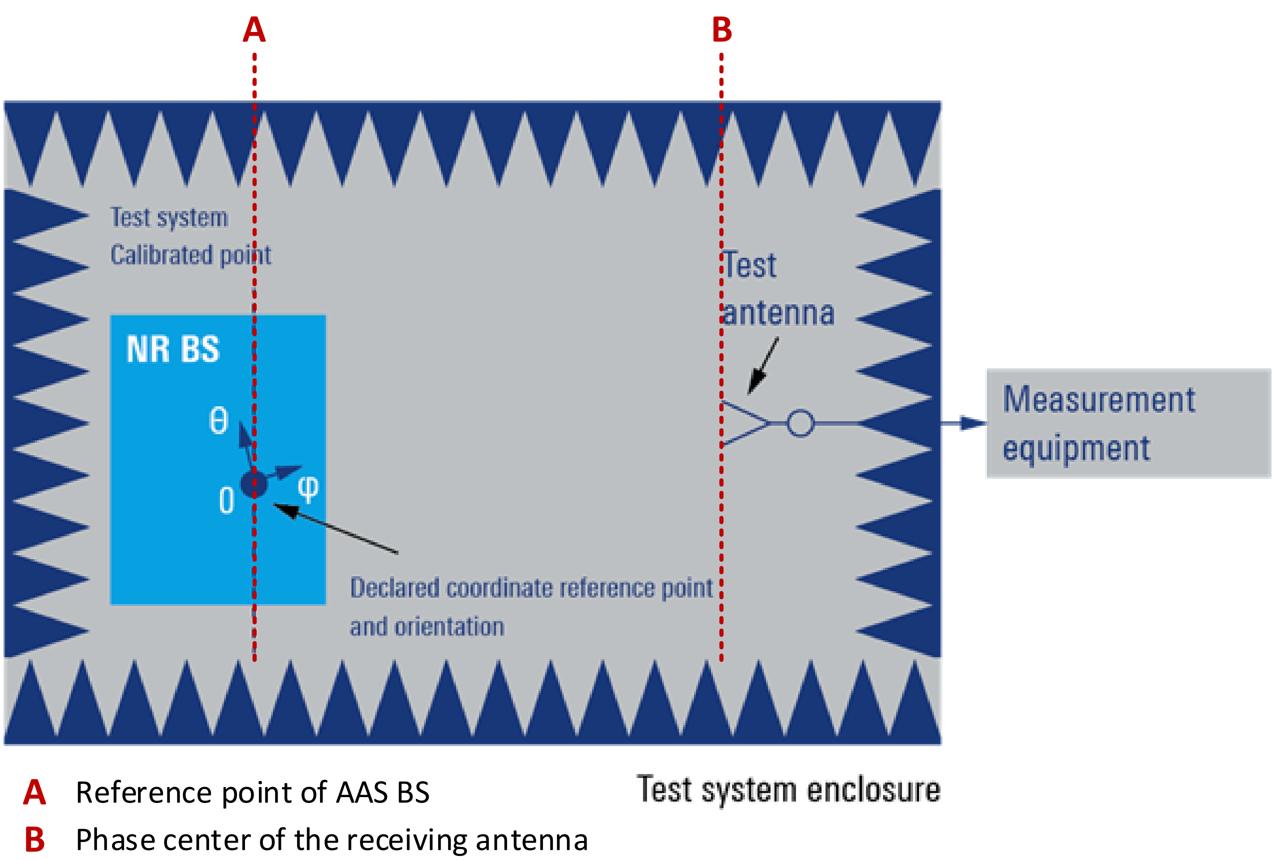


Figure 26: Test setup OTA time alignment error

Test procedure

1. Place the base station at the positioner and align the coordinate system
2. Move the base station in order that the direction to be tested aligns with the test antenna
3. Configure the beamforming settings of the base station to the direction to be tested
4. Select the corresponding test model
   a) BS type 2-O: NR-FR2-TM1.1 or any DL signal using MIMO transmission or carrier aggregation
   b) BS type 1-O: NR-FR1-TM1.1 or any DL signal using MIMO transmission or carrier aggregation

   Note: For MIMO transmission, different ports may be configured in NR-FR1-TM1.1 and NR-FR2-TM1.1 (using DMRS ports p = 1000 and 1001 with CDM)
   For a BS declared to be capable of single carrier operation only, set the BS to transmit according to the applicable test configuration using the corresponding test model at manufacturer's declared rated output power, $P_{rated,c,TRP}$.
5. Measure the time alignment error between the different reference symbols on different beams on the carriers

5.8 OTA unwanted emissions (6.7)

OTA unwanted emissions consist of so-called out-of-band emissions and spurious emissions according to ITU definitions. In ITU terminology, out of band emissions are unwanted emissions immediately outside the BS channel bandwidth resulting from the modulation process and non-linearity in the transmitter but excluding spurious emissions. Spurious emissions are emissions which are caused by unwanted transmitter effects such as harmonics emission, parasitic emission, intermodulation products and frequency conversion products, but exclude out of band emissions. The OTA out-of-band emissions requirement for the BS type 1-O and BS type 2-O transmitter is specified both in terms of Adjacent Channel Leakage Power Ratio (ACLR) and operating band unwanted emissions (OBUE). The OTA operating band unwanted emissions define all unwanted emissions in each supported downlink operating band plus the frequency ranges Δf_{OBUE} above and Δf_{OBUE} below each band. OTA Unwanted emissions outside of this frequency range are limited by an OTA spurious emissions requirement. [2]

The maximum offset of the operating band unwanted emissions mask from the operating band edge is Δf_{OBUE}. The value of Δf_{OBUE} is defined in Table 20.

Table 20: Maximum offset Δf_{OBUE} outside the downlink operating band

BS type	Operating band characteristics	Δf_{OBUE} (MHz)
BS type 1-O	$F_{DL\_high} – F_{DL\_low} < 100$ MHz	10
	100 MHz $\leq F_{DL\_high} – F_{DL\_low} \leq$ 900 MHz	40
BS type 2-O	$F_{DL\_high} – F_{DL\_low} \leq$ 3250 MHz	1500

5.8.1 OTA occupied bandwidth (6.7.2)

The OTA occupied bandwidth is the width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to a specified percentage β/2 of the total mean transmitted power. The value of β/2 shall be taken as 0.5%.

The test purpose is to verify that the emission at the RIB does not occupy an excessive bandwidth for the service to be provided and is, therefore, not likely to create interference to other users of the spectrum beyond undue limits. [2]

Table 21: Span and number of measurement points for OBW measurements for FR1

Bandwidth	BS channel bandwidth BWChannel (MHz)					Aggregated BS channel bandwidth BWChannel_CA (MHz)
	5	**10**	**15**	**20**	**> 20**	**> 20**
Span (MHz)	10	20	30	40	$2 \times BW_{Channel}$	$2 \times BW_{Channel\_CA}$
Minimum number of measurement points	400	400	400	400	$\left\lceil \frac{2 \times BW_{Channel}}{100kHz} \right\rceil$	$\left\lceil \frac{2 \times BW_{Channel\_CA}}{100kHz} \right\rceil$

Table 22: Span and number of measurement points for OBW measurements for FR2

Bandwidth	BS channel bandwidth BWChannel (MHz)				Aggregated BS channel bandwidth BWChannel_CA (MHz)
	50	**100**	**200**	**400**	**> 50**
Span (MHz)	$2 \times BW_{Channel}$				$\mathbf{2 \times BW_{Channel\_CA}}$
Minimum number of measurement points	$\left\lceil \frac{2 \times BW_{Channel}}{200kHz} \right\rceil$				$\left\lceil \mathbf{\frac{2 \times BW_{Channel\_CA}}{200kHz}} \right\rceil$

The measured OTA occupied bandwidth for each carrier shall be smaller than the channel bandwidth. For contiguous CA, the occupied bandwidth shall be less than or equal to the aggregated BS channel bandwidth (see Table 21 and Table 22).

