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TECHNICAL REPORT

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General aspects for Base Station (BS)
Radio Frequency (RF) for NR
(3GPP TR 38.817-02 version 15.11.0 Release 15)

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Contents

Foreword

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will not indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

might indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

might not indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

is (or any other verb in the indicative mood) indicates a statement of fact

is not (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

1 Scope

The present document is a technical report for the work item on Work Item on New Radio (NR) Access Technology, covering the general aspects for BS RF for NR.

NOTE: In Rel-15, multiple clauses related to the OTA measurements of the BS were shifted to the OTA BS testing TR 37.941 [36], which includes such aspects as e.g., test tolerance and measurement uncertainty derivations, OTA test chambers descriptions, calibration and test procedure descriptions, etc.

2 References

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

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] Recommendation ITU-R M.1036-5 (10/2015), "Frequency arrangements for implementation of the terrestrial component of International Mobile Telecommunications (IMT) in the bands identified for IMT in the Radio Regulations (RR)".

[3] 3GPP TS 38.104: "NR; Base Station (BS) radio transmission and reception".

[4] ITU-R Recommendation SM.329: "Unwanted emissions in the spurious domain".

[5] ITU-R Recommendation SM.328: "Spectra and bandwidth of emissions".

[6] 3GPP TS 36.104: "Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception".

[7] 3GPP TS 37.105: "Active Antenna System (AAS) Base Station (BS) transmission and reception".

[8] 3GPP TR 37.842: "Evolved Universal Terrestrial Radio Access (E-UTRA) and Universal Terrestrial Radio Access (UTRA; Radio Frequency (RF) requirement background for Active Antenna System (AAS) Base Station (BS)".

[9] 3GPP TR 37.843: "Radio Frequency (RF) requirement background for Active Antenna System (AAS) Base Station (BS) radiated requirements".

[10] R4-1700305, "LS on Characteristics of terrestrial IMT systems for frequency sharing/interference analysis in the frequency range between 24.25 GHz and 86 GHz".

[11] Code of Federal Regulations, Title 47, Part 30.203, Upper Microwave Flexible Use Service; Emission limits, Federal Communications Commission.

[12] Recommendation ITU-R M.1545: "Measurement uncertainty as it applies to test limits for the terrestrial component of International Mobile Telecommunications-2000".

[13] Void.

[14] ETSI EN 301 489: "Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services".

[15] 3GPP TS 38.113: "NR; Base Station (BS) and repeater ElectroMagnetic Compatibility (EMC)".

[16] 3GPP TS 37.114: " Active Antenna System (AAS) Base Station (BS) Electromagnetic Compatibility (EMC)".

[17] 3GPP TS 38.141-1: "NR; Base Station (BS) conformance testing; Part 1: Conducted conformance testing".

[18] 3GPP TS 38.141-2: "NR; Base Station (BS) conformance testing; Part 2: Radiated conformance testing".

[19] 3GPP TS 37.104: " NR, E-UTRA, UTRA and GSM/EDGE; Multi-Standard Radio (MSR) Base Station (BS) radio transmission and reception".

[20] 3GPP TS 38.817-01: "General aspects for User Equipment (UE) Radio Frequency (RF) for NR".

[21] 3GPP TR 36.815: "Further Advancements for E-UTRA; LTE-Advanced feasibility studies in RAN WG4".

[22] 3GPP TS 36.133: "Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for support of radio resource management".

[23] 3GPP TS 37.113: "Multi-Standard Radio (MSR) Base Station (BS) Electromagnetic Compatibility (EMC)".

[24] 3GPP TR 38.803: "Study on new radio access technology: Radio Frequency (RF) and co-existence aspects".

[25] 3GPP TS 38.211: "NR; Physical channels and modulation".

[26] 3GPP TR 37.843: "Radio Frequency (RF) requirement background for Active Antenna System (AAS) Base Station (BS) radiated requirements". v15.2.0

[27] 3GPP TS 36.141: "Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) conformance testing".

[28] IEC 61000-4-3: 2006+AMD1:2007+AMD2:2010: “Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test”

[29] ITU-T Recommendation K.114: “Electromagnetic compatibility requirements and measurement methods for digital cellular mobile communication base station equipment”

[30] ITU-T Recommendation K.48: “EMC requirements for telecommunication equipment - Product family Recommendation”

[31] 3GPP TS 38.133: "NR; Requirements for support of radio resource management".

[32] 3GPP TS 37.141: "NR, E-UTRA, UTRA and GSM/EDGE; Multi-Standard Radio (MSR) Base Station (BS) conformance testing".

[33] 3GPP TS 37.145-1: "Active Antenna System (AAS) Base Station (BS) conformance testing; Part 1: Conducted conformance testing".

[34] 3GPP TS 37.145-2: "Active Antenna System (AAS) Base Station (BS) conformance testing; Part 2: radiated conformance testing".

[35] ERC Recommendation 74-01, "Unwanted emissions in the spurious domain".

[36] 3GPP TR 37.941: "Radio Frequency (RF) conformance testing background for radiated Base Station (BS) requirements"

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

active antenna system base station: BS system which combines an a*ntenna array* with an *transceiver unit array*. An AAS BS may include a radio distribution network

array element: subdivision of a passive *antenna array*, consisting of a single radiating element or a group of radiating elements, with a fixed radiation pattern

antenna connector: connector at the conducted interface of the *BS type 1-C*

antenna array: group of radiating elements characterized by the geometry and the properties of the *array elements*

antenna gain: ratio of the radiation intensity, in a given direction, to the radiation intensity that would be obtained if the power accepted by the antenna were radiated isotropically

NOTE: If the direction is not specified, the direction of maximum radiation intensity is implied.

array factor: radiation pattern of an array antenna when each *array element* is considered to radiate isotropically

NOTE: When the radiation pattern of individual *array elements* are identical, and the *array elements* are congruent under translation, then the product of the *array factor* and the *array element* radiation pattern gives the radiation pattern of the entire array.

angle of arrival: is the direction of propagation of electromagnetic wave incident on an AAS BS *antenna array*

basic limit: emissions limit from a single transceiver unit of the non-AAS BS type, used for the formulation of the unwanted emissions and output power requirements for 1-C type NR BS, as well as for the formulation of the unwanted emissions minimum requirements for *1-H* and *1-O* types NR BS by using emissions scaling

beam: beam (of the antenna) is the main lobe of the radiation pattern of an *antenna array*

NOTE: For certain AAS BS *antenna array*, there may be more than one beam.

beam centre direction: direction equal to the geometric centre of the half-power contour of the beam

beam direction pair: data set consisting of the *beam centre direction* and the related *beam peak direction*

beam peak direction: direction where the maximum EIRP is found

beamwidth: beam which has a half-power contour that is essentially elliptical, the half-power beamwidths in the two pattern cuts that respectively contain the major and minor axis of the ellipse

BS channel bandwidth: RF bandwidth supporting a single NR RF carrier with the transmission bandwidth configured in the uplink or downlink.

NOTE: The channel bandwidth is measured in MHz and is used as a reference for transmitter and receiver RF requirements.

NOTE: It is possible for the BS to transmit to and/or receive from one or more UE Bandwidth parts that are smaller than or equal to the BS transmission bandwidth configuration, in any part of the BS transmission bandwidth configuration.

BS type 1-C: NR base station operating at FR1 with requirements set consisting only of conducted requirements defined at individual *antenna connectors*

BS type 1-H: NR base station operating at FR1 with a requirement set consisting of conducted requirements defined at individual *TAB connectors* and OTA requirements defined at RIB

BS type 1-O: NR base station operating at FR1 with a requirement set consisting only of OTA requirements defined at the RIB

BS type 2-O: NR base station operating at FR2 with a requirement set consisting only of OTA requirements defined at the RIB

cell specific beam: *Cell specific beam* is a beam which is intended to facilitate communication for multiple UEs within a cell

cell splitting: division of the cell's coverage in a sector into multiple subsectors

NOTE: The subsectors may be divided into the vertical and/or horizontal plane.

demodulation branch: single input to the demodulation algorithms

NOTE: For UTRA a *demodulation branch* is referred to as a receive diversity branch or a UL MIMO branch. For E-UTRA a *demodulation branch* is referred to as an RX antenna in the performance requirement tables.

NOTE: The term "RX antenna" in chapter 8 of the E-UTRA specification 3GPP TS 36.104 [8] does not refer to physical receiver antennas, but to the *demodulation branches*.

directions diagram: two-dimensional Cartesian diagram showing φ on the horizontal axis and minus θ on the vertical axis

directivity: ratio of the radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions

NOTE: If the direction is not specified, the direction of maximum radiation intensity is implied.

EIRP accuracy directions set: *beam peak directions* for which the EIRP accuracy requirement is intended to be met

NOTE: The *beam peak directions* are related to a corresponding contiguous range or discrete list of *beam centre directions* by the *beam direction pairs* included in the set.

EMC antenna port: RF connector referred to as antenna port in EMC requirements

equivalent isotropic radiated power: in a given direction, the relative *antenna gain* of a transmitting antenna with respect to the *antenna gain* of an isotropic radiating element multiplied by the net power accepted by the antenna from the connected transmitter

NOTE: For an AAS BS the EIRP can be seen as the equivalent power radiated from an isotropic radiating element, producing the same field intensity as the field intensity radiated in the declared beam pointing direction of the active antenna system being considered.

equivalent isotropic sensitivity: power level relative to an isotropic antenna that is required to be incident on the AAS BS array from a specified azimuth/elevation direction in order to meet a specified receiver sensitivity requirement

NOTE: EIS is directly related to field-strength via free-space impedance and effective aperture antenna area. EIS is expressed as the receiver power that would be collected by an isotropic antenna if it were subject to a uniform field around the whole sphere as the AAS BS array experiences in the specified azimuth/elevation direction.

front-to-back ratio: ratio of maximum directivity of an antenna to its directivity in a specified rearward direction

hybrid AAS BS: AAS BS which has both a conducted RF interface and a radiated RF interface in the far field and conforms to a *hybrid requirements set*

hybrid requirements set: Complete set of requirements applied to a *hybrid AAS BS* with both conducted and radiated requirements

minSENS: the lowest declared EIS value for the OSDD’s declared for OTA sensitivity requirement

multi-band connector: *antenna connector* of the *BS type 1-C* or *TAB connector* of the *BS type 1-H*, associated with a transmitter or receiver that is characterized by the ability to process two or more carriers in common active RF components simultaneously, where at least one carrier is configured at a different operating band than the other carrier(s) and where this different operating band is not a sub-band or superseding-band of another supported operating band

multi-band RIB: *operating band* specific RIB which is paired with one or more additional operating band specific RIBs where the multiple bands are supported through common active electronic component(s)

OTA AAS BS: AAS BS which has a radiated RF interface only and conforms to the *OTA requirements set*

OTA coverage range: a common range of directions within which TX OTA requirements that are neither specified in the *OTA peak directions sets* nor as TRP are intended to be met

OTA peak directions set(s): set(s) of *beam peak directions* within which certain TX OTA requirements are intended to be met, all *OTA peak directions set(s)* are subsets of the *OTA coverage range*

NOTE: The *beam peak directions* are related to a corresponding contiguous range or discrete list of *beam centre directions* by the *beam direction pairs* included in the set.

OTA REFSENS RoAoA: is the RoAoA determined by the contour defined by the points at which the achieved EIS is 3dB higher than the achieved EIS in the reference direction.

NOTE: This contour will be related to the average element/sub-array radiation pattern 3dB beam width

OTA requirements set: complete set of OTA requirements applied to an OTA AAS BS.

radiating element: basic building block of an *array element* characterized by its radiation properties

radiation pattern: angular distribution of the radiated electromagnetic field or power level in the far field region

radio distribution network: passive network which distributes radio signals generated by the active *transceiver unit array* to the *antenna array*, and/or distributes the radio signals collected by the *antenna array* to the active *transceiver unit array*.

NOTE: The number of transmission outputs from the RDN should be greater than or equal to the number of transmission inputs for a single frequency.

NOTE: In the case when the active *transceiver units* are physically integrated with the *array elements* of the *antenna array*, the radio distribution network is a one-to-one mapping.

operating band: frequency range in which NR operates (paired or unpaired), that is defined with a specific set of technical requirements**.**

OTA sensitivity directions declaration: set of manufacturer declarations comprising an EIS value and the directions where it applies

polarization match: condition that exists when a plane wave, incident upon an antenna from a given direction, has a polarization that is the same as the receiving polarization of the antenna in that direction.

receiver target: angles of arrival in which reception is performed

receiver target redirection range: union of all the *sensitivity RoAoA* achievable through redirecting the *receiver target* related to the OSDD

receiver target reference direction: direction, inside the *receiver target redirection range* declared by the manufacturer for conformance testing

NOTE: For an OSDD without *receiver target redirection range*, this is a direction inside the *sensitivity RoAoA.*

reference beam direction pair: declared *beam direction pair*, including reference *beam centre direction* and reference *beam peak direction* where the reference *beam peak direction* is the direction for the intended maximum EIRP within the EIRP accuracy compliance directions set

sensitivity RoAoA: RoAoA within which the declared EIS of an OSDD is intended to be achieved at any instance of time for a specific AAS BS direction setting

single band RIB: operating band specific RIB without any common active electronic component(s) shared with other *operating bands*

single direction requirement: AAS BS requirement which is applied in a specific direction within the OTA coverage range for the Tx and FFS for the receiver.

single-band TAB connector: *TAB connector* supporting either operation only in a single operating band, or operation in multiple operating bands without any common active electronic component(s)

TAB connector: transceiver array boundary connector

TAB connectors beam forming group: group of *TAB connectors* associated with an EIRP beam declaration, comprising of the complete set of *TAB connectors* from which a declared beam is transmitted

transceiver array boundary: conducted interface between the transceiver unit array and the composite antenna

transceiver unit: active unit consisting of transmitter and/or receiver which transmits and/or receives radio signals, and which may include passive RF filters

transceiver unit array: array of transceiver units which generate radio signals in the transmit direction and accept radio signals in the receive direction

TRP requirement: AAS BS requirements, which requires dual-polarized measurements of the figure of merit over the whole sphere around the DUT

UE channel bandwidth: The RF bandwidth supporting a single NR RF carrier with the transmission bandwidth configured in the uplink or downlink of a cell. The channel bandwidth is measured in MHz and is used as a reference for transmitter and receiver RF requirements.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

A_A	The composite *antenna array* pattern in dB
A_E	The *array element* pattern in dB
BeW_{Θ}	The Beam width in Θ
BeW_{ϕ}	The Beam width in ϕ
BeW_{θ}	The beamwidth equivalent to the range of OTA REFSENS RoAoA in the θ-axis in degrees.
BeW_{ϕ}	The beamwidth equivalent to the range of OTA REFSENS RoAoA in the ϕ-axis in degrees.
Ci	Weighting coefficient
$EIS_{minsens}$	The EIS declared for the *minimum OSDD*
$\Delta_{minSENS}$	Difference between conducted reference sensitivity and OTA REFSENS
$\Delta_{REFSENS}$	Difference between conducted reference sensitivity and minSENS
$EIS_{REFSENS}$	OTA REFSENS EIS value
E_{FF}	Far field pattern
E_{meas}	Measured near field
EVM	Error Vector Magnitude
F_{basis}	Basis functions (near field to far field transformation)
L_{RX}	loss factor accounting for antenna losses, distribution losses, integration losses etc. in the receiver path inside the operating band
L_{TX}	loss factor accounting for antenna losses, distribution losses, integration losses etc. in the transmitter path inside the operating band
N_{cells}	The declared number corresponding to the minimum number of cells that can be transmitted by an AAS BS in a particular operating band.
N_{RB}	Transmission bandwidth configuration (number of resource blocks)
$P_{Rated,c,TRP}$	The rated total radiated power when all the transmitter units are operating at their rated output power for a single carrier
$\tilde{W}$	The *array factor*
φ	The azimuth angle (defined between -180° and 180°)
θ	Elevation angle of the signal direction (defined between -90° and 90°, 0° represents the direction perpendicular to the *antenna array*)
σ	Standard uncertainty
ρ	The signal correlation coefficient

ϕ	The angle in the reference coordinate system between the x-axis and the projection of the radiation vector onto the x/y plane defined between -180° and 180°
Θ	The angle in the reference coordinate system between the projection of the x/y plane and the radiation vector defined between -90° and 90°. 0° represents the direction perpendicular to the y/z plane. The angle is aligned with the down-tilt angle
$P_{REFSENS}$	Conducted reference Sensitivity power level

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

AA	Antenna Array
AAS BS	Active Antenna System Base Station
ACLR	Adjacent Channel Leakage Ratio
ACS	Adjacent Channel Selectivity
AoA	Angle of Arrival
AWGN	Additive White Gaussian Noise
BLER	Block Error Rate
BS	Band Category
BW	Bandwidth
CA	Carrier Aggregation
CACLR	Cumulative ACLR
CATR	Compact Antenna Test Range
CC	Component Carrier
CRS	Common Reference Signals
DMRS	Demodulation Reference Signal
DUT	Device Under Test
EIRP	Equivalent Isotropic Radiated Power
EIS	Equivalent Isotropic Sensitivity
EMC	Electromagnetic compatibility
EMC RE	EMC Radiated Emissions
EUT	Equipment Under Test
EVM	Error Vector Magnitude
FFT	Fast Fourier Transform
FR	Frequency Range
FRC	Fixed Reference Channel
FSPL	Free Space Path-Loss
IM	Intermodulation
IMD	Intermodulation
IM	Implementation Margin
ISD	Inter-Site Distance
ITU	International Telecommunications Union
LA	Local Area
MCL	Minimum Coupling Loss
MR	Medium Range
MRTD	Maximum Receive Timing Difference
NF	Noise Figure
OBUE	Operating Band Unwanted Emissions
OSDD	OTA Sensitivity Direction Declaration
RAT	Radio Access Technology
REFSENS	Reference Sensitivity
RDN	Radio Distribution Network
RE	Resource Element
RF RSE	RF Radiated Spurious Emissions
RIB	Radiated interface boundary
RoAoA	Range of Angles of Arrival
RXU	Receiver Unit
SCS	SubCarrier Spacing

SEM	Spectrum Emission Mask
SNR	Signal-to-Noise Ratio
SS	Synchronization Signal
TAB	Transceiver Array Boundary
TAE	Time Alignment Error
TRP	Total Radiated Power
TRXU	Transceiver Unit
TRXUA	Transceiver Unit Array
TXU	Transmitter Unit
UEM	Unwanted Emissions Mask
WA	Wide Area

4 General and common aspects

The general and common aspects for BS RF and UE RF for NR are in clause 4 of 3GPP TS 38.817-01 [20].