Test setup

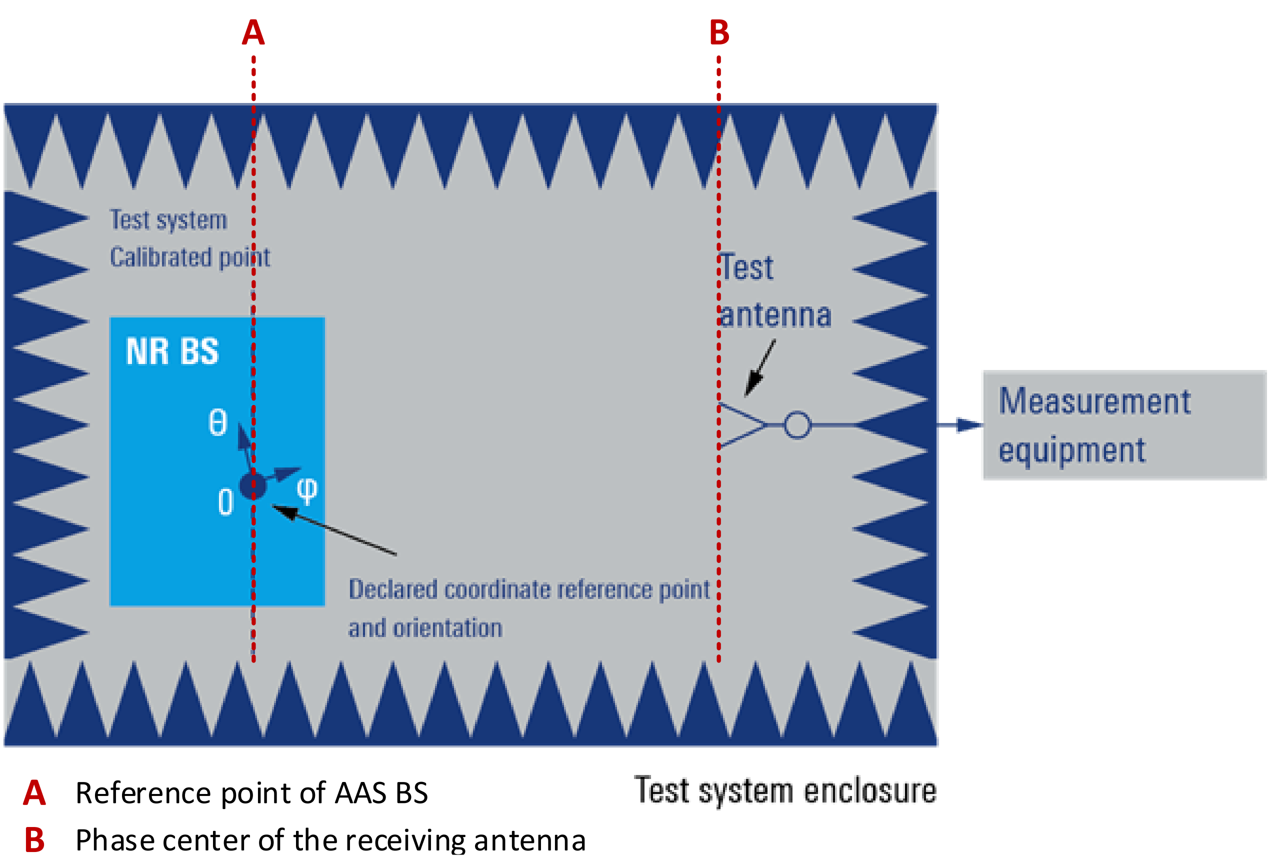


Figure 27: Measurement setup for OTA occupied bandwidth test

Test procedure

1. Place the base station at the positioner and align the coordinate system
2. Move the base station in order that the direction to be tested aligns with the test antenna
3. Configure the beam peak direction of the base station to the declared beam direction pair
4. Set the base station to transmit signal
   a) BS type 2-O: NR-FR2-TM1.1
   b) BS type 1-O: according to TS 38.141-1 [1]
5. Measure the spectrum emission of the transmitted signal (measurement settings according to Table 21 and Table 22
6. Compute total EIRP (P0) of all measurement cells in the measurement span
7. Compute the EIRP (P1) outside the occupied bandwidth on each side
8. Measure EIRP for any two orthogonal polarizations (p1 and p2) and calculate total radiated transmit power: $\mathrm{EIRP} = \mathrm{EIRP}_{p1} + \mathrm{EIRP}_{p2}$
9. Determine the lowest frequency (f_1) for which the sum of all EIRP in the measurement cells from the beginning of the span to f_1 exceeds P1
10. Determine the highest frequency (f_2) for which the sum of all EIRP in the measurement cells from the end of the span to f_2 exceeds P1
11. Calculate OTA occupied bandwidth: $OBW_{OTA} = f_2 - f_1$

5.8.2 OTA Adjacent Channel Leakage Power Ratio (ACLR) (6.7.3)

OTA Adjacent Channel Leakage power Ratio (ACLR) is the ratio of the filtered mean power centered on the assigned channel frequency to the filtered mean power centered on an adjacent channel frequency. The measured power is TRP. [2]

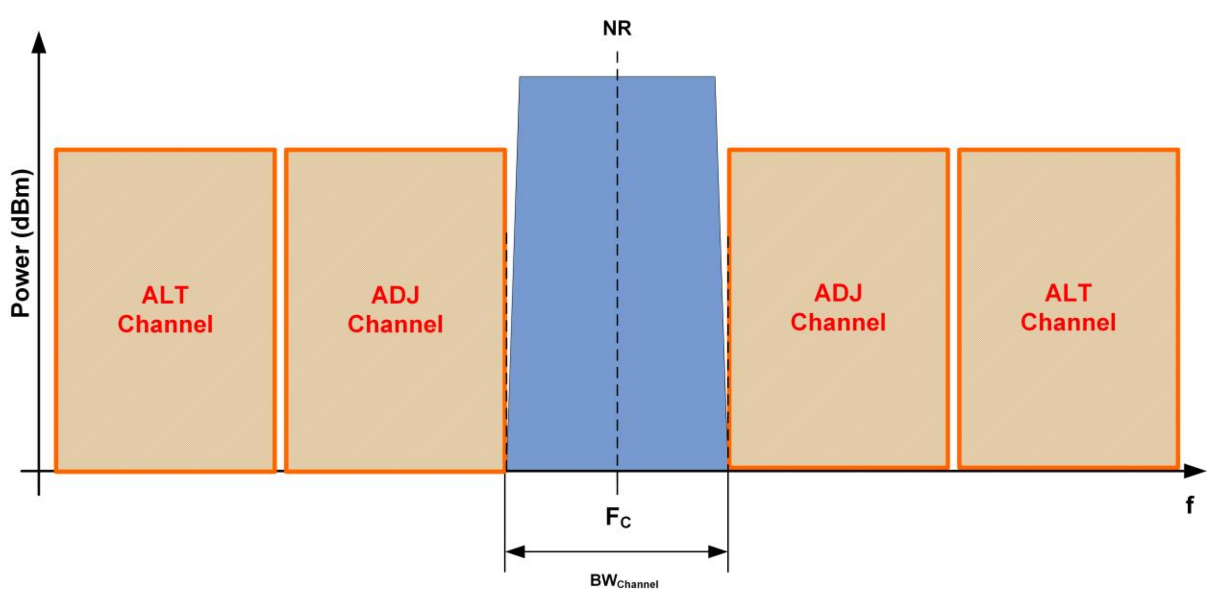


Figure 28: ACLR

For the OTA ACLR requirement either the OTA ACLR limits or the OTA ACLR absolute limits shall apply, whichever is less stringent. Furthermore the OTA CACLR limits or the OTA CACLR absolute limits shall apply, whichever is less stringent.

Table 23: BS type 1-O ACLR absolute limit

BS category / BS class	OTA ACLR absolute limit
Category A Wide Area BS	-4 dBm/MHz
Category B Wide Area BS	-6 dBm/MHz
Medium Range BS	-16 dBm/MHz
Local Area BS	-23 dBm/MHz

Table 24: BS type 1-O ACLR limit

BS channel bandwidth of lowest/highest NR carrier transmitted BWChannel (MHz)	BS adjacent channel center frequency offset below the lowest or above the highest carrier center frequency transmitted	Assumed adjacent channel carrier (informative)	Filter on the adjacent channel frequency and corresponding filter bandwidth	OTA ACLR limit (0 – 3 GHz)	OTA ACLR limit (3 – 6 GHz)
5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90,100	$BW_{Channel}$	NR of same BW[2)]	Square (BW_{Config})	44 dB	43.8 dB
	2 x $BW_{Channel}$	NR of same BW[2)]	Square (BW_{Config})	44 dB	43.8 dB
	$BW_{Channel}$ /2 + 2.5 MHz	5 MHz E-UTRA	Square (4.5 MHz)	44 dB[3)]	43.8 dB[3)]
	$BW_{Channel}$ /2 + 7.5 MHz	5 MHz E-UTRA	Square (4.5 MHz)	44 dB[3)]	43.8 dB[3)]