5 General BS RF aspects

5.1 Relationship with other core specifications

The following relations among the single RAT NR BS core specification and the MSR BS, AAS BS and EMC specifications are identified:

RAT NR BS: 3GPP TS 38.104 [3] is a Single RAT NR BS specification. It is expected to capture BS requirements for the following aspects:

- Tx, Rx and BS demodulation core requirements for NR BS,
- Conducted and radiated sets of core requirements for the above listed categories (i.e. Tx, Rx and BS demodulation),
- Requirements for NSA NR and SA NR deployments (with the consideration of the NSA/SA prioritization in Rel-15),
- Requirements for FR1 and FR2 frequency ranges, based on the classification defined in 3GPP TR 38.803 [24]:
    - FR1: Both conducted and OTA requirements will be required for FR1. The applicability may depend on the requirements.
        - Requirement set 1-C: Conducted requirements for FR1 Non-AAS BS (which doesn't include antenna functionality).
        - Requirement set 1-H: Conducted requirements and OTA requirements for FR1 hybrid AAS BS (which includes antenna functionality).
        - Requirement set 1-O: OTA requirements for FR1 OTA AAS BS (which includes antenna functionality).
    - FR2: Only OTA requirements will be required for FR2.
        - Requirement set 2-O: OTA requirements for FR2 OTA AAS BS.

MSR BS: The MSR BS specification in 3GPP TS 37.104 [19] will be updated in Rel-15 for capability sets of Single RAT NR BS and LTE+NR MSR BS.

- It shall be noted that the MSR BS specification is considered as non-AAS specification, defining conducted requirements.

AAS BS: The AAS BS specification in 3GPP TS 37.105 [7] will be updated in Rel-15 for capability sets of Single RAT NR BS and LTE+NR MSR BS. In Rel-15, the AAS BS specification is expected to be extended with the full set of OTA requirements.

EMC: New EMC specification for the NR BS will be defined in 3GPP TS 38.113.

- The NR BS EMC specification will reuse the eAAS WI work on the EMC requirements for the OTA AAS BS, i.e. EMC testing of DUT's with radiating antenna elements.
- It shall be noted, that each of the EMC specifications for Single RAT refers to the MSR EMC specification in 3GPP TS 37.113 [23] for the additional optional applicability of the MSR EMC requirements.
- NR BS EMC specification shall also consider additional optional conformance requirements in the extended Rel-15 version of the MSR EMC specification in 3GPP TS 37.113 [23].

Furthermore, relations among conformance BS specifications are identified as follows:

Single RAT NR BS: New conformance specifications in 3GPP TS 38.141-1 and in 3GPP TS 38.141-2 for the NR BS conformance for conducted and radiated testing will be defined, respectively,

MSR BS: 3GPP TS 37.141 [32] MSR BS conformance testing specification will be updated with the NR RAT.

AAS BS: AAS BS conformance testing specifications in 3GPP TS 37.145-1 [33] and 3GPP TS 37.145-2 [34] will be updated based on the AAS BS core specification modifications.

5.2 Relationship between minimum requirements and test requirements

While 3GPP TS 38.104 [3] describes conducted and OTA core requirements, the conformance to the requirements is demonstrated by fulfilling the test requirements specified in the conformance specification 3GPP TS 38.141-1 [17] for conducted testing and 3GPP TS 38.141-2 [18] for radiated testing. An allowance for measurement uncertainty through application of test tolerances is used to create the conformance test requirements using the shared risk principle.

This is explained through clause 4.2 in 3GPP TS 38.104 [3], in a way aligned with the specifications for E-UTRA in 3GPP TS 36.104 [6] and for AAS BS in 3GPP TS 37.105 [7]. The shared risk principle is defined in recommendation ITU-R M.1545 [12].

For selected requirements, conducted FR1 requirements and FR1 OTA requirements are derived from the same limit, leading to the same core requirement values in 3GPP TS 38.104 [3]. Test tolerances associated with conducted and OTA testing may differ. In practice, this means that the test requirement value for a conducted requirement and an analogous OTA requirement may differ, even if both requirements have been derived from the same limit.

5.3 General BS architectures

5.3.1 Background

For E-UTRA all BS specifications are in frequency range 1, historically requirements applied to the antenna connector of a single transceiver and were all conducted.

Evolution of the AAS initially led to the AAS specification which had both a conducted interface and an OTA interface, this was then enhanced to provide an OTA only set of requirements, this has led to 2 types of AAS and corresponding requirement sets. The hybrid AAS BS which has both a conducted and a radiated interface and the OTA AAS BS which has only a radiated interface.

The work on the AAS BS lead for the need to refer to the original BS specifications with a unique term, the term non-AAS was adopted and whilst it is not ideal to refer to something by what it is not, there has been no more appropriate alternative has been found so the term non-AAS has stuck.

There are 2 major differences between the non-AAS and the AAS architectures and requirement sets

1. The AAS BS refers to a system of many transceiver units and the requirements are related to the sum of all the transceiver units. Non-AAS specifications refer to only a single Transceiver

2. The AAS BS has the antenna included as part of the architecture and has a radiated interface.

The intention of the AAS BS specification was to maintain the same levels of protection and performance as an equivalent non-AAS system with the same number of transceiver units. As it is possible for an AAS to have a very large number of transceiver units whereas practical non-AAS installations are likely to have only as many transceivers as there are MIMO channels available (8 for E-UTRA), hence AAS emission (wanted and unwanted) are capped at the equivalent of 8 transceivers no matter how many transceiver units they have.

An E-UTRA AAS does not have to have mandatory beam forming, hence all OTA requirements which involve assumptions on antenna gain are designed so they can be met with a passive antenna gain with the same coverage area.

NR range 1 has the same 3 BS types as E-UTRA, in addition there is NR range 2 which is OTA only due to the high frequency. In addition, a certain level of beam forming is required for range 2 BS so the relationship between coverage range and antenna gain is not the same as in range 1.

5.3.2 General

There are 4 distinct types of NR BS each has a different architecture and requirements set corresponding to Table 5.3.2-1

Table 5.3.2-1: Supported requirement sets

BS type / Requirement set	BS Description	Additional information
1-C	A BS operating at FR1 with all requirements defined at individual antenna connectors.	Following the approach used in 3GPP TS 36.104 and 3GPP TS 37.104 [19]
1-H	A BS operating at FR1 with a requirement set holding requirements defined at the TAB and OTA requirements defined at RIB.	The requirement set is like the one defined for Hybrid AAS BS. Following the approach used in 3GPP TS 37.105 [7]
1-O	A BS operating at FR1 with a requirement set consisting only OTA requirements defined at the RIB.	Following the approach developed in eAAS and documented in 3GPP TR 37.843 [9].
2-O	A BS operating at FR2 with a requirement set consisting only of OTA requirements defined at the RIB.	This requirement set is relevant for AAS BS and does not require access to RF connectors.

5.3.3 BS type 1-C

BS type 1-C requirements are applied at the BS antenna connector (port A) for a single transmitter or receiver with a full complement of transceivers for the configuration in normal operating conditions. If any external apparatus such as an amplifier, a filter or the combination of such devices is used, requirements apply at the far end antenna connector (port B).

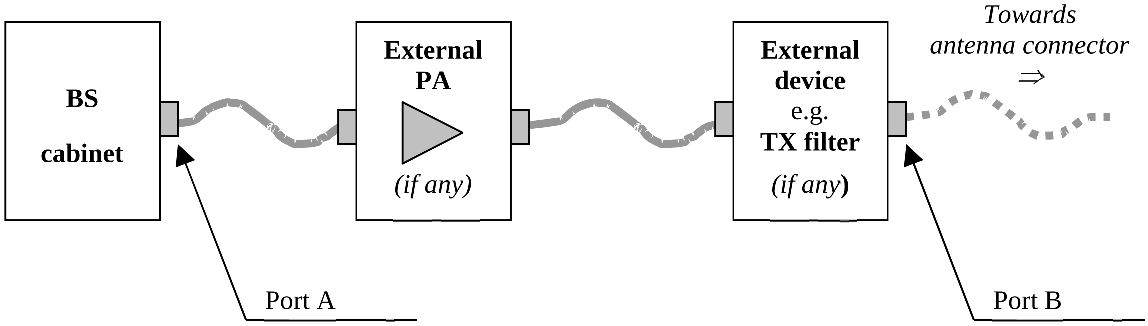


Figure 5.3.3-1: 1-C BS Transmitter interface

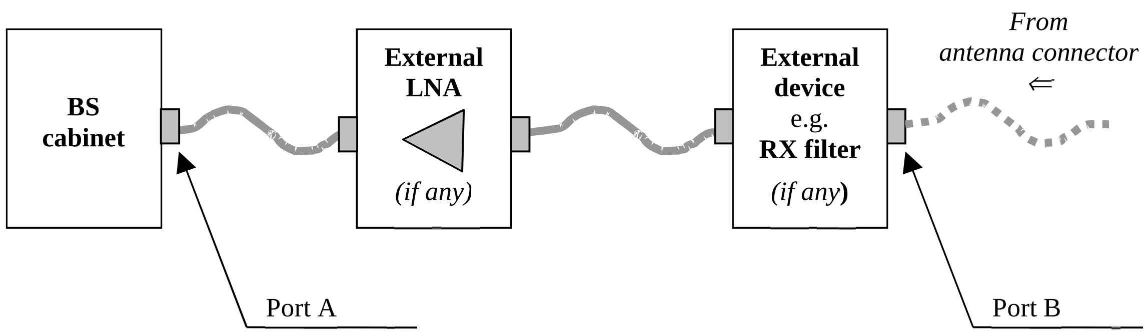


Figure 5.3.3-2: 1-C BS Receiver interface

5.3.4 BS type 1-H

The BS type 1-H the radio architecture is represented by three main functional blocks, the *transceiver unit array* (TRXUA), the *radio distribution network* (RDN), and the *antenna array* (AA). The *transceiver units* (TRXU) interface with the base band processing within the AAS BS.

The TRXUA consists of multiple transmitter units (TXU) and receiver units (RXUs). The TXU takes the baseband input from the AAS BS and provides the RF TX outputs. The RF TX outputs are distributed to the AA via a RDN. The RXU performs the reverse of the TXU operations. The RDN performs the distribution of the TX outputs into the corresponding antenna paths and antenna elements, and a distribution of RX inputs from antenna paths in the reverse direction. The TXU and RXU can be separated and can have different mapping through the RDN towards the AA.

The transceiver array boundary (TAB) is the point or points at which the TRXUA is connected to the RDN. The point where a TXU or RXU connects with the RDN is called "Transceiver Array Boundary connector" (*TAB connector*). The *TAB connector* is defined as conducted requirement reference point. The transmitted signal per carrier from one Transmitter Unit appear at one or more *TAB connector(s)* and the received signals per carrier from one or more *TAB connector(s)* appear at a single RXU.

Figure 5.3.4-1 shows a general architecture of a *BS type 1-H* radio architecture, where M is the total number of *transceiver units* and K is the total number of *TAB connectors* at the transceiver array boundary.

NOTE 1: The RDN may consist of a simple one to one mapping between the TXU(s)/RXU(s) and the passive *antenna array*. In this case, the RDN would be a logical entity but not necessarily a physical entity.

NOTE 2: The *antenna array* includes various implementations and configurations e.g. polarization, array geometry (including element factor and element separation), etc.

NOTE 3: The physical location of the TRXUA, the RDN, and the AA may differ from this logical representation and is implementation dependent.

NOTE 4: No specific mapping in the RDN between *TAB connectors* and antenna elements is assumed. Further the number of separate receiver and transmitter units as well as the mapping in the RDN between *TAB connectors* and radiating elements can differ between the transmit and receive directions. The *BS type 1-H* reference architecture allows for full asymmetry between receiver path and transmit path.

NOTE 5: For BS type 1-H capable of supporting applications employing beamforming, all or subgroups of *TAB connectors* can be configured with designated amplitude and phase weights such that one or more beams are radiated from the *antenna array*.

NOTE 6: If the TR text and figure 5.3.4-1 contradict each other, then the TR text applies.

NOTE 7: The fixed scaling factor of 8 is based on the maximum number of layers/streams specified in release 12 of 3GPP E-UTRA specifications. The scaling function may be further reconsidered for future releases if the maximum number of layers/streams supported in NR is changed.

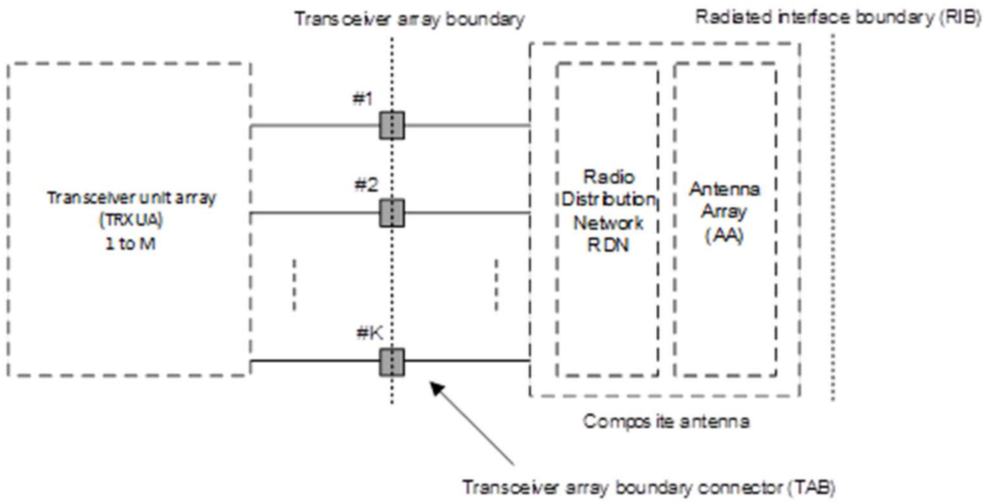


Figure 5.3.4-1: General architecture of *BS type 1-H*

5.3.5 BS type 1-O and BS type 2-O

BS type 1-O and 2-O BS requirement are applied in the far field at the radiated interface boundary.

The *OTA BS* types have no transceiver array boundary or *TAB connectors* defined as they have no conducted requirements.

Figure 5.3.5-1 shows a general architecture of *OTA BS*, where P is the total number of *transceiver units* and P ≥ 8.

NOTE 1: If a BS type 1-O is declared to support more than 1 cell (N_{cells}>1) the total number of transceiver units must be greater than 8* N_{cells}.

NOTE 2: The fixed scaling factor of 8 is based on the maximum number of layers/streams specified in release 12 of 3GPP E-UTRA specifications. The scaling function may be further reconsidered for future releases if the maximum number of layers/streams supported in NR is changed.