Table 25: BS type 1-O ACLR limit in non-contiguous spectrum or multiple bands

BS channel BW of lowest/ highest NR carrier transmitted $BW_{Channel}$ (MHz)	Sub-block or Inter RF BW gap size (W_{gap}) where the limit applies (MHz)	BS adjacent channel center frequency offset below or above the sub-block or BS RF BW edge (inside the gap)	Assumed adjacent channel carrier	Filter on the adjacent channel frequency and corresponding filter bandwidth	OTA ACLR limit (0-3 GHz)	OTA ACLR limit (3-6 GHz)
5, 10, 15, 20	$W_{gap} \geq 15$ $W_{gap} \geq 45$	2.5 MHz	5 MHz NR	Square (BW_{Config})	44 dB	43.8 dB
	$W_{gap} \geq 20$ $W_{gap} \geq 50$	7.5 MHz	5 MHz NR	Square (BW_{Config})	44 dB	43.8 dB
25, 30, 40, 50, 60, 70, 80, 90, 100	$W_{gap} \geq 60$ $W_{gap} \geq 30$	10 MHz	20 MHz NR	Square (BW_{Config})	44 dB	43.8 dB
	$W_{gap} \geq 80$ $W_{gap} \geq 50$	30 MHz	20 MHz NR	Square (BW_{Config})	44 dB	43.8 dB

Table 26: BS type 1-O CACLR limit

BS channel BW of lowest/ highest NR carrier transmitted $BW_{Channel}$ (MHz)	Sub-block or Inter RF BW gap size (W_{gap}) where the limit applies (MHz)	BS adjacent channel center frequency offset below or above the sub-block or BS RF Bandwidth edge (inside the gap)	Assumed adjacent channel carrier	Filter on the adjacent channel frequency and corresponding filter bandwidth	OTA CACLR limit (0-3 GHz)	OTA CACLR limit (3-6 GHz)
5, 10, 15, 20	$5 \leq W_{gap} < 15$ $5 \leq W_{gap} < 45$	2.5 MHz	5 MHz NR	Square (BW_{Config})	44 dB	43.8 dB
	$10 < W_{gap} < 20$ $10 \leq W_{gap} < 50$	7.5 MHz	5 MHz NR	Square (BW_{Config})	44 dB	43.8 dB
25, 30, 40, 50, 60, 70, 80,90, 100	$20 \leq W_{gap} < 60$ $20 \leq W_{gap} < 30$	10 MHz	20 MHz NR	Square (BW_{Config})	44 dB	43.8 dB
	$40 < W_{gap} < 80$ $40 \leq W_{gap} < 50$	30 MHz	20 MHz NR	Square (BW_{Config})	44 dB	43.8 dB

Table 27: BS type 1-O CACLR absolute limit

BS category / BS class	OTA CACLR absolute limit
Category A Wide Area BS	-4 dBm/MHz
Category B Wide Area BS	-6 dBm/MHz
Medium Range BS	-16 dBm/MHz
Local Area BS	-23 dBm/MHz

Table 28: Filter parameters for the assigned channel

RAT of the carrier adjacent to the sub-block or Inter RF Bandwidth gap	Filter on the assigned channel frequency and corresponding filter bandwidth
NR	NR of same BW with SCS that provides largest transmission bandwidth configuration

Table 29: BS type 2-O ACLR absolute limit

BS class	ACLR absolute limit
Wide-area BS	-10.3dBm/MHz
Medium-range BS	-17.3 dBm/MHz
Local-area BS	-17.3 dBm/MHz

Table 30: BS type 2-O ACLR limit

BS channel BW of lowest/ highest NR carrier transmitted $BW_{Channel}$ (MHz)	BS adjacent channel center frequency offset below the lowest or above the highest carrier center frequency transmitted	Assumed adjacent channel carrier	Filter on the adjacent channel frequency and corresponding filter bandwidth	OTA ACLR limit (dB)
50, 100, 200, 400	$BW_{Channel}$	NR of same BW	Square (BW_{Config})	25.7 23.4

Table 31: BS type 2-O ACLR limit in non-contiguous spectrum

BS channel bandwidth of lowest/highest NR carrier transmitted (MHz)	Sub-block gap size (Wgap) where the limit applies (MHz)	BS adjacent channel centre frequency offset below or above the sub-block edge (inside the gap)	Assumed adjacent channel carrier	Filter on the adjacent channel frequency and corresponding filter bandwidth	OTA ACLR limit (MHz)
50, 100	$W_{gap} \geq 100$ $W_{gap} \geq 250$	25 MHz	50 MHz NR	Square (BW_{Config})	25.7 23.4
200, 400	$W_{gap} \geq 400$ $W_{gap} \geq 250$	100 MHz	200 MHz NR	Square (BW_{Config})	25.7 23.4

Table 32: BS type 2-O ACLR limit in non-contiguous spectrum

BS channel bandwidth of lowest/ highest NR carrier transmitted (MHz)	Sub-block gap size (W_{gap}) where the limit applies (MHz)	BS adjacent channel centre frequency offset below or above the sub-block edge (inside the gap)	Assumed adjacent channel carrier	Filter on the adjacent channel frequency and corresponding filter bandwidth	OTA CACLR limit (dB)
50, 100	$50 \leq W_{gap} < 100$ $50 \leq W_{gap} < 250$	25 MHz	50 MHz NR	Square (BW_{Config})	25.7 23.4
200, 400	$200 \leq W_{gap} < 400$ $200 \leq W_{gap} < 250$	100 MHz	200 MHz NR	Square (BW_{Config})	25.7 23.4

Table 33: BS type 2-O CACLR absolute limit

BS class	CACLR absolute limit
Wide area BS	-10.3 dBm/MHz
Medium range BS	-17.3 dBm/MHz
Local area BS	-17.3 dBm/MHz

Table 34: Filter parameters for the assigned channel

RAT of the carrier adjacent to the sub-block gap	Filter on the assigned channel frequency and corresponding filter bandwidth
NR	NR of same BW with SCS that provides largest transmission bandwidth configuration

Test setup

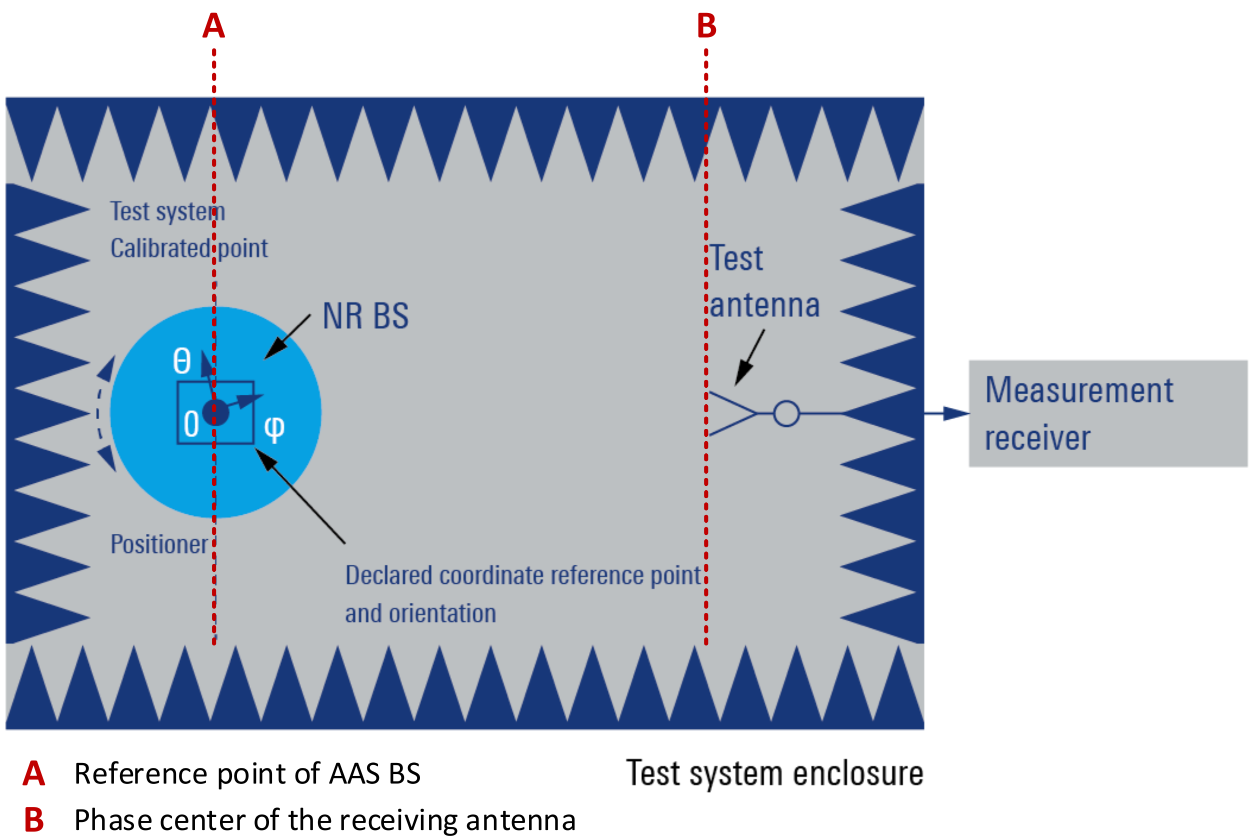


Figure 29: Measurement setup for OTA ACLR

Test procedure

1. Place the base station at the positioner and align the coordinate system
2. Measurement devices characteristics
   a) Detection mode: true RMS voltage or true power averaging
   b) Measurement filter bandwidth: according to the preceding tables
3. Set the base station to transmit test model
   a) BS type 2-O: NR-FR2-TM1.1
   b) BS type 1-O: according to TS 38.141-1 [1]
4. Align the BS and the test antenna (TRP measurement can be performed)
5. Measure the absolute power of the assigned frequency and the adjacent channel frequency
6. Repeat step 4 and step 5 for all directions in the TRP measurement grid
7. Calculate $TRP_{Estimate}$ (wanted channel and adjacent channel)

$$\text{TRP}_{\text{Estimate}} = \frac{\pi}{2NM} \sum_{n=0}^{N-1} \sum_{m=0}^{M-1} \text{EIRP}(\theta_n, \varphi_m) \sin \theta_n$$

8. Calculate relative ACLR estimate
   ACLR is calculated by the ratio of the absolute TRP of the assigned channel frequency and the absolute TRP of the adjacent frequency channel.
9. Measure OTA ACLR for the frequency offsets both side of channel frequency (according to Table 24 and Table 30)
10. For the OTA ACLR requirement applied inside sub-block gap for non-contiguous spectrum operation
    a) Measure OTA ACLR inside sub-block gap
    b) Measure OTA CACLR inside sub-block gap
11. Repeat the test with the channel setup using NR-FR1-TM1.2 for BS type 1-O

5.8.3 OTA operating band unwanted emissions (6.7.4)

This test measures the emissions of the BS, close to the assigned channel bandwidth of the wanted signal, while the BS is in operation. The OTA limits for operating band unwanted emissions are specified as TRP per RIB, unless otherwise stated. [2]

As of the large scope, the test requirements for this test were not printed in this application note. The requirements can be found in TS 38.141-2 [2] section 6.7.4.5.

Test setup

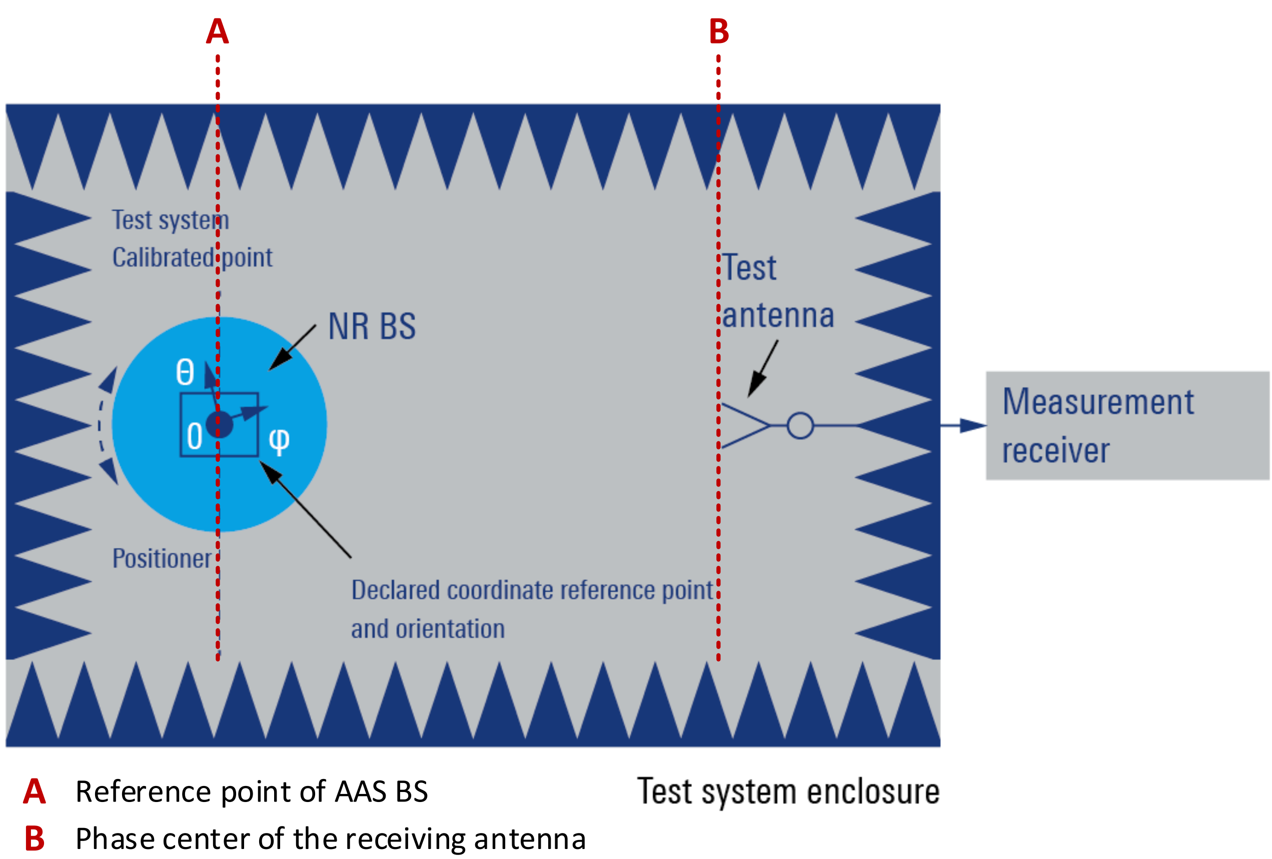


Figure 30: Measurement setup for OTA operating band unwanted emissions

Test procedure

1. Place the base station at the positioner and align the coordinate system
2. Measurement devices characteristics
   a) Detection mode: True RMS voltage or true power averaging
   b) Measurement filter bandwidth: according to the test requirement tables
3. Set the base station to transmit
   a) BS type 2-O: NR-FR2-TM1.1
   b) BS type 1-O: according to TS 38.141-1 [1]
4. Align the BS in order that the direction to be tested aligns with the test antenna such that TRP measurements can be performed
5. Sweep the center frequency of the measurement filter in contiguous steps
6. Measure emission power within the specified frequency ranges, with the specified measurement bandwidth
7. Repeat step 4, 5 and 6 for all directions in the TRP measurement grid
8. Calculate $TRP_{Estimate}$ (wanted channel and adjacent channel)

$$\mathrm{TRP}_{\mathrm{Estimate}} = \frac{\pi}{2NM}\sum_{n=0}^{N-1}\sum_{m=0}^{M-1}\mathrm{EIRP}(\theta_n, \varphi_m)\sin\theta_n$$

Note: For BS type 1-O and multi-band RIB and single band tests, repeat the steps above per involved band where single band test configurations and test models shall apply with no carrier activated in the other band.

5.8.4 OTA transmitter spurious emissions (6.7.5)

The OTA transmitter spurious emission limits for FR1 shall apply from 30 MHz to 12.75 GHz, excluding the frequency range from Δf_{OBUE} below the lowest frequency of each supported downlink operating band, up to Δf_{OBUE} above the highest frequency of each supported downlink operating band, where the Δf_{OBUE} is defined in Table 20. For some operating bands, the upper limit of the spurious range might be higher than 12.75 GHz in order to comply with the 5th harmonic limit of the downlink operating band.

The OTA transmitter spurious emission limits for FR2 shall apply from 30 MHz to 2nd harmonic of the upper frequency edge of the downlink operating band, excluding the frequency range from Δf_{OBUE} below the lowest frequency of each supported downlink operating band, up to Δf_{OBUE} above the highest frequency of each supported downlink operating band, where the Δf_{OBUE} is defined. [2]

5.8.4.1 General OTA transmitter spurious emissions (6.7.5.2)

The test purpose is to verify if the radiated spurious emissions from the BS at the RIB are within the specified minimum requirements. [2]

Table 35: RF channels to be tested

FR	From - To	RF channel
FR1	30MHz to F_{DL_low} - Δf_{OBUE}	B
	F_{DL_high} + Δf_{OBUE} to 12.75 GHz (or to 5th harmonic)	T
FR2	30 MHz to F_{DL_low} - Δf_{OBUE}	B
	F_{DL_high} + Δf_{OBUE} to 2nd harmonic (or to 60 GHz)	T

Table 36: General OTA BS transmitter spurious emission limits for BS type 1-O, category A

Spurious frequency range	Test limit	Measurement bandwidth
30 MHz – 1 GHz	-13 + X dBm	100 kHz
1 GHz – 12.75 GHz		1 MHz
12.75 GHz – 5th harmonic of the upper frequency edge of the DL operating band in GHz		1 MHz

Table 37: General OTA BS transmitter spurious emission limits for BS type 1-O, category B