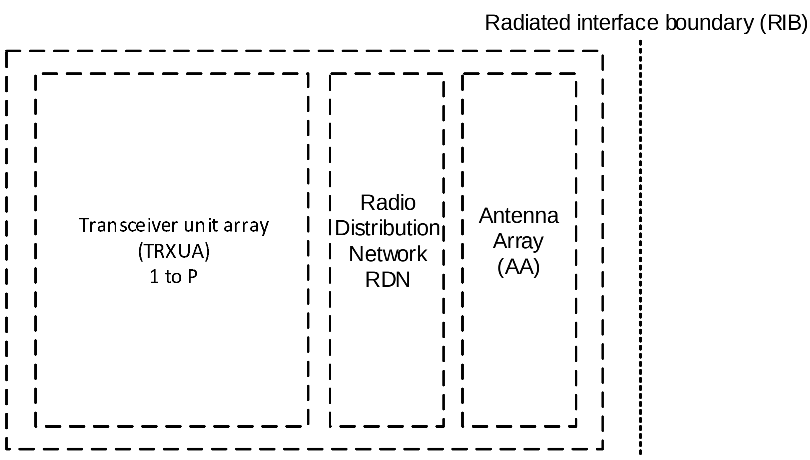


Figure 5.3.5-1: General architecture of *BS type 1-O* and *BS type 2-O*

5.4 Base station classes

The requirements for NR BS apply to Wide Area Base Stations, Medium Range Base Stations and Local Area Base Stations unless otherwise stated. The associated deployment scenarios for each class are exactly the same for BS with and without antenna connectors or *TAB connectors*.

NR BS classes for BS type 1-C and 1-H are defined as indicated below:

- Wide Area Base Stations are characterised by requirements derived from Macro Cell scenarios with a BS to UE minimum coupling loss equal to 70 dB.
- Medium Range Base Stations are characterised by requirements derived from Micro Cell scenarios with a BS to UE minimum coupling loss equals to 53 dB.
- Local Area Base Stations are characterised by requirements derived from Pico Cell scenarios with a BS to UE minimum coupling loss equal to 45 dB.

NR BS classes for BS type 1-O and 2-O are defined as indicated below:

- Wide Area Base Stations are characterised by requirements derived from Macro Cell scenarios with a BS to UE minimum distance along the ground equal to 35 m.
- Medium Range Base Stations are characterised by requirements derived from Micro Cell scenarios with a BS to UE minimum distance along the ground equal to 5 m.
- Local Area Base Stations are characterised by requirements derived from Pico Cell scenarios with a BS to UE minimum distance along the ground equal to 2 m.

5.5 Regional requirements

Some requirements for NR in 3GPP TS 38.104 [3] may only apply in certain regions either as optional requirements, or as mandatory requirements set by local and regional regulation. It is normally not stated in the 3GPP specifications under what exact circumstances the regional requirements apply, since this is defined by local or regional regulation.

A list of such requirements is provided in clause 4.5 of 3GPP TS 38.104 [3].

5.6 Applicability of requirements

The mapping between requirement set and individual requirement is captured in Table 5.6-1.

Table 5.6-1: Requirement set applicability

Requirement	Requirement set				Spatial applicability of the requirements
	1-C	1-H	1-O	2-O	
Base station output power	6.2	6.2	NA	NA	Conducted requirement
Output power dynamics	6.3	6.3	NA	NA	
Transmit ON/OFF power	6.4	6.4	NA	NA	
Transmitted signal quality	6.5	6.5	NA	NA	
Occupied bandwidth	6.6.2	6.6.2	NA	NA	
ACLR	6.6.3	6.6.3	NA	NA	
Operating band unwanted Emissions	6.6.4.x	6.6.4.x	NA	NA	
Transmitter spurious emissions	6.6.5.x	6.6.5.x	NA	NA	
Transmitter intermodulation	6.7.2	6.7.2 and 6.7.3	NA	NA	
Reference sensitivity level	7.2	7.2	NA	NA	
Dynamic range	7.3	7.3	NA	NA	
In-band selectivity and blocking	7.4	7.4	NA	NA	
Out-of-band blocking	7.5	7.5	NA	NA	
Receiver spurious emissions	7.6	7.6	NA	NA	
Receiver intermodulation	7.7	7.7	NA	NA	
In-channel selectivity	7.8	7.8	NA	NA	
Performance requirements	Note	Note	NA	NA	
Radiated transmit power	NA	9.2	9.2	9.2	Radiated directional requirement
OTA Base station output power	NA	NA	9.3	9.3	Radiated TRP requirement
OTA Output power dynamics	NA	NA	9.4	9.4	Radiated directional requirement
OTA Transmit ON/OFF power	NA	NA	9.5	9.5	Co-location requirement for 1-O Radiated TRP requirement for 2-O
OTA Transmitted signal quality	NA	NA	9.6	9.6	Radiated directional requirement
OTA Occupied bandwidth	NA	NA	9.7.2	9.7.2	Radiated directional requirement
OTA ACLR	NA	NA	9.7.3	9.7.3	Radiated TRP requirement
OTA Operating band unwanted emission	NA	NA	9.7.4	9.7.4	Radiated TRP requirement
OTA Transmitter spurious emission	NA	NA	9.7.5	9.7.5	Radiated TRP requirement except for co-location requirements applicable for 1-O
OTA Transmitter intermodulation	NA	NA	9.8	NA	Co-location requirement
OTA sensitivity	NA	10.2	10.2	NA	Radiated directional requirement
OTA Reference sensitivity level	NA	NA	10.3	10.3	Radiated directional requirement
OTA Dynamic range	NA	NA	10.4	NA	Radiated directional requirement
OTA In-band selectivity and blocking	NA	NA	10.5	10.5	Radiated directional requirement
OTA Out-of-band blocking	NA	NA	10.6	10.6	Radiated directional requirement except for co-location requirements applicable for 1-O
OTA Receiver spurious emission	NA	NA	10.7	10.7	Radiated TRP requirement
OTA Receiver intermodulation	NA	NA	10.8	10.8	Radiated directional requirement
OTA In-channel selectivity	NA	NA	10.9	10.9	Radiated directional requirement
Radiated Performance requirements	NA	NA	Note	Note	Radiated directional requirement
NOTE: Performance requirements / radiated performance requirements were developed based on performance requirements for eAAS BS in TR 37.843 [9].					

5.7 Requirements for contiguous and non-contiguous spectrum

Requirements for contiguous and non-contiguous spectrum are well defined in existing single-RAT and MSR specifications. Both contiguous and non-contiguous operation has been requested in various NR-LTE CA/DC combinations and is considered to be completed within Rel-15 timeframe.

The text to Technical Specification for requirements for contiguous and non-contiguous spectrum Clause is as follows:

A spectrum allocation where an BS operates can either be contiguous or non-contiguous. Unless otherwise stated, the requirements in the present specification apply for BS configured for both contiguous spectrum operation and non-contiguous spectrum operation.

For BS operation in non-contiguous spectrum, some requirements apply both at the Base Station RF Bandwidth edges and inside the sub-block gaps. For each such requirement, it is stated how the limits apply relative to the Base Station RF Bandwidth edges and the sub-block edges respectively.

5.8 Requirements for BS capable of multi-band operation

Multi-band band operation concept is well defined in existing single-RAT and MSR specifications. The most important feature of multi-band BS is to support dynamic power sharing between different bands and hence allow operators more flexibility in the network deployment. From the site engineering point of view, multi-band BS can reduce installation complexity for different bands at the same site. Furthermore, multi-band BS can reduce insertion loss for the antenna sharing multi-band scenario since no combiner is needed.

Multi-band operation for *BS type 1-C, BS type 1-H* and *BS type 1-O* is included in Rel-15 NR specifications.

5.9 Basic limits and scaling of emissions

For conducted Tx unwanted emissions requirements on ACLR, spectrum emission mask, operating band unwanted emissions and transmitter spurious emissions in clause 6 (and for conducted Rx spurious emissions requirement in clause 7), as well as for the BS output power requirement, the following sub-clauses apply:

6.x.y Conducted requirement A

6.x.y.1 Basic limits

Table with basic limits for NR BS in FR1.

6.x.y.2 non-AAS requirement A

Minimum conducted requirement for 1-C type NR BS in FR1 is defined as basic limit, i.e. no scaling and no antenna considered.

Minimum 1-C requirement [dBm] = basic limit

Where:

- basic limit is defined in 6.x.y.1

6.x.y.3 AAS requirement A

Minimum conducted requirement for 1-H type NR BS in FR1 is defined based on basic limit with the emissions scaling applied, i.e. basic limit is scaled up to an AAS BS requirement according to the number of *active transceiver units*.

Minimum 1-H requirement [dBm] = basic limit + $10*\log_{10}(N)$

Where:

- basic limit is defined in 6.x.y.1
- Scaling factor $N \leq 8$

For operation in Region 2, where the FCC guidance for MIMO systems in [FCC publication number 662911] is applicable, N shall be equal to 1 for the purposes of calculating the spurious emissions limits. For all other unwanted emissions requirements, N value shall be according to the number of active transmitters per cell. Note, that such limitation of the applicability of the emissions scaling will be reflected in 3GPP TS 38.104 [3].

9.x.y Radiated requirement A

9.x.y.1 AAS requirement A

Minimum radiated requirement for 1-O NR BS in FR1 is defined based on basic limit with the emissions scaling applied, i.e. basic limit is scaled up to an AAS BS requirement according to the number of *active transceiver units*.

Minimum 1-O requirement [dBm] = basic limit + $10*\log_{10}(N)$

Where:

- basic limit is defined in 6.x.y.1
- Scaling factor N is fixed to 8

Therefore the resulting OTA limit can be derived as:

Minimum 1-O requirement [dBm] = basic limit + 9 dB

For operation in Region 2, where the FCC guidance for MIMO systems in [FCC publication number 662911] is applicable, N shall be equal to 1 for the purposes of calculating the spurious emissions limits. For all other unwanted emissions requirements, N value shall be according to the number of active transmitters per cell. Note, that such limitation of the applicability of the emissions scaling will be reflected in 3GPP TS 38.104 [3].

5.10 In-band and out-of-band boundaries for FR1

Agreements of the boundary between OBUE and spurious emissions are summarized in tables 5.10-1 and 5.10-2. The boundary is valid regardless of whether it is single-RAT case or MSR case, and NR new band or refarming band (except Band 46). If wider band(s) than current maximum bandwidth is specified (i.e. wider than 900MHz for NR), the values of the boundary should be discussed.

Table 5.10-1: Δf_{OBUE} (NR single-RAT case)

Applicable specification		**3GPP TS 38.104 3GPP TS 38.141-1**	**3GPP TS 38.104 3GPP TS 38.141-1 3GPP TS 38.141-2**
Applicable BS type		BS type 1-C	BS type 1-H BS type 1-O
Δf_{OBUE}	$F_{DL\_high} – F_{DL\_low} < 100$ MHz	10 MHz	10 MHz
	100 MHz $\le F_{DL\_high} – F_{DL\_low} \le$ 200 MHz	10 MHz	40 MHz
	200 MHz $< F_{DL\_high} – F_{DL\_low} \le$ 900 MHz	40 MHz	40 MHz

Table 5.10-2: Δf_{OBUE} (NR MSR case)

Applicable specification		**3GPP TS 37.104 3GPP TS 37.141**	**3GPP TS 37.105 3GPP TS 37.145-1 3GPP TS 37.145-2**
Applicable BS type		BS type 1-C	BS type 1-H BS type 1-O
Δf_{OBUE}	$F_{DL\_high} – F_{DL\_low} < 100$ MHz	10 MHz	10 MHz
	100 MHz $\le F_{DL\_high} – F_{DL\_low} \le$ 200 MHz	10 MHz	40 MHz
	200 MHz $< F_{DL\_high} – F_{DL\_low} \le$ 900 MHz	40 MHz	40 MHz

6 Conducted BS transmitter characteristics

6.1 General

General aspects of *BS type 1-H* and *BS type 1-C* is given in clause 6.1. of 3GPP TS 38.104 [3].

6.2 Base station output power

6.2.1 General

NR BS conducted output power requirement is at antenna connector for *BS type 1-C*, or at *TAB connector* for *BS type 1-H*.

Despite the general requirements for the NR BS output power described in sub-clauses 6.2.2 – 6.2.4, additional regional requirements might be applicable.

6.2.2 Basic limit

Basic limits for NR BS output power are defined based on the *rated carrier output power*.

The *basic limits* for the Medium Area BS and for the Local Area BS are adopted from the 3GPP TS 36.104 [6] conducted E-UTRA requirements values for the the *rated carrier output power*.

Similar to the E-UTRA BS and MSR BS, there is no upper limit for the *rated carrier output power* of the Wide Area Base Station.

6.2.3 Non-AAS BS output requirement

For *BS type 1-C*, the output power limit requirement equals to the *basic limits*, as defined in clause 6.2.2 and applies per antenna connector during the *transmitter ON period*.

Minimum conducted output power accuracy requirement for the 1-C type BS is reused from the AAS BS specification in 3GPP TS 37.105 [7]. Requirement for normal and extreme conditions is reused.

6.2.4 AAS BS output power requirement

For *BS type 1-H*, the output power limit requirement applies both per *TAB connector* and per system during the *transmitter(s) ON period*.

The output power limit per *TAB connector,* $P_{rated,c,TABC}$, equals to the *basic limits* as defined in clause 6.2.2. The output power limit per system, $P_{rated,c,sys}$, equals to the *basic limits* scaled by the number of *active transmitter units*, $N_{TXU,counted}$.

Minimum conducted output power accuracy requirement for the *BS type 1-H* is reused from the AAS BS specification in 3GPP TS 37.105 [7]. Requirement for normal and extreme conditions is reused.

6.3 Output power dynamics

6.3.1 General

Similar to E-UTRA, gNB output power dynamics requirements can be divided into,

1. RE power control dynamic range.
2. Total power dynamic range .

6.3.2 RE power control dynamic range

In E-UTRA, the eNB RE power control dynamic range is defined as the difference between the power of an RE and the average RE power for a BS at maximum output power for a specified reference condition. RE power up and down range for each modulation scheme was derived by considering the relation between RE power boosting/de-boosting and other RF requirements like UEM, ACLR and EVM.

- Power boosting on some REs within the BS channel bandwidth may cause unequal PSD for the wanted signal. Then the unequal PSD will increase the unwanted emission level in the adjacent channel compared to the case for equal PSD. Power up limit should ensure that the UEM and ACLR requirements are not violated.

- RE power down requirement is limited by the EVM requirement as power de-boosting on some EPREs will lead to reduced Tx SNR which effectively requires a lower EVM requirement. To tighten the EVM requirement due to power control is not preferred from system and implementation perspective.

For NR, the same CP-OFDM waveform as E-UTRA is used for downlink. Although multiple numerologies are supported by the gNB, the E-UTRA definition of RE power dynamic range is generic and the applicability can be easily expanded to all the numerologies for NR.

The conducted requirement for NR BS RE power control dynamic range is reused from E-UTRA (as captured in 3GPP TS 36.104 [6], table 6.3.1.1-1) for the modulations schemes applicable to NR.

The conducted RE power control dynamic range requirement has no specific test and it is tested together with the EVM. The core requirements is in Table 6.3.2.2-1 of 3GPP TS 38.104 [3].

6.3.3 Total power dynamic range

The total power dynamic range is the difference between the maximum and the minimum transmit power of an OFDM symbol for a specified reference condition. The upper limit of the dynamic range is the OFDM symbol power for a BS at maximum output power per carrier. The lower limit of the dynamic range is the OFDM symbol power for a BS when one resource block is transmitted.

For NR, the same definitions can be used for total power dynamic range requirement by using PDSCH as the concerning channel. The upper limit of the dynamic range is the OFDM symbol power for a BS at maximum output power. The lower limit of the dynamic range is the average OFDM symbol power for a BS when one resource block is transmitted.

The requirement derivation for NR channel bandwidths and SCS is following the requirement derivation for E-UTRA. The minimum requirement is expressed as the corresponding total power dynamic range for each BS channel bandwidth of difference SCS as shown in Table 6.3.3.2-1 of 3GPP TS 38.104 [3].

6.4 Transmit ON/OFF power

6.4.1 Transmitter OFF power

Transmitter OFF power is defined as the mean power measured over 70/N us filtered with a square filter of bandwidth equal to the transmission bandwidth configuration of the BS (BW_{Config}) centred on the assigned channel frequency during the transmitter OFF period. N = SCS/15, where SCS is Sub Carrier Spacing in kHz.

The requirements for transmitter OFF power spectral density is agreed to be less than [-85 dBm/MHz, as currently specified in E-UTRA].

Following the same principle applied to E-UTRA multi-band operation, it is agreed that for NR BS capable of multi-band operation, the requirement to be only applicable during the transmitter OFF period in all supported operating bands.

6.4.2 Transmitter transient period

The transmitter transient period is the time period during which the transmitter is changing from the OFF period to the ON period or vice versa. The transmitter transient period is illustrated in Figure 6.4.2-1 as adopted from the E-UTRA requirement on transmitter transient period as specified in 3GPP TS 36.104.

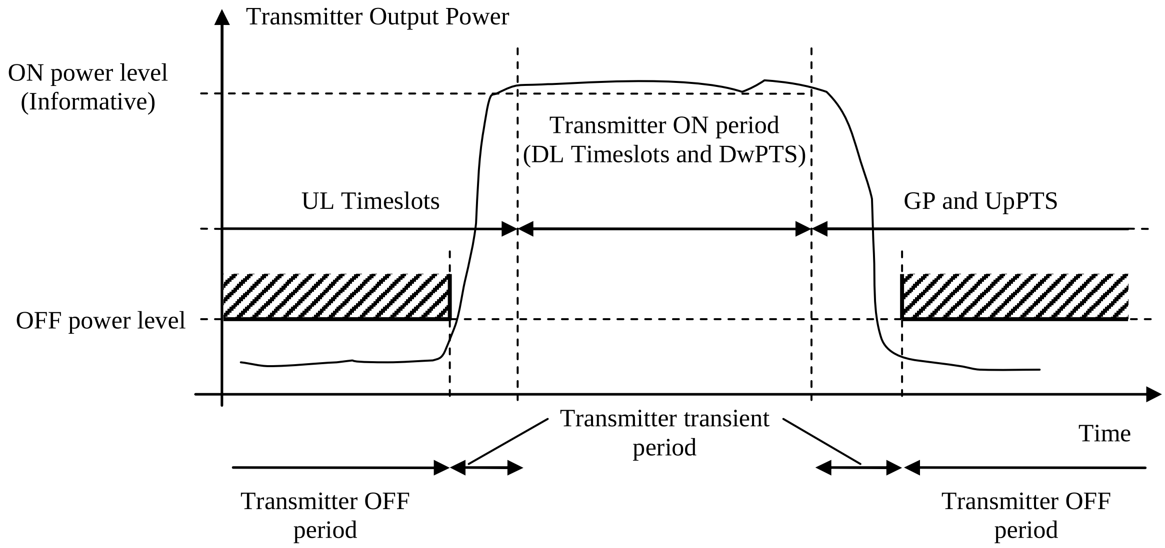


Figure 6.4.2-1: Illustration of the relations of transmitter ON period, transmitter OFF period and transmitter transient period.

In E-UTRA BS, the transmitter transient period for both OFF to ON and ON to OFF are specified to be shorter than 17us.

For NR, since larger sub-carrier spacing are introduced, such as 30kHz, 60kHz and 120kHz, the length of symbol is reduced significantly. It means if the same transient period is kept and the same number of symbol is configured for gap period (GP), the cell coverage will be reduced and BS to BS distance without interference will also be reduced. This may bring the risk of introducing BS to BS interference in the network. Balance needs to be considered between transient period requirements and BS to BS interference in the network. So, NR BS transient periods need to be optimized.

Based on the aforementioned argument, it is agreed to adopt shorter transient periods for NR BS than the values specified for E-UTRA BS by considering the capabilities of current hardware. A value of 10us has been agreed and accepted for the transmitter transient periods for FR1.

The transmitter transient period for non-AAS NR BS is agreed to be shorter than the values listed in the minimum requirement Table 6.4.2.2-1 in 3GPP TS 38.104 [3] for FR1.

The transmitter transient period for AAS NR BS is agreed to be shorter than the values listed in the minimum requirement Table 6.4.2.2-1 in 3GPP TS 38.104 [3] for FR1.

6.5 Transmitted signal quality

6.5.1 General

Unless otherwise stated, the requirements in clause 6.5 apply per antenna connector for 1-C type NR BS, or per *TAB connector* for 1-H type NR BS, during the *transmitter ON period.*

6.5.2 Frequency error

Frequency error performance mainly depends on PLL performance within transceiver chain and the timing and synchronization performance. The example approach of timing and synchronization in the real network is to deploy one GNSS receiver with BS, then high quality GNSS receiver derives frequency and timing from the satellite signals and the synchronization equipment then use it as reference clock for network timing. This approach has been adopted for legacy system, like GSM, UTRA and E-UTRA for many years. Therefore for range1 NR, it is also quite beneficial to reuse existing timing and synchronization network directly to reduce the network construction cost. Meanwhile, similar

PLL performance of NR BS as E-UTRA BS is also expected as they are operating at the same frequency range. Based on the above considerations, RAN4 agreed that frequency error requirement of LTE can be reused for NR range1.

The frequency error requirement is defined to capture the maximum allowable difference between an assigned frequency and the actual generated frequency. The frequency error requirement is a regulatory requirement in some regions.

The core requirement for the conducted frequency error for FR1 requirement will be reused from conducted frequency error requirement from 3GPP TS 37.105 [7] specification.

For conformance testing purposes, the frequency error shall be tested at the maximum and minimum power settings (together with the EVM test).

6.5.3 Time alignment error

6.5.3.1 General

Frames of NR signals present at antenna connectors (for 1-C type NR BS), or at *TAB connectors* (for 1-H type NR BS) are not perfectly aligned in time. In relation to each other, the RF signals present at the BS transmitter antenna port(s) or at the *transceiver array boundary* may experience certain timing differences.

For a specific set of NR signals/transmitter configurations/transmission modes, the conducted Time Alignment Error (TAE) is defined as the largest allowed timing difference (i.e. error) between two different reference signals belonging to different antenna connectors (for 1-C type NR BS), or *TAB connectors* (for 1-H type NR BS).

TAE is only applicable for NR BS transmitting from multiple antennas via MIMO, CA, or combination of them.

In UTRA and E-UTRA, TAE requirement was defined for TX diversity, MIMO transmission, carrier aggregation and their combinations. However in NR, there is no TX diversity transmission mode defined. As a result, no TAE tests need to be developed for TX diversity for NR operation.

In case of 1-H type NR BS the number of *TAB connectors* could be large. Therefore, a concept for reducing number of test combinations was introduced in 3GPP TS 37.105 [7]. In TAE requirement for AAS BS is designed as:

The TAE between any two *TAB connectors* from different transmitter groups shall not exceed the specified minimum requirements above, where transmitter groups are associated with the *TAB connectors* in the transceiver unit array corresponding to MIMO transmission, CA, etc.

6.5.3.2 Carrier aggregation

6.5.3.2.1 General

TAE requirements for CA is generally discussed and set as a requirement isolated at the base station while it is the TAE at the UE that matters (generally referred as MRTD). This can lead to wrong or unbalanced requirements.

The maximum <u>allowed</u> TAE at the UE depends of implementation choices and potential design restrictions within the UE, so this is not a single fixed figure.

The TAE depends on:

- The relative synchronization error between the transmission points involved in the CA service (ΔTsync)
- The differences in signal arrival time at the UE due to difference in propagation distance between the transmission point and the UE (ΔTprop) which depends on actual deployment scenario and UE relative position.

Discussing CA TAE requirements isolated at the base station can lead to wrong or unbalanced requirements, it is not the TAE at the base station that matters, it is the TAE at the UE (MRTD) that matters. The TAE at the UE (MRTD) depends of synchronization error between transmission points ΔT_{sync} and differences in propagation time from the transmission points (ΔT_{prop}).

6.5.3.2.2 UE implementation

As stated above the maximum allowed timing difference at the UE depends on actual UE implementation.

For CA the UE can be implemented with independent receiver paths for the CCs as shown to the left in Figure 6.5.3.2.2-1 below or with some common part resulting in dependencies between the paths.

Figure 6.5.3.2.2-1 UE implementation

Different receiver architectures were already highlighted in LTE [21] where two types of receiver options option A and B are described, see Figure 6.5.3.2.2-2.

Table 5.3.3-1: Possible UE Architecture for the three aggregation scenarios

Rx Characteristics				
Option	Description (Rx architecture)	Intra Band aggregation		Inter Band aggregation
		Contiguous (CC)	Non contiguous (CC)	Non contiguous (CC)
A	Single (RF + FFT + baseband) with BW>20MHz	Yes		
B	Multiple (RF + FFT + baseband) with BW≤20MHz	Yes	Yes	Yes

Option A

- UE may adopt a single wideband-capable (i.e., >20MHz) RF front end (i.e., mixer, AGC, ADC) and a single FFT, or alternatively multiple "legacy" RF front ends (<=20MHz) and FFT engines. The choice between single or multiple transceivers comes down to the comparison of power consumption, cost, size, and flexibility to support other aggregation types.

Option B

- In this case, using a single wideband-capable RF front end is undesirable in the case of Intra band non contiguous CC due to the unknown nature of the signal on the "unusable" portion of the band. In the case non adjacent Inter separate RF front end are necessary

Figure 6.5.3.2.2-2 LTE CA receiver options (from 3GPP TR 36.815 [21])

As can be seen receiver option B is more flexible to support different CA types since introduces less dependencies between the CC.

Receiver option A with a single wide band receiver and FFT also requires strict timing requirements that relates to a fraction of the CP. As shown in the Figure 6.5.3.2.2-2, option A only supports intra band contiguous CA and it would generally be intra band contiguous that might be implemented with strict timing dependencies. As an example, CA between NR sub 6GHz and NR >24GHz high BW system would likely be implemented as separate receiver paths without any strict dependencies since very different receiver characteristics.

Similar for the transmitter, the UE can be implemented with independent paths or dependent paths as also shown in [21].

It is also important that CA now is a mature implemented technology in LTE and much knowledge have been gain over the years, potential UE implementation restrictions in the early days when introducing CA might not be applicable anymore and therefore not necessarily inherited as restrictions also in NR.

Implementation assumptions about the UE must be made to understand its MRTD requirements and UEs can be implemented without any strict dependencies (i.e. no strict requirement for MRTD) which would give better service availability.

6.5.3.2.3 Deployment scenarios

As stated in the beginning the TAE at the UE depends of the differences in signal arrival time at the UE due to difference in distance between the transmission point and the UE (ΔT_{prop}) which depends of the deployment scenarios as shown in Figure 6.5.3.2.3-1.

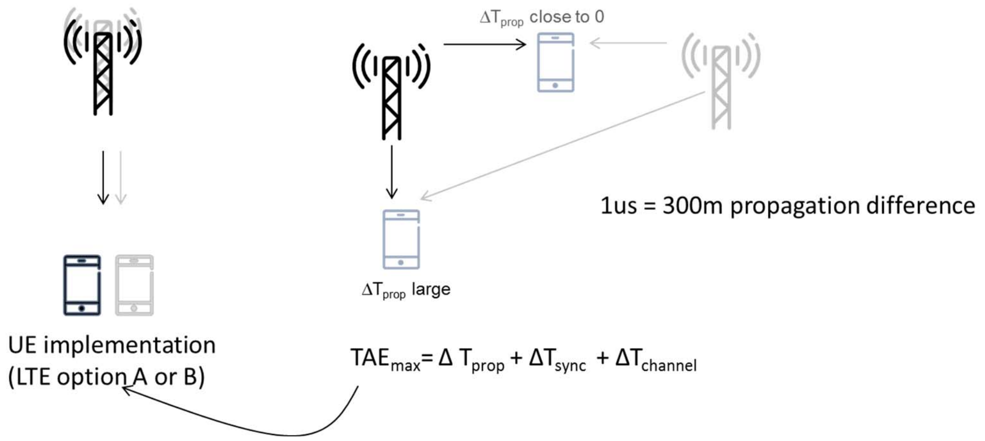


Figure 6.5.3.2.3-1 Deployment scenarios

To the left in Figure 6.5.3.2.3-1 an intra base station deployment is shown and this is normally where the strict base station synchronization requirements can be met since close to a common timing source.

300m corresponds to approximately 1us RF propagation delay, as shown in the right part of Figure 6.5.3.2.3-1 a separation of the base station transmission points (different Radio Units connected to a common Digital Unit) will give a difference in signal arrival time at the UE.

In addition, dependent radio channel condition (depends on frequency bands and environment) there will also be a $\Delta T_{channel}$ component that adds to the total TAE at the UE.

This means that potential UE architecture requirements specified as a fraction of the CP e.g. based on a common FFT and will be intra site with co-located antenna transmission points. It is also worth noting, separating the transmission points will put strict requirements on the interfaces towards a common aggregation node at the MAC layer.

To allow for distributed and separated transmission points in CA (e.g. heterogenous deployments with (different Radio Units connected to a common Digital Unit) the UE cannot be designed to have strict TAE requirement since ΔT_{prop} quickly will be the dominating part of the complete TAE budget. It is either not desirable to only allow for short ΔT_{prop} since it will seriously limit the availability of the service and where it can be provided.

6.5.3.2.4 Intra band contiguous CA

To understand requirements for NR it is beneficial to first understand existing requirements in LTE since there will be dependencies in various forms.

If we then consider the intra band contiguous CA in LTE with a TAE requirement of 130ns at the UE, it is then clear that this can only be met as an intra base station requirement with the transmission points close to each other. This since a propagation difference of 39m would correspond to a ΔT_{prop} =130ns (leaving unrealistically $\Delta T_{sync} = \Delta T_{channel}$ =0ns) or making the service unpractical since limit it to certain small areas where symmetric propagation delays are fulfilled.

The 130 ns LTE intra band contiguous CA requirement is strict and only ~ 2.5% of the LTE CP. Compared to CoMP and MBSFN the CA requirement is much stricter, hence it should not be used unconditionally as a base for scaling NR without new simulations, as an example keeping 130ns would still only correspond to ~10% of the CP for 60kHz numerology and 20% for the 120kHz numerology.

The main technical motivation for strict TAE requirements in NR would be the possibility to use a single FFT in the UE, that is Option A in Figure 6.5.3.2.2-2. However, as we will see in subsequent clauses, 2.4 and 2.5, CA non-contiguous intra band and CA inter band has allowed non-colocated Radio Units with a ΔT_{prop} requirement of 30 µs for the relative time of arrival difference for LTE. It is fair to assume that NR CA non-contiguous intra band and NR CA inter band will have similar requirements, to allow non-colocated Radio Units connected to a common gNB Base Band Unit. This will drive UE architecture B with multiple FFT to be implemented for NR CA non-contiguous intra band and

NR CA inter band. The same thing can be said about Dual Connectivity (DC) feature. DC is non-colocated for most cases and has to handle different SCS between carriers. The non-colocated nature of DC feature as well as the need to support different SCS for different carriers drives the need to have separate FFT in UE implemented. One may conclude that multiple FFT will be implemented for other CA variants (non-contiguous intra band and interband) and other features (DC). A UE architecture B with multiple FFT also for contiguous NR CA would also be more flexible when it comes to different SCS for NR contiguously aggregated carriers, in case of different latency needs or different BWP TAE requirements can be relaxed for the case of separate FFT in UE.

Existing LTE intra band contiguous CA TAE requirement of 130 ns is an intra base station requirement.

The LTE 130 ns intra band contiguous CA requirement is very strict since only ~ 2.5% of the CP. It should not just be used unconditionally as a base for scaling NR without new simulations proving actual need, as an example keeping 130ns would still only correspond to ~10% of the CP for 60kHz numerology and 20% for the 120kHz numerology

Main motivation for strict TAE is the possibility to use common FFT, but that multiple FFT will be implemented for other CA variants (non-contiguous intra band and interband) and other features (DC). TAE requirements can be relaxed for the case of separate FFT in UE.

6.5.3.2.5 Intra band non-contiguous CA

From [21] existing relative base station synchronization requirement is 260 ns however in [22] the TAE requirements at the UE receiver is 30.260 us. The chosen 30 us is dedicated for the ΔT_{prop} and corresponds to a relative difference of 9km from the transmission points, and then it does not relate to the CP. The requirements require an ideal interface towards common aggregation node.

The 260 ns of the total 30.26 us corresponds to only 0.85% and cannot be considered as a well-balanced requirement.

Marginally increasing the TAE error at the UE e.g. to 33 us (i.e. same as for DC) would allow for a less strict synchronization requirement (T_{sync} = 3 us) and hence allow for more flexible deployments. Alternative keeping the UE 30.26 us TAE requirement and decreasing the relative propagation difference to 8.2 km instead of 9 km would also allow for T_{sync} = 3 us.