Spurious frequency range	Test limit	Measurement bandwidth
30 MHz – 1 GHz	-36 + X dBm	100 kHz
1 GHz – 12.75 GHz	-30 + X dBm	1 MHz
12.75 GHz – 5th harmonic of the upper frequency edge of the DL operating band in GHz		1 MHz

Table 38: General OTA BS transmitter spurious emission limits for BS type 2-O

Spurious frequency range	Test limit	Measurement bandwidth
30 MHz – 1 GHz	-13 dBm	100 kHz
1 GHz – min(2nd harmonic of the upper frequency edge of the DL operating band in GHz; [60] GHz)		1 MHz

Table 39: BS radiated Tx spurious emission limits in FR2 (category B)

Frequency range (Note 4)	Test limit	Measurement Bandwidth
30 MHz ↔ 1 GHz	-36 dBm	100 kHz
1 GHz ↔ 18 GHz	-30 dBm	1 MHz
18 GHz ↔ $F_{step,1}$	-20 dBm	10 MHz
$F_{step,1}$ ↔ $F_{step,2}$	-15 dBm	10 MHz
$F_{step,2}$ ↔ $F_{step,3}$	-10 dBm	10 MHz
$F_{step,4}$ ↔ $F_{step,5}$	-10 dBm	10 MHz
$F_{step,5}$ ↔ $F_{step,6}$	-15 dBm	10 MHz
$F_{step,6}$ ↔ min(2nd harmonic of the upper frequency edge of the DL operating band in GHz; [60] GHz)	-20 dBm	1 MHz

Table 40: Step frequencies for defining the BS radiated Tx spurious emission limits in FR2 (category B)

Operating band	$F_{step,1}$ [GHz]	$F_{step,2}$ [GHz]	$F_{step,3}$ [GHz]	$F_{step,4}$ [GHz]	$F_{step,5}$ [GHz]	$F_{step,6}$ [GHz]
n258	18.00	21.00	22.75	29.00	30.75	40.50

Test setup

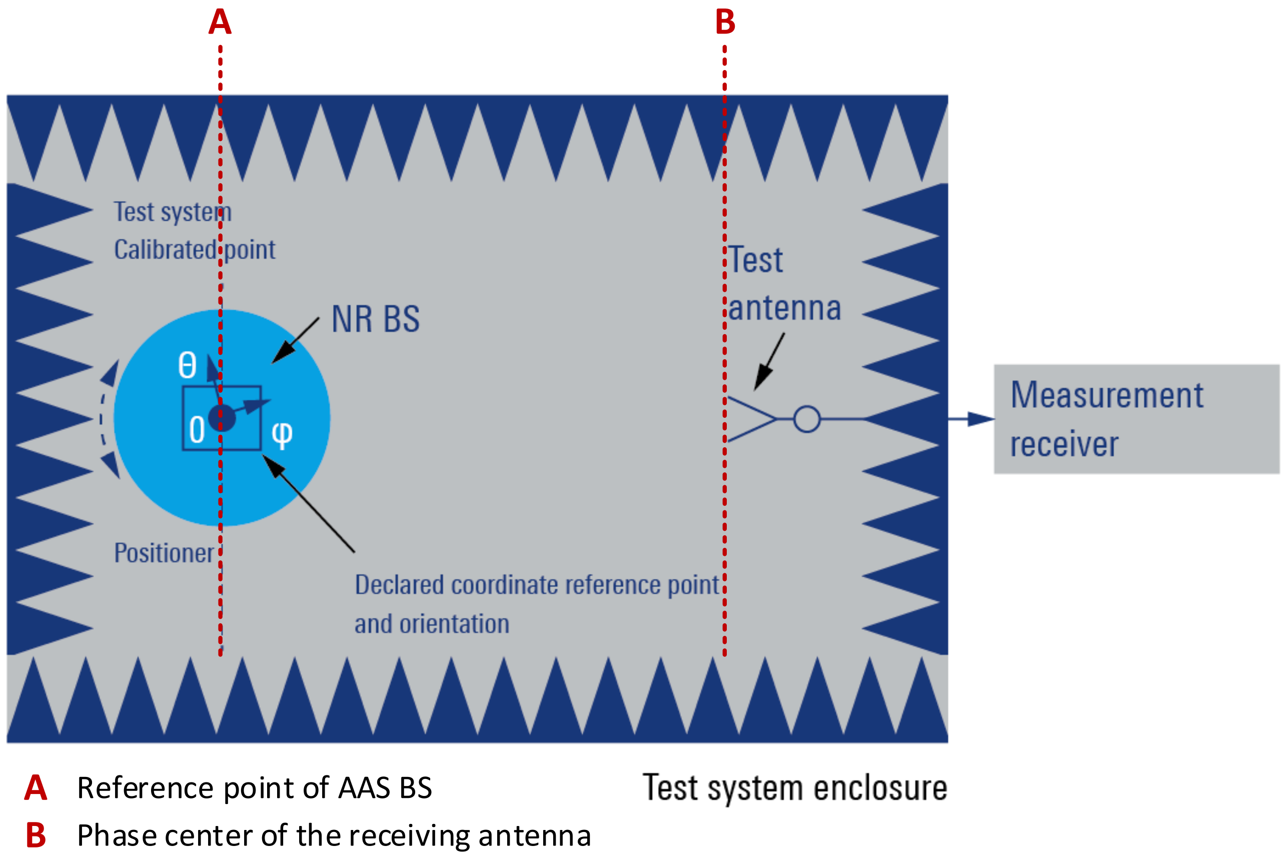


Figure 31: Measurement setup for OTA spurious emissions

Test procedure

1. Place the base station at the positioner and align the coordinate system
2. Measurements shall use a measurement bandwidth according to Table 36 to Table 39
3. Select detection mode: True RMS
4. Set the base station to transmit
   For BS type 2-O: NR-FR2-TM1.1
   For BS type 1-O: NR-FR1-TM1.1
5. Align the BS in order that the direction to be tested aligns with the test antenna such that TRP measurements can be performed
6. Measure the emission at the specified frequencies with specified measurement bandwidth according to Table 36 to Table 39.
7. Repeat step 5 and step 6 for all directions in the appropriated TRP measurement grid
8. Calculate TRP at each specified frequency

Note: For BS type 1-O and multi-band RIBs and single band tests, repeat the steps above per involved band where single band test configurations and test models shall apply with no carrier activated in the other band.

5.8.4.2 Protection of the BS receiver of own or different BS (6.7.5.3)

This requirement shall be applied for NR FDD operation in order to prevent the receivers of own or a different BS of the same band being desensitized by emissions from a BS type 1-O. This requirement is a co-location requirement. [2]

The test purpose is to verify that the emission is within the specified requirement limits at the CLTA conducted output(s). The co-location spurious emission is measured at the CLTA conducted output(s). [2]

RF channels to be tested for single carrier: M

Table 41: BS type 1-O OTA spurious emissions limits for protection of the BS receiver

BS class	Frequency range	Maximum Level for bands below 3GHz	Maximum Level for bands between 3 and 4.2GHz	Maximum Level for bands between 4.2 and 6GHz	Measurement bandwidth
Wide Area BS	$F_{UL\_low} – F_{UL\_high}$	-113.9 dBm	-113.7 dBm	-113.6 dBm	100 kHz
Medium Range BS		-108.9 dBm	-108.7 dBm	-108.6 dBm	
Local Area BS		-105.9 dBm	-105.7 dBm	-105.6 dBm	