Worth noting, intra band between two > 24 GHz systems with its smaller cell sizes, a need for 9 km propagation difference would not be reasonable.

The condition with a max propagation difference ≤ 9 km will not be needed for e.g. intra band CA > 24 GHz.

From TS 38.133 [31], in Release 15 only co-located deployment is applied for intra-band CA. And RAN4 made the further agreement that intra-band non-contiguous CA TAE requirements in FR1 and FR2 are aligned with intra-band non-contiguous CA MRTD requirements for FR1 and FR2 in TS 38.133 [31].

6.5.3.2.6 Inter band CA

From 3GPP TS 38.104 [3] the existing relative base station synchronization requirement is 260ns however in [22] the TAE requirements at the UE receiver is 30.260 us and hence same as for intra band non-contiguous CA and everything valid in previous clause are also valid here.

3GPP 36.300 Annex J contains CA deployment scenarios.

For both intra non-contiguous and inter band CA the base station LTE requirement of 260 ns is not a well-balanced requirement since only ~0.85% of total budget.

For both intra and inter band non-contiguous CA, marginally increasing the LTE MRTD error at the UE would allow for a less strict synchronization requirement or allocating slightly reduced max propagation difference would reduce the synchronization requirement and allow for more flexible deployments.

6.5.3.2.7 Other dependencies

There could be other intra/inter RAT dependencies and e.g. for CA sometimes minimizing overhead for UE measurement gaps is mentioned. However, for that specific scenario it can be show that e.g. using 33us instead of specified 30.26us would have a very small impact.

Even if an early NR design principle has been to avoid strict timing relations, potential cross dependencies must be analyzed to get the complete picture of potential timing dependencies.

For a full analysis, potential new NR inter/intra RAT CC cross dependencies must be analyzed to get the complete picture of potential timing dependencies.

6.5.3.2.8 Conclusion

Requirements for TAE cannot be set isolated at the base stations since will lead to wrong or unbalanced requirements as sometimes seen in the past. The TAE at the base station is just one part of a total budget while in the end, it is the MRTD at the UE that matters. Different UE architectures options will impose different requirements.

If requirements at the UE are set too strict it will reduce deployment flexibility, limit area where the UE can be served (small ΔT_{prop}) and drive cost for synchronization**.**

Main motivation for strict TAE is the possibility to use common FFT, but that multiple FFT will be implemented for other CA variants (non-contiguous intra band and inter band) and other features (DC). TAE requirements can be relaxed for the case of separate FFT in UE.

6.5.4 Modulation Quality

6.5.4.1 General

The modulation quality requirement is defined by the difference between the measured carrier signal and an ideal signal. Modulation quality can be expressed Error Vector Magnitude (EVM).

The core requirement for the conducted modulation quality for FR1 requirement will be reused from conducted modulation quality requirement from 3GPP TS 37.104 [7] specification. Although some aspects, such as the requirement level is reused other aspects such as EVM window and equalization algorithms will need to differ to suit NR aspects such as spectrum utilization, reference signal structure, and numerologies. The requirements apply per *TAB connector*.

A DM-RS pattern will be transmitted, and a standardized receiver will be used to mitigate some linear aspects of the EVM. With the removal of Common Reference Signals (CRS) present in LTE and the new design of demodulation reference signals (DM-RS) the specifics of pattern configurations are needed to be considered as part of the overall requirement conditions. The overall link performance was studied in a fading channel and also in an AWGN channel for different DM-RS pattern designs. In fading channels during operation (as opposed to just test operation), the simulations showed that a minimum DM-RS density configuration of comb 2 (every other subcarrier) in symbols 3 and 11 would be required to achieve similar performance with CRS in LTE.

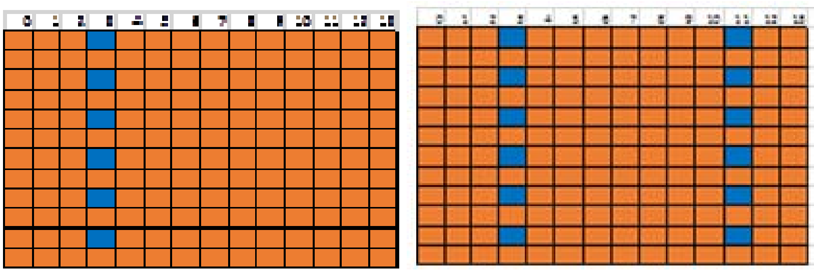
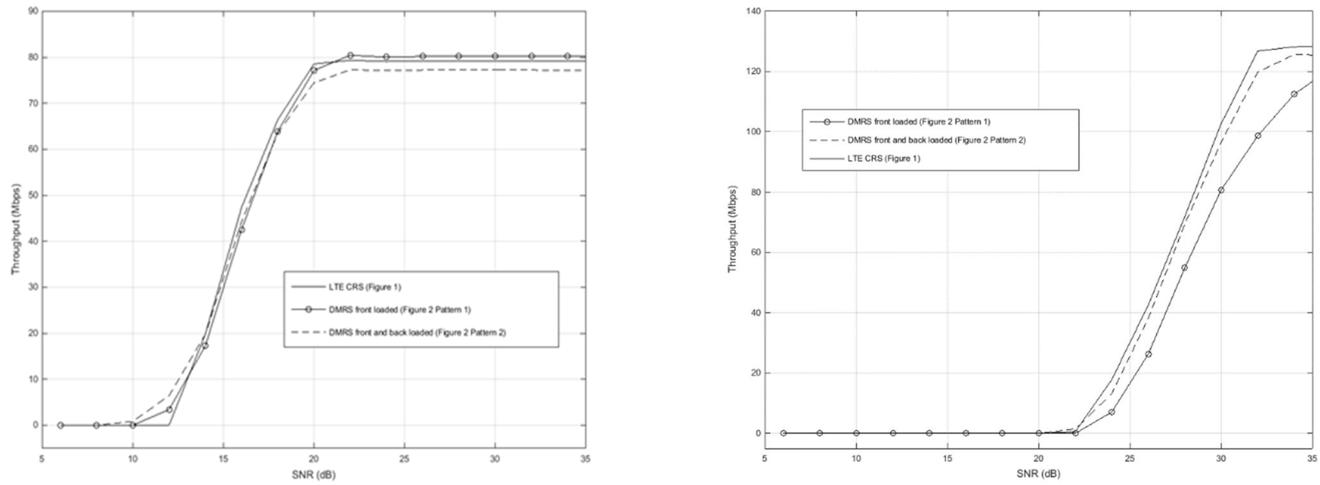
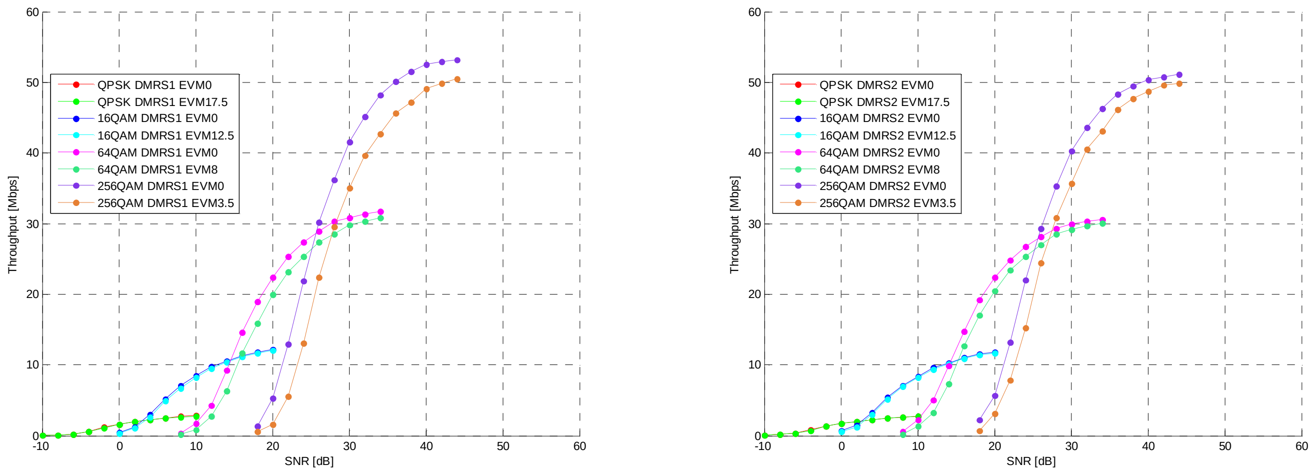


Figure 6.5.4-1: DM-RS patterns for DL Single Layer Front Loaded and Front and Back Loaded (pattern 1 and 2)



EVM 8% for 64 QAM EVM 3.5% for 256 QAM

Figure 6.5.4-1: Throughput for PDSCH vs SNR simulation results [R4-1711162, Ericsson]



EVM impacts on throughput performance, NR DMRS Pattern 1 EVM impacts on throughput performance, NR DMRS Patterr

Figure 6.5.4-1: Throughput for PDCCH vs SNR simulation results [R4-1713672, NEC]

In the following clauses, background on the EVM measurement is introduced in detail.

6.5.4.2 Example N_{RB} values

For NR specification, it is agreed to use 100 MHz channel bandwidth with 30 kHz SCS for FR1 as example case.

6.5.4.3 RSTP and OSTP

The RS TX power (RSTP) is mainly used for testing the DL RS power accuracy requirement as specified for UTRA and E-UTRA system, however for NR specification, DL RS power accuracy requirement is not specified.

The OFDM symbol TX power (OSTP) is required for testing total power dynamic range. In the TS 36.141 [27] specification, the RETP and OSTP is defined as following with considerations on the supported SCS.

$$RETP = |Z'(t,f)|^2 \Delta f$$

where Δf is the subcarrier spacing in Hz.

In the TS 36.141 [27] specification, from RETP the OFDM Symbol TX power (OSTP) is derived as follows:

$$OSTP = \sum_{\substack{all\, N_{RB}^{DL} N_{sc}^{RB}\, RE\, locations \\ of\ 4th\, symbol\, within\, subframe}} RETP$$

For NR system, the 4th symbol is used to explicitly indicate which OFDM symbols should be used for single RB power measurement and whole RB power measurement.

From RETP the OFDM Symbol TX power (OSTP) is derived as follows:

$$OSTP = \sum RETP$$

Where the summation accumulates $N_{RB}N_{sc}^{RB}$ RETP values of the 4th OFDM symbol. The 4th (out of 14 OFDM symbols within a slot in case of normal CP length) contains exclusively PDSCH. $N_{sc}^{RB} = 12$

6.6.7.4 TDD EVM measurements

Moving average length 19 from E-UTRA specification is to be used for FR1 in NR.

6.6.7.5 EVM window

For the $\Delta\tilde{c}$ configurations, the example case for FR1 is 100 MHz channel bandwidth with 30 kHz SCS, then sampling rate should be 122.88 Msps, therefore μ is 1 and κ is 64 for Tc (1/480kHz * 4096).

$\Delta\tilde{c}$ is on T_f=144 ($72\kappa \cdot 2^{-\mu} \cdot T_c \cdot 122.88e6$) within the CP of length 288 ($144\kappa \cdot 2^{-\mu} \cdot T_c \cdot 122.88e6$) (in OFDM symbol $l \neq 0$ or $l \neq 14\left(7 \cdot 2^{\mu}\right)$).

$\Delta\tilde{c}$ is on T_f=208 ($\left(144\kappa \cdot 2^{-\mu} + 16\kappa - 72\kappa \cdot 2^{-\mu}\right) \cdot T_c \cdot 122.88e6$) within the CP of length 352 ($\left(144\kappa \cdot 2^{-\mu} + 16\kappa\right) \cdot T_c \cdot 122.88e6$) (in OFDM symbol $l = 0$ or $l = 14\left(7 \cdot 2^{\mu}\right)$).

6.6 Unwanted emissions

6.6.1 General

An overview of unwanted emissions and the relation and frequency boundary between the OBUE and spurious emissions is given in clause 6.6.1 of 3GPP TS 38.104 [3].

6.6.2 Occupied bandwidth (FR1)

The 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 (=0.5%) of the total mean transmitted power. See also Recommendation ITU-R SM.328.

It was agreed that the same principle with existing E-UTRA (99% power should be within BS channel bandwidth can be reused, and the minimum requirement for FR1 occupied bandwidth shall be less than the BS channel bandwidth supported by NR.

Furthermore, the minimum requirement may be applied regionally.

6.6.3 Adjacent Channel Leakage Power Ratio (ACLR)

The following have been agreed for conducted ACLR requirement in FR1:

- Adopt the E-UTRA BS (45dB) ACLR1 and ACLR2 to all NR BS classes.

- Adopt each E-UTRA BS absolute limit to the corresponding NR BS class, whichever is less stringent compared to the ACLR.
- The same channel bandwidth with wanted signal can be assumed as the adjacent channel bandwidth.
- Transmission bandwidth configuration of wanted channel (it would differ depend on subcarrier spacing and/or BS channel bandwidth) should be used as a measurement bandwidth for wanted signal power measurement.
- Maximum transmission bandwidth configuration of the BS channel bandwidth (between subcarrier spacing) specified in Release 15 should be used as a measurement bandwidth for adjacent channel power measurement, i.e. the measurement bandwidth should also apply to future releases regardless of whether new SU is introduced or not.
- For bands defined also for E-UTRA or UTRA:
    - Specify BS 45 dB ACLR conducted requirement for 5MHz adjacent channel bandwidth.
    - The same measurement bandwidth is used for adjacent channel power measurement with existing E-UTRA specification.
    - Not to specify against other E-UTRA channel bandwidth than 5MHz.
    - No need to specify ACLR against UTRA in core specification since it is already covered by ACLR against E-UTRA case.

Based on above agreements, the ACLR requirement is specified in Table 6.6.3.2-1of 3GPP TS 38.104 [3].

The following have been agreed for conducted CACLR requirement in FR1:

- Adopt the E-UTRA BS relative (45dBc) and absolute (for each BS class) CACLR limits for NR BS.
- Only specify CACLR against NR in core specification.
- Apply the 5 MHz adjacent channel carrier to NR channel bandwidth ≤20 MHz and the 20 MHz adjacent channel carrier to NR channel bandwidth >20 MHz.
- Apply different gap sizes for different combinations of NR channel bandwidth (≤20 or >20 MHz) at the edges of the gap, as shown in figures 6.6.3-1 to 6.6.3-8.

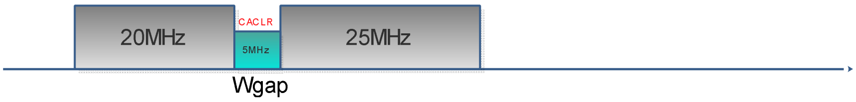


Figure 6.6.3-1: CACLR1 scenario for 20MHz BS channel bandwidth (min frequency separation)

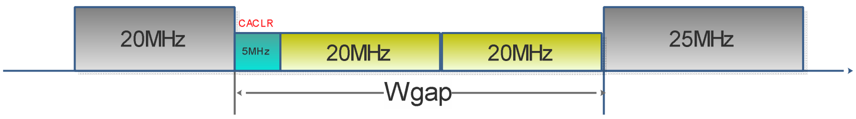


Figure 6.6.3-2: CACLR1 scenario for 20MHz BS channel bandwidth (max frequency separation)

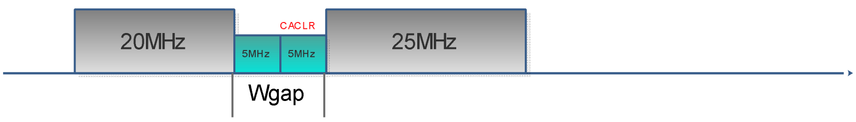


Figure 6.6.3-3: CACLR2 scenario for 20MHz BS channel bandwidth (min frequency separation)

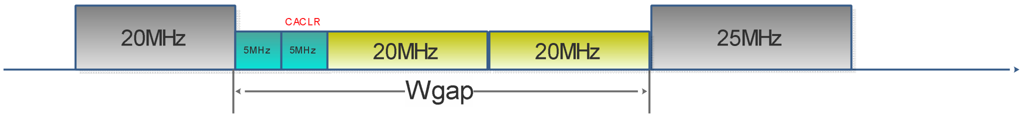


Figure 6.6.3-4: CACLR2 scenario for 20MHz BS channel bandwidth (max frequency separation)

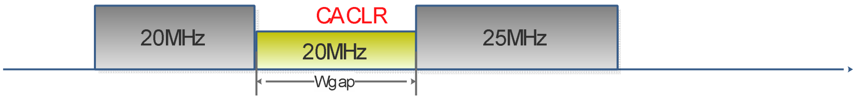


Figure 6.6.3-5: CACLR1 scenario for 25MHz BS channel bandwidth (min frequency separation)

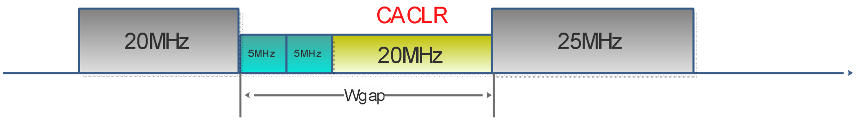


Figure 6.6.3-6: CACLR1 scenario for 25MHz BS channel bandwidth (max frequency separation)

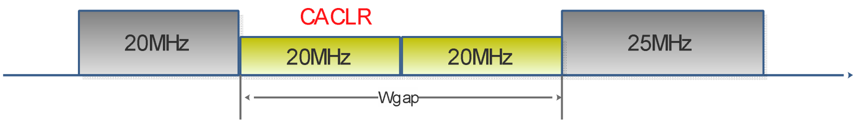


Figure 6.6.3-7: CACLR2 scenario for 25MHz BS channel bandwidth (min frequency separation)

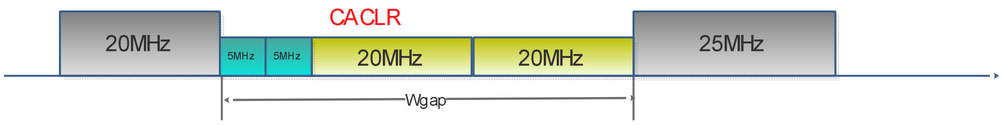


Figure 6.6.3-8: CACLR2 scenario for 25MHz BS channel bandwidth (max frequency separation)

Based on above agreements, the CACLR requirement is specified in Table 6.6.3.2-3 of 3GPP TS 38.104 [3].

Based on above agreements, the ACLR requirement in non-contiguous spectrum or multiple bands is specified in Table 6.6.3.2-2a of 3GPP TS 38.104 [3].

6.6.4 Operating band unwanted emissions

A set of band-centric masks are defined for NR in Frequency Range 1, based on the same principles as for LTE. Details of the masks are as follows:

- The UEM should be defined up to an offset Δf_{OBUE} from the band edge, where Δf_{OBUE} = 40 MHz for NR bands equal to and wider than 100 MHz. This serves as a baseline for the boundary between UEM and spurious emission for both Category A and Category B spurious emission limits.
- The emission levels for the UEM will be the same as for LTE (5 MHz and larger channel BW) in the full frequency range (F_{DL}_low– Δf_{OBUE}) ~ (F_{DL}_high+Δf_{OBUE}).
- The same UEM tables will be used for the different Δf_{UEM}. For Category B spurious emissions, the limits will be taken from LTE Category B Option 1.
- The following variations for the Unwanted Emissions Mask (UEM) tables should be used for sub-6 GHz:

– BS classes

– Category of emission (A/B)

– Frequency range (above/below 1 GHz)

– Power levels (for some BS classes)

The value of Δf_{OBUE} determines the extent of the mask outside the operating band, but it also defines the spurious emissions requirements. It is a parameter that will vary between bands and is therefore best documented in a table, listing its value for different bands. Since it is common to spurious emissions and UEM requirements, the table should be placed in the general clause of Unwanted emissions (6.6.1).

Specification of UEM relies on a few common parameters defining the frequency offset. These can largely be re-used from LTE:

- Since the limits will be the same as for LTE, we also need to consider re-using the concept of two definitions of offset from the channel edge: Δf defining offset to the edge of the measurement filter and f_offset defining the offset to the centre of the filter. Both should be kept, since the difference (half the measurement bandwidth) is not negligible.

- Keeping both Δf and f_offset, we also need to define two maximum values setting the maximum offset to which the UEM extends: Δf_{max} and f_offset_{max}.

- For LTE, the UEM is in general extended to Δf_{OBUE} = 10 MHz beyond the operating band edges. This will now be out to Δf_{OBUE} = 40 MHz for some bands.

For Wide Area BS, the UEM level in the spurious domain is aligned with ITU-R recommendation SM.329. Consequently, there is a need to distinguish between Category A and B emission limits and also between frequencies below and above 1 GHz, since they have different limits and/or measurement bandwidths. For this reason, Category A and B should be in separate clauses:

Wide Area BS, Category A (clause)

Table: Category A (<1 GHz)

Table: Category A (1 GHz < f < 6 GHz)

Wide Area BS, Category B (clause)

Table: Category B (<1 GHz)

Table: Category B (1 GHz < f < 6 GHz)

Medium Range BS (clause)

Table: Category A & B

Local Area BS (clause)

Table: Category A & B

6.6.5 Transmitter spurious emissions

6.6.5.1 General

NR BS Tx spurious emission conducted requirement for FR1 should comply with the following:

- For conducted requirements (at antenna connector/ at the transceiver array boundary) use same limits as 3GPP TS 37.104 [19]/3GPP TS 37.105 [7] i.e. 9kHz lower limit, 5th harmonic upper limit

- The corresponding reference bandwidths for the specified spurious emission domain level measurement are:

  - 1kHz between 9 kHz and 150 kHz

  - 10kHz between 150 kHz and 30 MHz

- 100 kHz between 30 MHz and 1 GHz
- 1 MHz for above 1 GHz

6.6.5.2 Basic limits

Category A or Category B basic limits are defined for the conducted Tx spurious emissions requirements for NR BS in Range 1, as outlined in Table 6.6.5.2.1-1 and Table 6.6.5.2.1-2 of 3GPP TS 38.104 [3], respectively.

6.6.5.3 Conducted Tx spurious emissions requirement for *BS type 1-C*

Minimum conducted requirement for *BS type 1-C* in FR1 is defined as basic limit, i.e. no scaling and no antenna considered.

The transmitter spurious emission limits for *BS type 1-C* conducted requirement apply from 9 kHz 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 sub-clause 6.6.4.

The transmitter spurious emission limits for *BS type 1-C* are specified as basic limits in sub-clause 6.6.5.2.

For BS capable of multi-band operation where multiple bands are mapped on the same m*ulti-band connector*, this exclusion applies for each supported operating band. For BS capable of multi-band operation where multiple bands are mapped on separate antenna connectors (*TAB connectors*), the single-band requirements apply and the multi-band exclusions and provisions are not applicable.

The requirements shall apply whatever the type of transmitter considered (single carrier or multi-carrier). It applies for all transmission modes foreseen by the manufacturer's specification. Unless otherwise stated, all requirements are measured as mean power (RMS).

6.6.5.4 AAS conducted Tx spurious emissions requirement

The transmitter spurious emission limits for 1-H conducted requirement apply from 9 kHz 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 sub-clause 6.6.4.

The transmitter spurious emission limits for 1-H are based on the emissions scaling, where the emissions limits are defined as:

$$\text{Basic limit} + 10\log(N).$$

N is the scaling factor which is based on the number of active transmitter units as counted at the *transceiver array boundary*.

6.7 Transmitter intermodulation

6.7.1 General

Traditionally the transmitter intermodulation requirement was created to guarantee emission levels in a co-location scenario. The requirement is based on robustness against injection of a reverse interference signal from a co-located BS. In addition, for NR AAS BS reverse interference signals can be caused also by intra-system coupling.

Therefore, two types of transmitter intermodulation scenarios have been identified for NR BS:

1) Co-location transmitter intermodulation in which the interfering signal is from a co-located BS, and this is analogous to the existing transmitter intermodulation requirement in 3GPP TS 36.104 [6]. This scenario is applicable for requirement set 1-C and 1-H.

2) Intra-system transmitter intermodulation in which the interfering signal is determined by the sum of the co-channel leakage power coupled via the combined RDN and antenna array within the NR AAS BS. This scenario is applicable for requirement set 1-H.

For NR AAS BS following requirement set 1-H both scenarios are captured by the transmitter intermodulation requirement, where a reverse interference signal is feed to *TAB connector*, while maintaining emission levels.

The co-location transmitter intermodulation test is considered sufficient if it represents the greatest interference power at the tested antenna connector or *TAB connector*. Intra-system AAS transmitter intermodulation is only be tested where the maximum leakage power at the *transceiver unit* connector exceeds the interference signal power level at the *TAB connector* determined for co-location transmitter intermodulation.

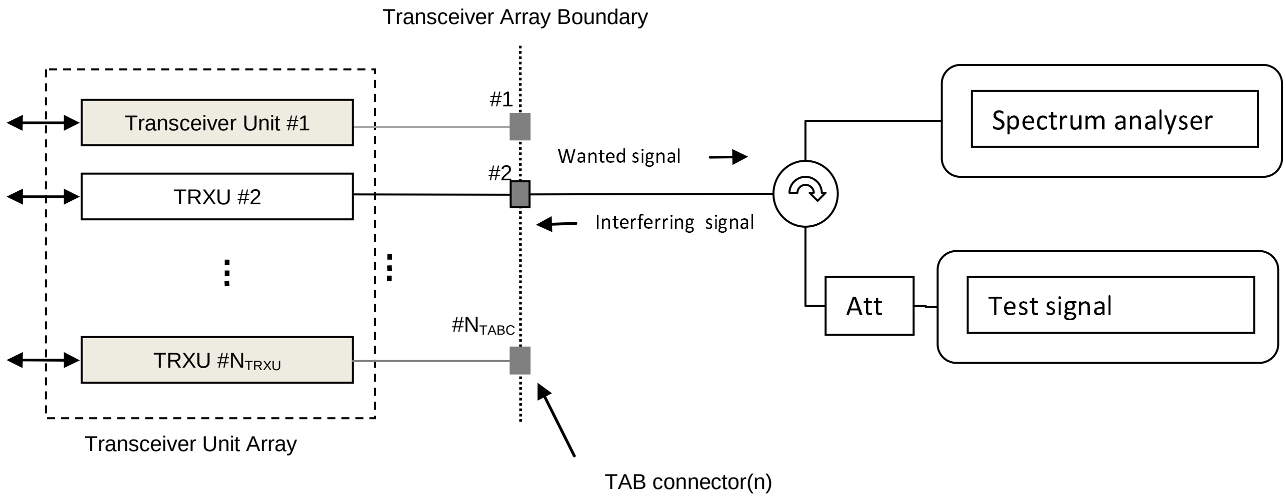


Figure 6.7.1-1: Set-up for testing transmitter intermodulation on one TAB connector

6.7.2 Co-location transmitter intermodulation

Traditionally for the transmitter intermodulation requirement is to address the coexistence between the transmitter antenna from one BS and the transmitter antenna from another BS in case the antennas are co-located with assumption that the worst-case coupling loss between them is 30 dB. The requirement assumes that they transmit the same level of power, and the transmitted signals are adjacent to each other in the frequency domain.

For BS type 1-C this results in the power level of the interfering signal being specified as the power at the antenna connector minus the coupling factor of 30dB.

For BS type 1-H the specific co-location coupling is between an aggressor co-located system and the element/sub array of the victim BS type 1-H. Whilst the top-level co-location scenario is the same the resulting interference power definition different as the TAB connector power is not necessarily the same as the aggressor signal power and the coupling between the aggressor antenna and the element/sub array is not necessarily 30dB. However, these 2 effects tend to cancel each other out resulting in the final definition of the interfere being very similar, where the interferer applied to each TAB connector is the wanted signal power at the TAB connector minus 30dB, according to 3GPP TR 37.842 [8], sub-clause 8.2.5.1.

As the co-location scenarios for NR are the same as those for E-UTRA the same respective solutions can be applied to NR BS type 1-C and BS type 1-H.

The signal parameters to be used for wanted signal and interfering signal is defined in Table 6.7.2-1.

Table 6.7.2-1: NR signal parameters for co-location transmitter intermodulation

Parameter	Value	
	BS type 1-C	BS type 1-H
Wanted signal	NR signal	
Interfering signal type	NR signal of minimum supported CBW (B_I) and SCS set to 15 kHz	
Interfering signal level	Rated total output power per antenna connector in the operating band – 30dB	Rated total output power per TAB connector in the operating band – 30dB
Interfering signal centre frequency offset from the lower (upper) edge of the wanted signal	$f_{offset} = \pm B_I \left(n - \frac{1}{2} \right)$, for n=1, 2 and 3	

The transmitter intermodulation emission level caused by the interference from co-located BS should not exceed the unwanted emission limits of the transmitter spurious emissions requirement, the BS operating band unwanted emission requirement and ACLR requirements in the presence of the interfering signal defined above.

Note: For BS type 1-C the emission levels are defined per antenna connector, for BS type 1-H they emission levels are defined as the sum of the output of all TAB connectors (per operating band).

6.7.3 Intra system transmitter intermodulation

For the E-UTRA hybrid AAS BS an intra system transmitter intermodulation requirement is defined.

In a hybrid AAS BS there could be coupling effects occurring in the RDN and the *antenna array*, which potentially can generate reverse interferers and consequently unwanted emissions due to intermodulation. In this case, the central frequencies of the transmitted signals are aligned in frequency domain, and they could transmit the same level of power.

The wanted signal and the interfering signal in a corresponding test would thus be within the bandwidth of the same carriers. The wanted signal and the interfering signal would have the same waveform characteristics, but they would be non-coherent. The wanted signal for intra hybrid AAS BS transmitter intermodulation testing is the same as the one defined for co-location transmitter intermodulation.

The transmitter intermodulation emission level caused by intra system interfering signal should not exceed the unwanted emission limits of the operating band unwanted emission requirement and ACLR requirement in the presence of the interference signal declared by the manufacturer as described below.

The manufacturer declares one of the following options:

- The maximum interference signal level for testing equal to the maximum intra array leakage power for each *TAB connector* in the transceiver array boundary for each operating band supported by that *TAB connector*.

- The maximum interference signal level for testing equal to the leakage power of the *TAB connector* experiencing the most leakage power in the array to be applied for all *TAB connectors*.

The maximum leakage power at each *TAB connector* at the transceiver array boundary is the sum of the co-channel leakage power coupled via the combined RDN and *antenna array* from all the other *TAB connectors*, but does not comprise power radiated from the *antenna array* and reflected back from the environment. All *TAB connectors* should be transmitting at $P_{Rated,c,TABC}$. The manufacturer can estimate the maximum leakage power at each *TAB connector* at the Transceiver Array Boundary by measurements and calculation. Measurement does not have to include all *TAB connectors* provided that the level of leakage power from the excluded *TAB connectors* have no impact on the estimated maximum leakage power.

The NR BS type 1-H has the same architecture as the hybrid AAS BS and hence the same requirement is applied.

7 Conducted BS receiver characteristics

7.1 General

A general description of applicability for conducted BS receiver characteristics is given in clause 7.1 of 3GPP TS 38.104 [3].

7.2 Reference sensitivity level

7.2.1 General

Reference sensitivity shall be specified according following formula:

$$P_{REFSENS}(dBm) = -174dBm + 10\times\log_{10} BW + N_F + I_M + SNR$$

Where:

- BW is the maximum transmission bandwidth
- N_F is BS noise figure, equal to 5 dB for Wide Area BS, 10 dB for Medium Range BS and 13 dB for Local Area BS.
- I_M is the implementation margin, equal to 2dB.
- SNR is the SNR value for which we reach 95% throughput. Each company provided simulation results, and average will be done for each BW.

7.2.2 FRCs

To specify Reference Sensitivity requirement, following agreements have been reached:

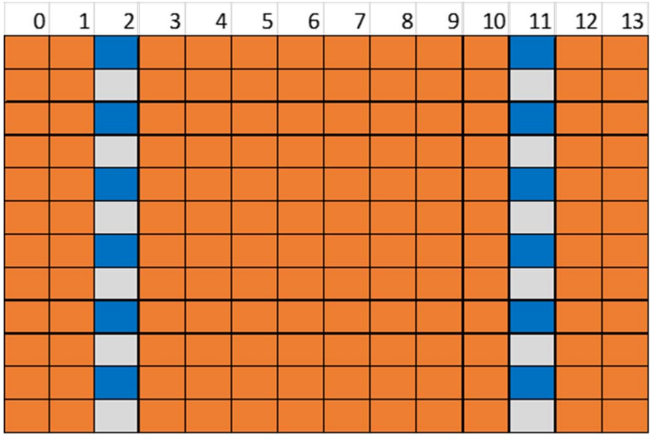
- Limit the number of FRCs to the strict minimum.
- It shall be possible to specify one requirement per *BS channel bandwidth* and per sub-carrier spacing.
- Due to the new spectrum allocation, for some *BS channel bandwidth*, it would not be possible anymore to cover all PRBs by juxtaposing FRC occurrences, some overlapping might be needed.