Test setup

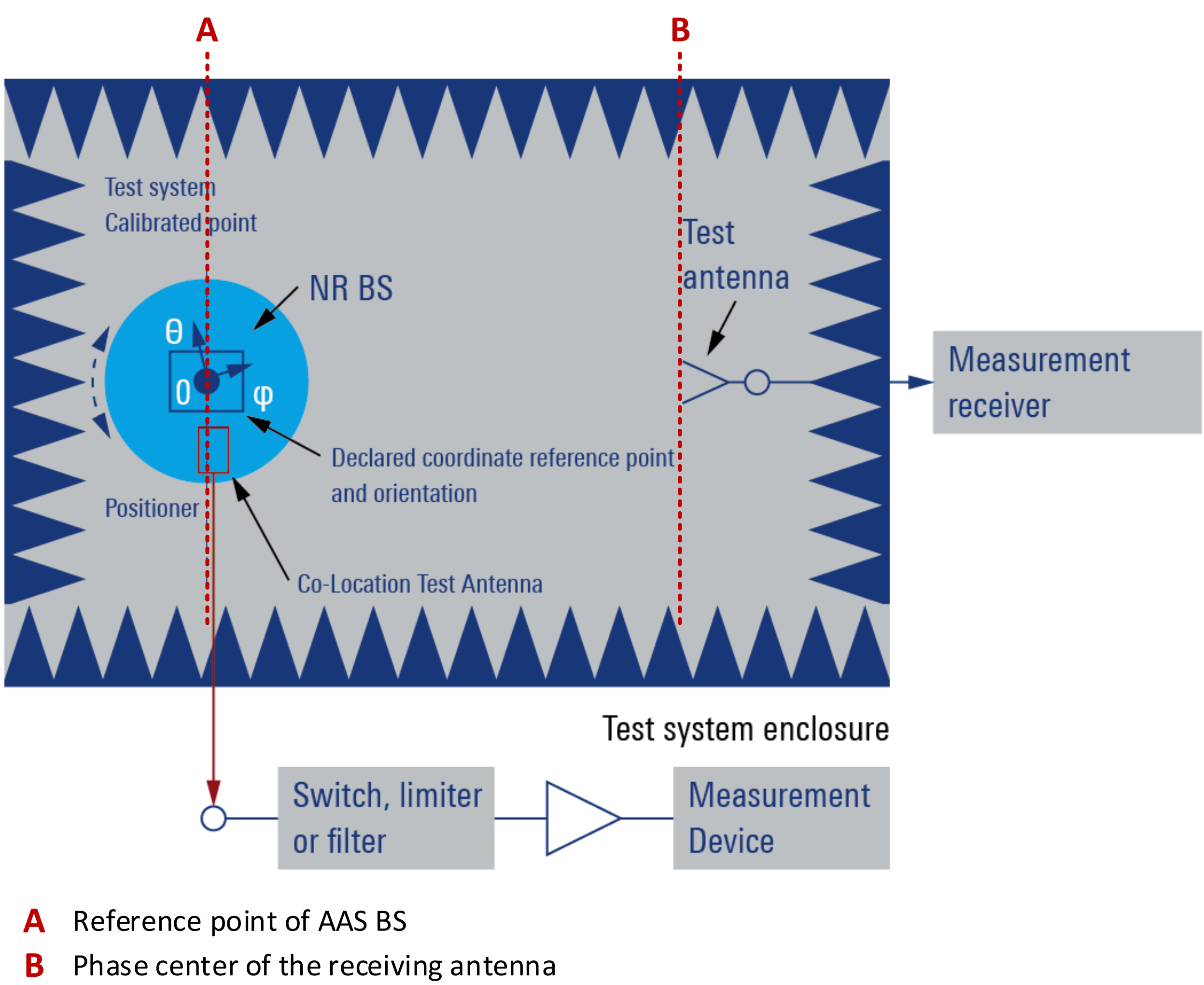


Figure 32: Measurement setup for OTA co-location emissions

Test procedure

1. Place the base station and the CLTA (Several CLTAs might be required to cover the whole co-location spurious emission frequency ranges; more information can be found in [2], subclause 4.12)
2. Place test antenna in reference direction at far-field distance, aligned in all supported
3. The test antenna shall be dual (or single) polarized with the same frequency range as the NR BS for co-location spurious emission test case
4. OTA co-location spurious emission is measured as the power sum over all supported polarizations at the CLTA conducted output(s)
5. The detection mode of the measurement device shall be "True RMS"
6. Set BS type 1-O to transmit test model according to TS 38.141-1 [1]
7. Measure the emission at the specified frequencies with specified measurement bandwidth

5.8.4.3 Additional spurious emissions requirements (6.7.5.4)

These requirements may be applied for the protection of systems operating in frequency ranges other than the BS downlink operating band. The limits may apply as an optional protection of such systems that are deployed in the same geographical area as the BS, or they may be set by local or regional regulation as a mandatory requirement for an NR operating band.

The test purpose is to verify the radiated spurious emissions from the BS at the RIB are within the specified additional spurious emissions requirements. [2]

Table 42: RF channels to be tested

FR	From - To	RF channel
FR1	30MHz to F_{DL_low} - Δf_{OBUE}	B
	F_{DL_high} + Δf_{OBUE} to 12.75 GHz (or to 5th harmonic)	T

As of the large scope, the test requirements for this test were not printed in this application note. The requirements can be found in TS 38.141-2 [2] section 6.7.5.4.5.

Test setup

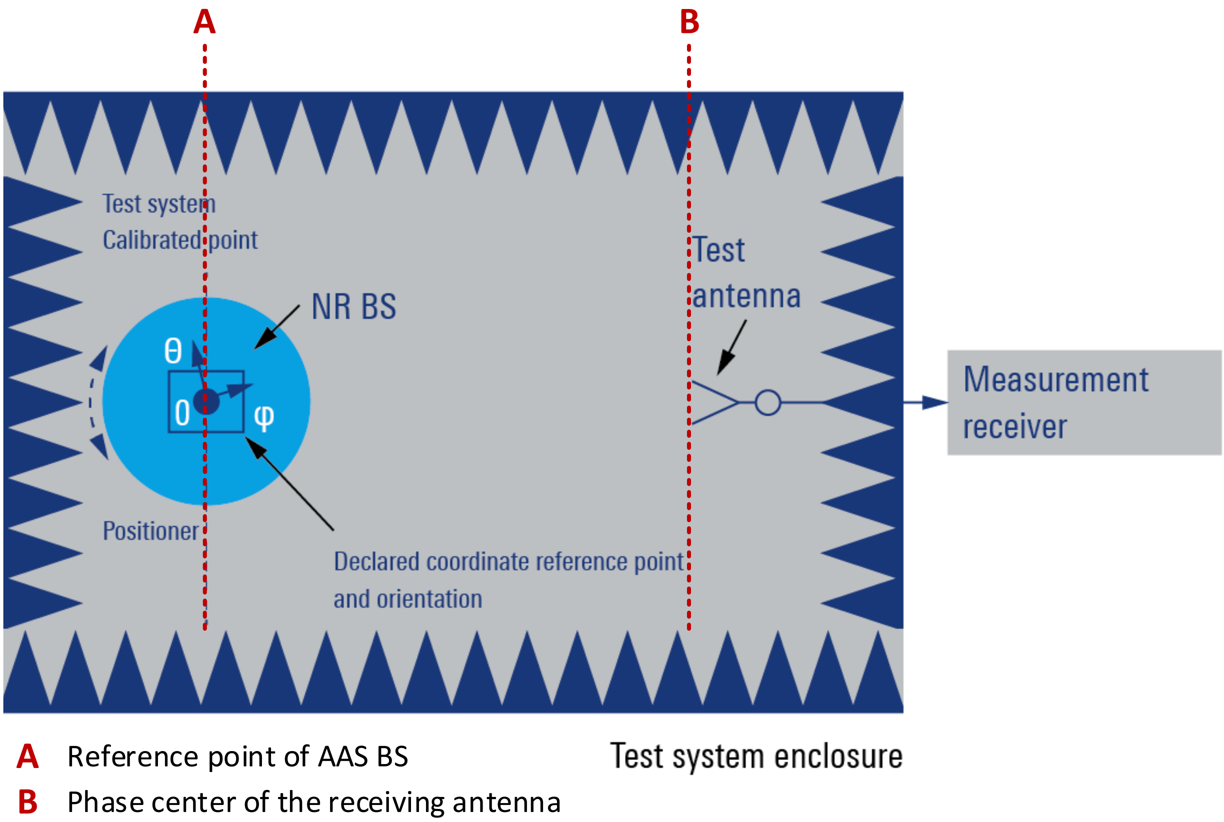


Figure 33: Measurement setup for OTA spurious emissions

Test procedure

1. Place the base station at the positioner and align the coordinate system
2. Measurements shall use a measurement bandwidth according
3. Select detection mode: True RMS
4. Select test model
   For BS type 1-O: NR-FR1-TM1.1
5. Align the BS in order that the direction to be tested aligns with the test antenna such that TRP measurements can be performed
6. Measure the emission at the specified frequencies with specified measurement bandwidth according to Table 36 to Table 39.
7. Repeat measurement for all directions in the appropriated TRP measurement grid
8. Calculate TRP at each specified frequency

Note: For BS type 1-O and multi-band RIBs and single band tests, repeat the steps above per involved band where single band test configurations and test models shall apply with no carrier activated in the other band.