Following FRCs have been selected so for FR1 REFSENS:

Table 7.2.2-1: Fixed reference channel for FR1 REFSENS.

	BS Channel BW	Subcarrier spacing	Number of PRBS
G-FR1-A1-1	5 MHz	15 kHz	25
G-FR1-A1-2	5 MHz	30 kHz	11
G-FR1-A1-3	10 MHz	60 kHz	11
G-FR1-A1-4	20 MHz	15 kHz	106
G-FR1-A1-5	20 MHz	30 kHz	51
G-FR1-A1-6	20 MHz	60 kHz	24

Following DMRS pattern (front loaded) was also selected. DMRS symbols are boosted by 3dB.



No PTRS was considered for FR1and FR2MCS index 4 was selected with target code rate equal to 308/1024 for Reference Sensitivity and In Channel Selectivity FRCs. Complete list of simulations assumptions could be found in Annex B.

7.3 Dynamic range

Dynamic range is specified as a measure of the capability of the receiver to receive a wanted signal in the presence of an interfering signal inside the received *BS channel bandwidth*. In this condition a throughput requirement shall be met for a specified reference measurement channel.

FRC

NR supports multiple numerologies as well as increased number of *BS channel bandwidth*s, e.g. up to 100MHz for frequency range 1. To better balance the spec complexity and test permutation, it was agreed to define the following FRCs for dynamic range requirement. The SNR @95% maximum throughput point for each FRC will be used for the wanted signal calculation.

Table 7.3-1: Fixed reference channel and SNR points for dynamic range

FRC	*BS channel bandwidth* (MHz)	Subcarrier spacing (kHz)
G-FR1-A2-1	5	15
G-FR1-A2-2	5	30
G-FR1-A2-3	10	60
G-FR1-A2-4	20	15
G-FR1-A2-5	20	30
G-FR1-A2-6	20	60

Interference level

Receiver dynamic range requirement is to ensure that the base station can receive high throughput also in the presence of increased interference levels. It measures the effects of base station receiver impairments. While measuring these effects, uncertainty due to the receiver's own thermal noise floor should be minimized. So the interference level should be increased by a certain amount of margin to mask the receiver's own noise floor. From a scenario of view, it is reasonable to adopt the similar amount of interference signal margin for NR as for E-UTRA. The mean power of interfering signal is defined in the following method:

$$P_{Intf} = -174\text{dBm/Hz}+10*\log10(N_{RB}*SCS*12) + NF + 20$$

Where:

- N_{RB} is the transmission bandwidth configuration N_{RB} of the lowest SCS defined in TS 38.104 [3] for each *BS channel bandwidth*;
- SCS is the lowest sub-carrier spacing defined in TS 38.104 [3] for each *BS channel bandwidth*;
- NF is noise figure of NR BS receiver in dB, where 5dB is assumed for WA, 10dB for MR ,13dB for LA;

Wanted signal

The mean power of the wanted signal is defined in the following method:

$$P_{wanted} = -174\text{dBm/Hz}+10*\log_{10}(N_{RB}*SCS*12) + NF + 20+SNR+IM$$

Where

- NF is noise figure of NR BS receiver in dB, where 5dB is assumed for WA, 10dB for MR ,13dB for LA;
- IM is implementation margin reserved for BS manufacturer in dB; for high MCS level, IM is assumed to be 2.5dB;
- N_{RB} depends on the FRCs defined for dynamic range requirement;
- SCS is the sub-carrier spacing of the wanted signal;
- SNR is the value to satisfy the 95% throughput of measurement channel;

7.4 In-band selectivity and blocking

7.4.1 Adjacent Channel Selectivity (ACS)

The following have been agreed for conducted ACS requirement in FR1:

- For *BS channel bandwidth*s of 5 MHz, adopt the E-UTRA BS (46dB) ACS to all NR BS classes.
- For *BS channel bandwidth*s more than 5 MHz, apply the same interferer power as for *BS channel bandwidth*s equal to 5 MHz.
- The allowed REFSENS degradation is 6 dB.
- Additional frequency offset similar to E-UTRA should be considered to avoid orthogonality between sub-carriers of wanted and interfering signal.
- ACS interfering signal should not extend to frequency range of OOB blocking.
- For *BS channel bandwidth*s less than or equal to 20 MHz, to specify 5 MHz as the interfering signal channel bandwidth for ACS requirements.
- For *BS channel bandwidth*s wider than 20 MHz, to specify 20 MHz as the interfering signal channel bandwidth.

The wanted signal and interfering signal power level are calculated in the following way in FR1:

Wanted signal power level = REFSENS + 6 dB

Interfering signal power level = BS noise floor + ACS + 4.7dB = -174 dBm/Hz+10*$\log_{10}$(BW) + NF + ACS + 4.7 dB

Where:

- BW is wanted signal bandwidth in Hz, e.g. 25PRB for 5 MHz SCS:15 kHz;
- NF is noise figure which is agreed as 5 dB for WA, 10 dB for MR, 13 dB for LA BS;
- ACS for 5 MHz *BS channel bandwidth* is agreed as 46 dBc;
- 4.7 dB is calculated from 10$\log_{10}$(10^(6/10)-1).

The ACS requirement may be specified with an offset calculated for the exact position of the interfering signal such that the sub-carrier grid of the interferer is ½ of the sub-carrier spacing offset from the sub-carrier grid of the wanted signal. Furthermore, the sub-carrier spacing of the interferer and the wanted signal could be set the same, such that the offset is achieved for all sub-carriers of the interferer and wanted signal. However, since only the first few sub-carriers tend to impact ACS performance it is preferable to apply 15 kHz sub-carrier spacing for the interferer regardless of the wanted signal sub-carrier spacing, since the 15 kHz sub-carrier spacing has the highest spectrum utilization. Testing with the minimum distance from the active PRBs of the interferer and the wanted signal bandwidth edge is seen as more important than aligning the sub-carrier spacings.

The required increment in frequency offset can be calculated by applying the following equation:

$$\Delta F_{Interferer} = \frac{\Delta f}{2} \cdot \left(x + (1+x) \bmod 2\right) - F_{Interferer}$$

where

$$x = \left\lceil \frac{F_{Interferer}}{\Delta f / 2} \right\rceil$$

$$\Delta f = 15kHz$$

and $F_{Interferer}$ is the nominal frequency offset (which is equal to half of the sum of the channel bandwidth of the wanted signal and the channel bandwidth of the interfering signal) and $\Delta F_{Interferer}$ is the calculated offset increment. Moreover, the frequency offset between the wider than 20 MHz wanted signal and the 20 MHz interfering signal is further reduced by 540 kHz (3 RBs) considering the DFT-s-OFDM interfering signal type.

The wanted signal subcarrier spacing should be the lowest subcarrier spacing supported by the BS for the *BS channel bandwidth* in question.

Based on above agreements, the ACS requirement is specified in Table 7.4.1.2-1 and Table 7.4.1.2-2 of 3GPP TS 38.104 [3].

7.4.2 In-band Blocking

The following have been agreed for conducted in-band blocking requirement in FR1:

- To specify the below 6GHz NR BS receiver in-band blocking conducted requirement for each NR BS class with an interfering signal power equal to that for the corresponding E-UTRA BS class, and the wanted signal level calculated as the BS reference sensitivity plus 6dB.
- The SNR for the BS reference sensitivity can be obtained at 95% relative throughput from link level simulations.
- The interfering signal should be defined as the same type as the interfering signal for the ACS requirement, with carrier frequency offset of two times the *BS channel bandwidth* of the interfering signal plus additional frequency offset like E-UTRA to avoid orthogonality between sub-carriers of wanted and interfering signal.
- Consider extension on the lower and upper boundaries for the in-band blocking requirements.
- Once the alignment of the boundary for both NR and E-UTRA is agreed for the transmitter the same solution is used for the receiver boundary.

For the narrowband blocking requirement, the requirement should be specified with an offset calculated for the exact position of the interfering signal such that the sub-carrier grid of the interferer is ½ of the sub-carrier spacing offset from the sub-carrier grid of the wanted signal. Furthermore, the SCS of the interferer and the wanted signal could be set the same, such that the offset is achieved for all sub-carriers of the interferer and wanted signal. However, since only the first few sub-carriers tend to impact blocking performance it is preferable to apply 15 kHz sub-carrier spacing for the interferer regardless of the wanted signal sub-carrier spacing, since the 15 kHz sub-carrier spacing has the highest spectrum utilization. Testing with the minimum distance from the active PRBs of the interferer and the wanted signal bandwidth edge is seen as more important than aligning the sub-carrier spacings. The required increment in frequency offset can be calculated using same method as the ACS requirement. Moreover, the frequency offset between the wanted signal and the interfering signal is further increased by 7.5 kHz (½ sub-carrier) considering the centre of the interfering RB refers to the frequency location between the two central sub-carriers.

For the general blocking requirement, since the requirement relates to the receiver processing a large general power level, it is not important to consider the SCS for the wanted signal or the offset. The SCS was assumed to be 15khz.

The wanted signal SCS should be the lowest SCS supported by the BS for the *BS channel bandwidth* in question.

Based on above agreements, the general blocking requirements is specified in Table 7.4.2.2-1 of 3GPP TS 38.104 [3] and the narrowband blocking requirement in Table 7.4.2.2-2 and Table 7.4.2.2-3 of 3GPP TS 38.104 [3].

7.5 Out-of-band blocking

7.5.1 General

The out-of-band blocking characteristics is a measure of the receiver ability to receive a wanted signal at its assigned channel in the presence of an unwanted interferer out of the operating band, which is a CW signal for out-of-band blocking.

The conducted out-of-band blocking requirements are reused from E-UTRA and MSR BS.

For a BS capable of multi-band operation, the requirement in the out-of-band blocking frequency ranges apply for each operating band, with the exception that the in-band blocking frequency ranges of all supported operating bands shall be excluded from the out-of-band blocking requirement.

7.5.2 Non-AAS conducted out-of-band blocking

The blocking requirements apply in the out-of-band blocking frequency range, for FR1 non-AAS BS which is more than 20 MHz below the lowest frequency of the uplink operating band or more than 20 MHz above the highest frequency of the uplink operating band for an operating band less than or equal to 200 MHz wide, or is more than 60MHz below the lowest frequency of the uplink operating band or more than 60 MHz above the highest frequency of the uplink operating band for an operating band more than 200 MHz wide, but includes the downlink frequency range of the operating band.

7.5.3 AAS conducted out-of-band blocking

The blocking requirements apply in the out-of-band blocking frequency range, for FR1 AAS BS which is more than 20 MHz below the lowest frequency of the uplink operating band or more than 20 MHz above the highest frequency of the uplink operating band for an operating band less than 100 MHz wide, or is more than 60MHz below the lowest frequency of the uplink operating band or more than 60 MHz above the highest frequency of the uplink operating band for an operating band more than or equal to 100 MHz wide, but includes the downlink frequency range of the operating band.

7.6 Receiver spurious emissions

7.6.1 Background for conducted receiver spurious emissions in LTE

For BS type 1-C the E-UTRA requirement for receiver spurious emissions in 3GPP TS 36.104 [6] is for the power of emissions generated or amplified in a receiver that appear at the BS receiver antenna connector. For BS type 1-H the E-UTRA requirement for receiver spurious emissions is in 3GPP TS 37.105 [7], the limit is based on the limits in 3GPP TS 36.104 [6] but applied to the hybrid AAS architecture. The requirements apply to all BS with separate RX and TX antenna ports. In this case for FDD BS the test shall be performed when both TX and RX are on, with the TX port terminated. The requirement consists of three parts:

- General spurious emissions requirements, based on internationally recognized limits.
- Additional requirements for protection of FDD BS receivers, and for co-existence with other systems. These requirements are incorporated by reference to the corresponding Transmitter spurious emission limits.
- Co-existence requirements that may apply for co-located base stations, also incorporated by reference.

For the general spurious emissions requirement in [6], the frequency range covered by the requirement is set as follows:

- The frequency range covered by the spurious emissions requirement for the BS transmitter should be included. For LTE, this is frequencies that are more than 10 MHz below the lowest frequency the BS downlink operating band or more than 10 MHz above the highest frequency of any of the BS downlink operating.

- In addition, the 250% rule must be met also within the downlink operating band. This must be explicitly stated for the Receiver, since there is no Rx requirement that corresponds to the Operating band unwanted emissions for the transmitter.

7.6.2 NR receiver spurious emissions limits (conducted)

The general spurious emission limits should exclude the frequency range in the transmitter out-of-band domain, i.e. out to the outermost carrier centres plus 250% of the necessary bandwidth. In order to align with the Transmitter spurious emissions requirements in Clause 6.6.5, frequencies that are more than Δf_{UEM} below or above the transmitter operating band are however not excluded from the requirement, even if they are within 2.5 * $BW_{Channel}$ from the carrier. The total frequency range covered by the limits will thus be the same as for transmitter spurious emissions, plus the additional frequencies inside the operating band that are not covered y the 250% rule. The reason is that there is no other unwanted emission limit for the receiver that would cover those frequencies inside the operating band.

For a type 1-C BS the spurious emissions power is the power of emissions generated or amplified in a receiver that appear at the BS receiver antenna connector. The limits apply to all BS type 1-C with separate RX and TX antenna ports. The test shall be performed when both TX and RX are on, with the TX port terminated.

For all BS type 1-C with common RX and TX antenna port the transmitter spurious emission limits as specified in clause 6.6.5 is valid.

The resulting spurious emissions limits are shown in Table 7.6.2-1 of 3GPP TS 38.104 [3].

In addition to the requirements in Table 7.6.2-1 of 3GPP TS 38.104 [3], additional limits for protection of FDD BS receivers, and for co-existence with other systems, plus the Co-existence limits that may apply for co-located base stations, should be incorporated by reference.

7.7 Receiver intermodulation

The following have been agreed for conducted receiver intermodulation requirements in FR1:

- To specify the below 6GHz NR BS receiver intermodulation conducted requirements for each NR BS class with an interfering signal power equal to that for the corresponding E-UTRA BS class, and the wanted signal level calculated as the BS reference sensitivity plus 6 dB.
- The SNR for the BS reference sensitivity can be obtained at 95% relative throughput from link level simulations.
- The bandwidth of the modulated interfering signal should be defined as the same as that of the interfering signal for the ACS requirement, with SCS is the same as that of the wanted signal to ensure that any peaks of the IM product align with the SCS of the wanted signal.
- The offsets between the CW and modulated interfering signal centre frequency and the nominal band edge of the wanted carrier specified to ensure the intermodulation products fall (almost) on the edge resource blocks of an operating *BS channel bandwidth* and avoid orthogonality between sub-carriers of wanted and interfering signal.
- Requirements are set for all possible SCS of the wanted signal, but only the lowest SCS supported by the BS needs to be tested.

For the general receiver intermodulation requirement, the frequency offset of the modulated interfering signal centre frequency from the lower/upper *Base Station RF Bandwidth* edge is calculated by the following equation:

$$\Delta f_{Mod} = 15 + \frac{BW_{interferer}}{2}$$

Where

$BW_{interferer}$ = Channel bandwidth of the modulated interfering signal (in MHz)

The modulated interfering signal resource blocks should be placed adjacent to the transmission bandwidth configuration edge which is closer to the *Base Station RF Bandwidth* edge.

Then the frequency offset of the CW interfering signal from the lower/upper *Base Station RF Bandwidth* edge is calculated by the following equation to ensure the intermodulation products fall (almost) on the edge resource blocks of the operating *BS channel bandwidth* at least with the lowest SCS defined for the wanted signal channel bandwidth:

$$\Delta f_{CW} = 7.5 - \frac{G_{wanted} - G_{interferer}}{2}$$

Where

G_{wanted} = Minimum guardband with the lowest SCS defined for the wanted signal channel bandwidth (in MHz)

$G_{interferer}$ = Minimum guardband with the lowest SCS defined for the interfering signal channel bandwidth (in MHz)

The lowest SCS defined for the wanted signal channel bandwidth is targeted here, as the resultant intermodulation products may fall partly outside the wanted signal resource blocks if the highest SCS (which is optional for UE to support) is targeted.

In case the frequency offset of the CW interfering signal is too close to the lower/upper *Base Station RF Bandwidth* edge, the modulated interfering signal centre frequency is increased by 5 MHz, so that the frequency offset of the CW interfering signal from the lower/upper *Base Station RF Bandwidth* edge can then be increased by 2.5 MHz.

Therefore, the frequency offsets of the interfering signals are calculated in table 7.7-1 below. It can be seen from the table that with the resultant intermodulation products fall on the wanted signal edge resource block at least with the lowest SCS defined for the wanted signal channel bandwidth.