5.8.4.4 Co-location requirements (6.7.5.5)

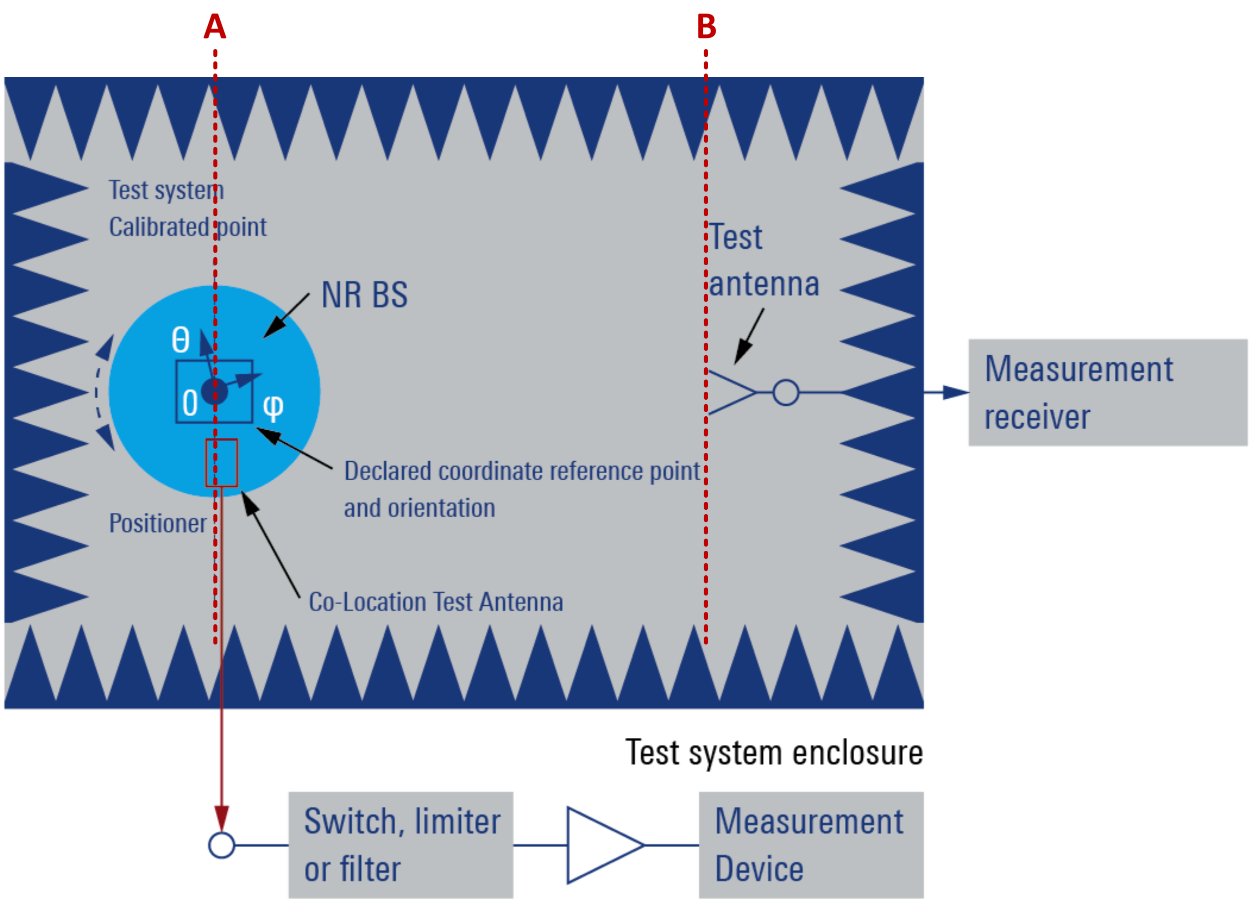
These requirements may be applied for the protection of other BS receivers when GSM900, DCS1800, PCS1900, GSM850, CDMA850, UTRA FDD, UTRA TDD,
E-UTRA and/or NR BS are co-located with a BS. The requirements assume co-location with base stations of the same class.

The test purpose is to verify that the emission is within the specified requirement limits at the CLTA conducted output(s). [2]

RF channels to be tested for single carrier: M

As of the large scope, the test requirements for this test were not printed in this application note. The requirements can be found in TS 38.141-2 [2] section 6.7.5.5.5

Test setup



A Reference point of AAS BS

B Phase center of the receiving antenna

Figure 34: Measurement setup for OTA co-location emissions

Test procedure

1. Place the base station and the CLTA (Several CLTAs might be required to cover the whole co-location spurious emission frequency ranges; more information can be found in [2], subclause 4.12)
2. Several CLTAs might be required to cover the whole co-location spurious emission frequency ranges
3. Place test antenna in reference direction at far-field distance, aligned in all supported
4. The test antenna shall be dual (or single) polarized with the same frequency range as the NR BS for co-location spurious emission test case
5. OTA co-location spurious emission is measured as the power sum over all supported polarizations at the CLTA conducted output(s)
6. The detection mode of the measurement device shall be "True RMS"
7. Set BS type 1-O to transmit test model according to TS 38.141-1 [1]
8. Measure the emission at the specified frequencies with specified measurement bandwidth

5.9 OTA transmitter intermodulation (6.8)

This test is not applicable for BS type 2-O.

The OTA transmitter intermodulation requirement is a measure of the capability of the transmitter unit to inhibit the generation of signals in its non-linear elements caused by presence of the wanted signal and an interfering signal reaching the transmitter unit via the RDN and antenna array from a co-located base station. The requirement applies during the transmitter ON period and the transmitter transient period.

The transmitter intermodulation level is the total radiated power of the intermodulation products when an interfering signal is injected into the colocation test antenna (CLTA).

For BS type 1-O, the transmitter intermodulation requirement is captured by the co-location transmitter intermodulation scenario case, in which the interfering signal is injected into the CLTA. [2]

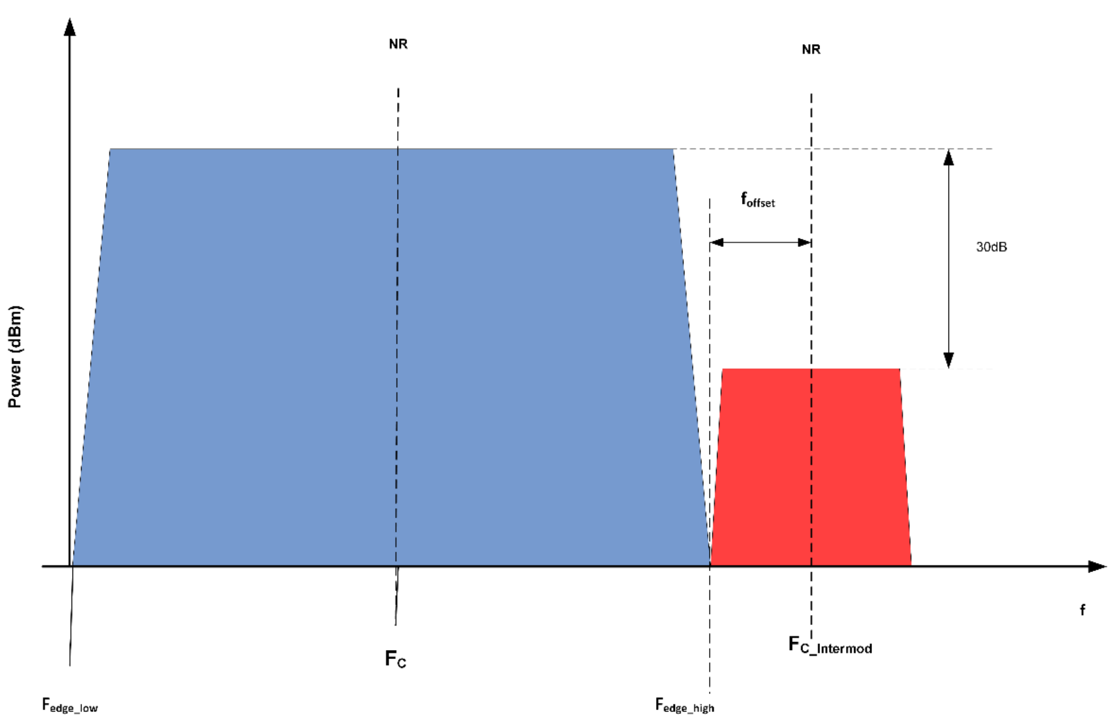


Figure 35: Transmitter intermodulation

The OTA transmitter intermodulation requirement is not applicable for BS type 2-O.

Table 43: Test requirements for BS type 1-O: Interfering and wanted signals for the OTA transmitter intermodulation requirement

Parameter	Value
Wanted signal	NR single or multi-carrier, or multiple intra-band contiguously or non-contiguously aggregated carriers
Interfering signal type	NR signal, the minimum BS channel bandwidth ($BW_{Channel}$) with 15 kHz SCS of the band defined in subclause 5.3.5 of TS 38.104 [2]
Interfering signal level	The interfering signal level is the same power level as the BS ($P_{rated,t,TRP}$) fed into a CLTA.
Interfering signal center frequency offset from the lower (upper) edge of the wanted signal or edge of sub-block inside a gap	$f_{offset} = \pm BW_{channel}\left(n - \frac{1}{2}\right)$ For n = 1, 2 and 3

Test setup

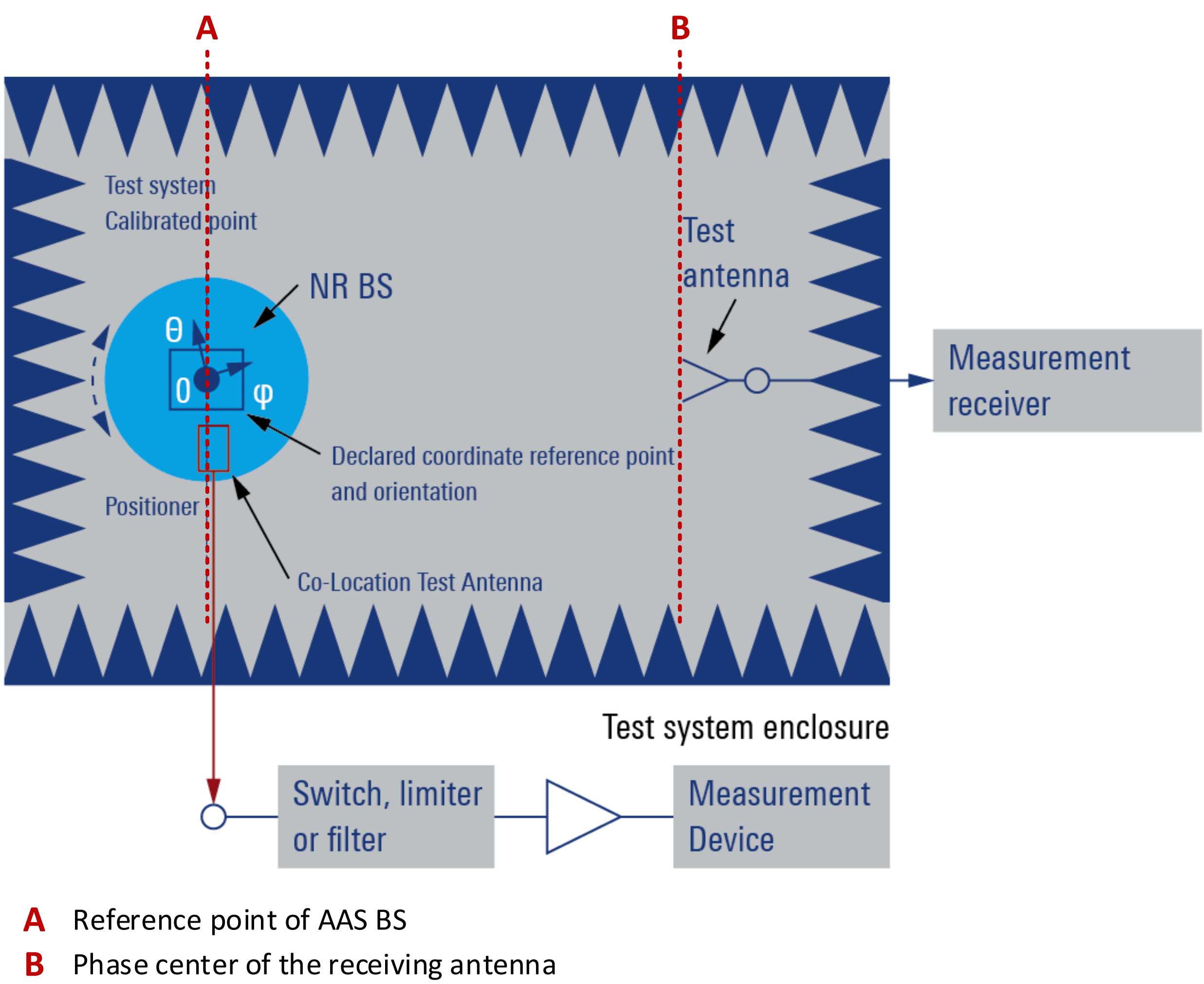


Figure 36: Measurement setup for OTA transmitter intermodulation

Test procedure

1. Select a CLTA; The test antenna(s) shall be dual (or single) polarized
   Note: Several test antennas are required to cover both the NR BS and the whole emission frequency range
2. Connect test antenna and CLTA to the measurement equipment according to Figure 36
3. The OTA emission measurement method shall be TRP and the detection mode of the measurement device shall be "True RMS"
4. Set the base station to transmit test model according to TS 38.141-1 [1]
5. SMW: Generating the interfering signal (via the CLTA)
   c) Select test model according to TS 38.141-1 [1]
   d) Center frequency offset according to Table 43
   e) Adjust the interfering signal (according to Table 43)
6. Perform OTA ACLR test (6.7.3), OTA OBUE test (6.7.4) and OTA spurious emission test (6.7.5) as specified in sub clause 5.8.2, 5.8.3 and 5.8.4
7. Repeat the test for the remaining interfering signal center frequency offsets

6 Literature

[1] 3GPP Technical Specification Group Radio Access Network, "NR Base station conformance testing, Part 1: Radiated conformance testing, Release 16; 3GPP TS 38.141-1, V16.3.0", 2020
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[4] 3GPP Technical Specification Group Radio Access Network, "NR Base Station (BS) radio transmission and reception, Release 15; TS 38.104, V16.3.0", 2020
Available: https://www.3gpp.org/DynaReport/38104.htm

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Available: https://www.rohde-schwarz.com/de/loesungen/test-and-measurement/wireless-communication/wireless-5g-and-cellular/5g-test-and-measurement/ota-white-paper_251028.html

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Available: https://scdn.rohde-schwarz.com/ur/pws/dl_downloads/dl_common_library/dl_brochures_and_datasheets/pdf_1/ATS1800C_pro-fly_en_3608-1298-32_v0100.pdf

[14] Rohde & Schwarz, "R&S PWC200 Plane Wave Converter - Product Flyer", 2019
Available: https://scdn.rohde-schwarz.com/ur/pws/dl_downloads/dl_common_library/dl_brochures_and_datasheets/pdf_1/PWC200_fly_en_5215-5971-32_v0200.pdf

7 Ordering Information

Type	Designation	Order No.
R&S®TS8991	OTA Performance Test System Note: includes WPTC test chambers	1119.4309.02
R&S®ATS1800C	Compact antenna test range (CATR) OTA test system	1534.1800K02
R&S®ATS-C50MF	50 GHz cable, length: 1.2m (M-F)	1535.7977.02
R&S®ATS-C50MM	50 GHz cable, length 1.2m (M-M)	1535.7983.02
R&S®PWC200	Plane Wave Converter	1532.3006.02
R&S®FSW67	Signal and spectrum analyzer	1331.5003.67
R&S®FSW-K144	3GPP 5G-NR downlink measurements	1338.3606.02
R&S®FSW-K544	User defined frequency response correction by SnP file	1338.2716.02
R&S®SMBV100B	Vector signal generator	1423.1003.02
R&S®SMBVB-B103	Frequency range 8 kHz to 3 GHz	1423.6270.02
R&S®SMBVBKB106	Frequency extension 6 GHz	1423.6370.02
R&S®SMBVB-K520	Baseband realtime extension	1423.7676.02
R&S®SMBVB-K144	5G New Radio	1423.8608.02
R&S®SMW200A	Vector signal generator	1412.0000.02
R&S®SMW-B1007	Frequency option	1428.7700.02
R&S®SMW-B10 or **R&S®SMW-B9**	Baseband generator option	1413.1200.02 or 1413.7350.02
R&S®SMW-B13T or **R&S®SMW-B13XT**	Baseband main module option	1413.3003.02 or 1413.8005.02
R&S®SMW-K144	5G New Radio	1414.4990.02
R&S®SMW-K544	User-defined frequency response correction	1414.3707.02

Please note that the above table does not include all the test instruments and system components needed for 5G NR base station conformance testing.

For further ordering information please contact your local sales team:

► https://www.rohde-schwarz.com/service-sales-locator

8 Appendix

A Glossary

Abbreviation	Description
5G NR	5G New Radio
ACLR	Adjacent channel leakage power ratio
BS	Base station
CA	Carrier aggregation
CATR	Compact antenna test range
CLTA	Colocation test antenna
DUT	Device under test
EIRP	Equivalent isotropically radiated power
EVM	Error vector magnitude
FDD	Frequency division duplex
FFS	For further study
FR1	Frequency range 1
IAC	Indoor anechoic chamber
MIMO	Multiple input multiple output
OBUE	Operating band unwanted emissions
OBW	Occupied bandwidth
OTA	Over the air
PDSCH	Physical downlink shared channel
P_{rat}	Rated output power
Px-	Performance-
RB	Resource block
RBW	Resolution bandwidth
RF	Radio frequency
RIB	Radiated interface boundary
RS	Reference signal
Rx-	Receiver-
SC	Single carrier
SCS	Subcarrier spacing
SSB	Synchronization signal block
TAB	Transceiver array boundary

TAE	Time alignment error
TDD	Time division duplex
TM	Test model
TRP	Total radiated power
Tx-	Transmitter-
UE	User equipment
VSWR	Voltage standing wave ratio
WPTC	Wireless Performance Test Chamber

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