Table 7.7-1: Interfering signals for general intermodulation requirement

***BS channel bandwidth* of the lowest/highest carrier received (MHz)**	**Interfering signal centre frequency offset from the lower/upper *Base Station RF Bandwidth* edge (MHz)**	**Distance between intermodulation products edge and wanted signal edge resource block edge with 15 kHz sub-carrier spacing (kHz)**	**Distance between intermodulation products edge and wanted signal edge resource block edge with 30 kHz sub-carrier spacing (kHz)**	**Distance between intermodulation products edge and wanted signal edge resource block edge with 60 kHz sub-carrier spacing (kHz)**
5	±7.5 ±17.5	0	0	N/A
10	±7.465 ±17.5	0	-90	-450
15	±7.43 ±17.5	0	0	-360
20	±7.395 ±17.5	0	-90	-630
25	±7.465 ±25	0	90	-450
30	±7.43 ±25	0	0	180
40	±7.45 ±25	0	0	-180
50	±7.38 ±25	0	0	0
60	±7.49 ±25	N/A	0	-180
70	±7.42 ±25	N/A	0	0
80	±7.44 ±25	N/A	0	0
90	±7.46 ±25	N/A	0	0
100	±7.48 ±25	N/A	0	0

For the narrowband receiver intermodulation requirement, the frequency offset of the modulated interfering RB centre frequency from the lower/upper *Base Station RF Bandwidth* edge is calculated by the following equation:

$$\Delta f_{Mod} = 700 + G_{wanted} + \frac{SCS_{wanted}}{2} + \frac{RB_{interferer}}{2}$$

Where

G_{wanted} = Minimum guardband with the highest SCS defined for the wanted signal channel bandwidth (in kHz)

SCS_{wanted} = The highest SCS defined for the wanted signal channel bandwidth (in kHz)

$RB_{interferer}$ = RB size with the highest SCS defined for the modulated interfering signal channel bandwidth (in kHz)

The modulated interfering RB centre frequency refers to the frequency location between the two central subcarriers. Although the highest SCS defined for the wanted signal channel bandwidth is targeted here, the resultant intermodulation products still fall wholly inside the wanted signal resource blocks with the lowest SCS, because the intermodulation products are only one RB wide.

In case the modulated interfering RB centre frequency does not align the RB grid of the adjacent channel with the lowest SCS defined for the modulated interfering signal channel bandwidth, the modulated interfering RB centre frequency is adjusted so that the modulated interfering RB will fall onto the closest RB position of the adjacent channel.

Then the frequency offset of the CW interfering signal from the lower/upper *Base Station RF Bandwidth* edge is calculated by the following equation to ensure the intermodulation products fall (almost) on the edge resource blocks of the operating *BS channel bandwidth* with the highest SCS defined for the wanted signal channel bandwidth:

$$\Delta f_{CW} = \frac{\Delta f'_{Mod} - SCS_{wanted}/2 - RB_{interferer}/2 - G_{wanted}}{2}$$

Where

$\Delta f'_{Mod}$ = Frequency offset of the modulated interfering RB centre frequency from the lower/upper *Base Station RF Bandwidth* edge after RB grid alignment (in kHz)

In case the frequency offset of the CW interfering signal is too close to the lower/upper *Base Station RF Bandwidth* edge, the modulated interfering RB centre frequency is increased by one RB size with the lowest SCS defined for the modulated interfering signal channel bandwidth, so that the frequency offset of the CW interfering signal from the lower/upper *Base Station RF Bandwidth* edge can then be increased by half of the RB size.

Therefore, the frequency offsets of the interfering signals are calculated in table 7.7-2 below. It can be seen from the table that the resultant intermodulation products consistently fall on the wanted signal edge resource blocks with the highest SCS defined for the wanted signal channel bandwidth.

Table 7.7-2: Interfering signals for narrowband intermodulation requirement

***BS channel bandwidth* of the lowest/highest carrier received (MHz)**	**Interfering signal centre frequency offset from the lower/upper *Base Station RF Bandwidth* edge (MHz)**	**Distance between intermodulation products edge and wanted signal edge resource block edge with 15 kHz sub-carrier spacing (kHz)**	**Distance between intermodulation products edge and wanted signal edge resource block edge with 30 kHz sub-carrier spacing (kHz)**	**Distance between intermodulation products edge and wanted signal edge resource block edge with 60 kHz sub-carrier spacing (kHz)**
5	±360 ±1420	360	0	N/A
10	±370 ±1960	810	360	0
15	±380 ±1960	720	360	0
20	±390 ±2320	990	540	0
25	±325 ±2350	1080	720	0
30	±335 ±2350	990	540	0
40	±355 ±2710	1350	900	0
50	±375 ±2710	1170	720	0
60	±395 ±2710	N/A	900	0
70	±415 ±2710	N/A	720	0
80	±435 ±2710	N/A	720	0
90	±365 ±2530	N/A	720	0
100	±385 ±2530	N/A	720	0

Based on above agreements, the receiver intermodulation requirement is specified in Table 7.7.2-1 and Table 7.7.2-2 of 3GPP TS 38.104 [3] for general intermodulation and Table 7.7.2-3 and Table 7.7.2-4 of 3GPP TS 38.104 [3] for narrowband intermodulation.

7.8 In-channel selectivity

In-channel selectivity (ICS) is a measure of the receiver ability to receive a wanted signal at its assigned resource block locations in the presence of another in-channel wanted signal received at a much larger power spectral density.

Similar as for E-UTRA BS, the UL signal is defined for 2 users, one being the "wanted" signal and the other one being the "interfering" signal at elevated power. The wanted signal and interfering signal power level are calculated in the following way:

Interfering signal power level = -174dBm/Hz+10*$\log_{10}$(BW)+NF+ICS;

Where:

- BW is interfering signal bandwidth in Hz, e.g. 10PRB for 5MHz SCS:15 kHz;
- NF is agreed as 5dB for WA, 10db for MR, 13dB for LA BS;
- ICS is agreed as 25dBc for all BS type which is the same as legacy E-UTRA ICS;

It should be noted that DFT-s-OFDM has been adopted as the interfering signal of ICS requirement, the PRB number of interfering signal should comply with basic DFT process principle $2^{\alpha 1} \cdot 3^{\alpha 2} \cdot 5^{\alpha 3}$ specified in TS 38.211 [25].

Wanted signal power level for ICS requirement for BS type 1-C and 1-H could be calculated as following:

Wanted signal power level = -174 dBm/Hz+10*$\log_{10}$(BW)+NF+SNR+IM+3;

Where:

- BW is wanted signal bandwidth in Hz, e.g. 15PRB for 5MHz SCS:15 kHz;
- NF is agreed as 5dB for WA, 10dB for MR, 13dB for LA BS;
- SNR is dependent on the link level simulation results;
- IM is implementation margin which is assumed as 2dB;
- 3dB is reference sensitivity degradation which is reused from legacy E-UTRA requirement;

Regarding the interferer level, the modulation scheme for interfering signal is assumed as 16QAM and modulation scheme for wanted signal is assumed as QPSK.

8 Void

9 Radiated BS transmitter characteristics

9.1 General

9.1.1 Spatial definitions

NOTE: For description of spatial definition for the OTA requirements, refer to the OTA BS testing TR 37.941 [36].

Table 9.1.1-1: Void

9.2 Radiated transmit power

9.2.1 General

The minimum requirements for radiated transmit power, are placed on one or more manufacturer declared beam(s) over a declared *OTA peak direction set*. OTA requirements for NR BS output power are defined for directional EIRP requirements as radiated transmit power requirements (sub-clauses 9.2.2 and 9.2.3) and for TRP requirements as OTA base station output power (sub-clauses 9.3.2 and 9.3.3).

Some NR bands have a significantly larger fractional band width than existing bands as shown in Table 9.2.1-1.

Table 9.2.1-1: NR bands

Band	*Band Definition* f_l to f_h (MHz)	Absolute Bandwidth $f_h - f_l$ (MHz)	Relative Bandwidth f_h/f_l (dB)	Fractional Bandwidth $100 \cdot (f_h - f_l)/f_c$ (%)
n41	2496 to 2690	194	0.3	7.5
n77	3300 to 4200	900	1.0	24.0
n78	3300 to 3800	500	0.6	14.1
n79	4400 to 5000	600	0.6	12.8
n257	26500 to 29500	3000	0.5	10.7
n258	24250 to 27500	3250	0.5	12.6
n260	37000 to 40000	2500	0.3	6.5
n261	27500 to 28350	850	0.13	3.0

The fractional bandwidth FBW is given in percent as:

$$FBW = 100\frac{f_h - f_l}{f_c} = 200\frac{f_h - f_l}{f_h + f_l} \quad (\%)$$

The radiated transmit power in a specific direction in terms of EIRP can be expressed as: EIRP = TRP + D in dBm, where TRP is the total radiated power in dBm and D is the directivity in dBi. For an array antenna the composite directivity is determined by the element directivity and the array factor directivity. From TR 38.803 [24] Annex C, the element directivity can be expressed as:

$$D_E \approx 10log\left(\frac{4\pi A_{eff}}{\lambda^2}\right)$$

where A_{eff} is the antenna aperture in m^2 and λ is the wave length in m.

For a uniform rectangular array antenna, where elements as separated $d\lambda$ m along both y-axis and the z-axis, the maximum area for the antenna aperture is limited to an area of $(d\lambda)^2$ m^2. Typically, the d is in the range of 0.5 to 0.7 and λ is derived from the highest supported frequency. Since the directivity is depending on frequency, it is interesting to analyze the directivity characteristics as function of very wide operation bands.

In Table 9.2.1-2, some wide NR bands have been analyzed with respect to directivity variations (δ) due to fixed antenna aperture.

Table 9.2.1-2: Directivity variation over supported frequency range

Band	δ (dB)
n41	-0.6
n77	-2.1
n78	-1.2
n79	-1.1
n257	-0.9
n258	-1.1
n260	-0.7

It's clear that the directivity is lower at lowest supported frequency compared with the highest supported frequency as expected. For a NR base station supporting wide bands the directivity variation is managed by declaring EIRP at lowest supported frequency and highest supported frequency within a specific band.

9.2.2 Minimum requirement for BS type 1-O and BS type 1-H

For requirement set 1-H and 1-O, the radiated transmit power requirements will be the same as those for E-UTRA, background information for the minimum requirement is captured in 3GPP TR 37.842 [8], sub-clause 7.2.4. The radiated transmit power requirements for FR1 are defined as the directional requirements on the output power accuracy for EIRP.

As the radiated transmit power for FR1 is based on the manufacturer's declarations, the *basic limit* concept does not apply to this requirement.

The technical background for BS type 1-O extreme condition requirement is captured in TR 37.843 [9].

9.2.3 Minimum requirement for BS type 2-O

Based on the background information in TR 37.842 [8], and aspects related to FR2 captured in TR 38.803 [24], the minimum requirement for BS type 2-O will be defined. For requirement set 2-O, the radiated transmit power requirements will be defined as the directional requirements on the output power accuracy for EIRP.

The technical background for BS type 2-O extreme condition requirement is influenced by TR 37.843 [9] and adapted for FR2.

9.3 OTA Base station output power

9.3.1 General

OTA base station output power requirements are valid when the beam has any specific *beam peak direction* associated with a *beam direction pair* within the *OTA peak directions set*. Conformance is only required in a single *beam peak direction*.

Despite the general requirements for the NR BS output power described in sub-clauses 9.3.2 – 9.3.3, additional regional requirements might be applicable.

9.3.2 Output power requirement for FR1

For 1-O requirements set, the TRP will be used as a metric for NR BS output power limit requirement. The OTA BS output power limit requirement for 1-O applies per RIB interface during the *transmitter ON period*.

For 1-O requirements set, the output power limit requirement is based on the *basic limits* defined in sub-clause 6.2.2, with the emissions scaling applied based on the *basic limit* as described in sub-clause 5.9.

Minimum radiated output power accuracy requirement for the 1-O type NR BS in normal conditions is reused from the AAS BS specification in 3GPP TS 37.105 [7].

No extreme condition requirement is specified for 1-O.

9.3.3 Output power requirement for FR2

Minimum radiated output power accuracy requirement for the 2-O type NR BS is+/- 3dB.

There is no upper limit for the *rated carrier TRP output power* of *BS type 2-O*. This is due to the expectation that co-existence between MR and LA BS with a WA network will not be compromised by output power due to beamforming and greater pathloss.

No extreme condition requirement is specified for 2-O.

9.4 OTA output power dynamics

9.4.1 General

Similar to the conducted requirement, the OTA output power dynamics requirement is divided into:

1. OTA RE power control dynamic range,
2. OTA total power dynamic range.

Verification of the OTA output power dynamics is not impacted by the spatial aspects around the DUT. Therefore the OTA output power dynamics requirements are considered as *directional requirements* and apply to the *beam peak directions* over the *OTA peak directions set*. These requirements shall apply at each RIB supporting transmission in the *operating band*.

9.4.2 OTA RE power control dynamic range for FR1

As verification of the OTA output power dynamics is not impacted by the spatial aspects around the DUT, the OTA RE power control dynamic range for *BS type 1-O* is specified the same as the conducted RE power control dynamic range requirement. The OTA RE power control dynamic range requirement for *BS type 1-O* has no specific test and it is tested together with the OTA EVM.

9.4.3 OTA RE power control dynamic range for FR2

Motivation of the OTA RE power dynamic range requirement by consideration of the power boosting/de-boosting for FR2 was considered as questionable. Coverage extensions for mmW scenarios was seen as not suitable due to challenging propagation conditions (i.e. it is considered that any sort of coverage extension will be done based on FR1 spectrum). Furthermore, interference mitigation by the power de-boosting is also questionable for FR2, as the mmW beamforming will allow granular spatial power allocations, which can be seen as interference reduction in spatial directions other than the wanted signal. Therefore, there is no radiated RE power control dynamic range requirement defined for *BS type 2-O*.

9.4.4 OTA total power dynamic range for FR1

As verification of the OTA output power dynamics is not impacted by the spatial aspects around the DUT, the OTA total power dynamic range for *BS type 1-O* is specified the same as the conducted total power dynamic range requirement.

9.4.5 OTA total power dynamic range for FR2

The derivation of the OTA total power dynamic range requirement for *BS type 2-O* for FR2 channel bandwidths and SCS is following the methodology used for the derivation of the legacy E-UTRA requirements for total power dynamic range.

9.5 OTA Transmit ON/OFF power

9.5.1 OTA Transmitter OFF power

9.5.1.1 General

OTA transmitter OFF power is defined as the mean power measured over 70/N µs filtered with a square filter of bandwidth equal to the Base Station RF transmission Bandwidth (s) centred on the assigned channel frequency of the Base Station RF Bandwidth (s) during the *transmitter OFF period*. N = SCS/15, where SCS is Sub Carrier Spacing in kHz. For BS type 1-O, the transmitter OFF power is defined as the output power at the co-location reference antenna. For BS type 2-O the transmitter OFF power is defined as the TRP. For BS capable of multi-band operation, the requirement is agreed to be only applicable during the transmitter OFF period in all supported operating bands, same as is currently applied for E-UTRA BS.

9.5.1.2 OTA Transmitter OFF power for NR BS 1-O

The transmitter OFF power spectral density for NR BS 1-O is a co-location requirement. The requirement is defined at the co-location reference antenna conductive output side.

The requirements for transmitter OFF power spectral density threshold at the co-location reference antenna is calculated based on the following formula - 85dBm/MHz – 30dB + X dB, where the scaling factor X is equal 9dB. This leads to a transmitter OFF power spectral density threshold of -106 dBm/MHz which is adopted as the minimum requirement in the technical specifications for NR BS type 1-O.

9.5.1.3 OTA Transmitter OFF power for NR BS Type 2-O

For BS Type 1-O three cases are analyzed:

- Own receiver – this is possible but, it is unlikely a TDD system will have separate Tx and Rx antennas so will be identified by the RX sensitivity requirement even for a conducted system.

- Co-located receivers – the requirement is measured for the Tx channel – however the same noise can be expected across the whole operational band. Other co-located receivers using other channels in the band are hence protected.

- Same geographical area receivers – most co-location requirements in the same geographical area assume a reasonable separation between BS’s, hence the isolation is assumed to be greater.

In the case of inter-site interference, the TDD system must be dimensioned with a Guard Period which corresponds to the cell size and its corresponding propagation delay. If we assume that the cell size corresponds to an ISD of d as illustrated in Figure 9.5.1.3-1, we can then calculate the OFF power interference at the neighboring site that can be tolerated as follows.

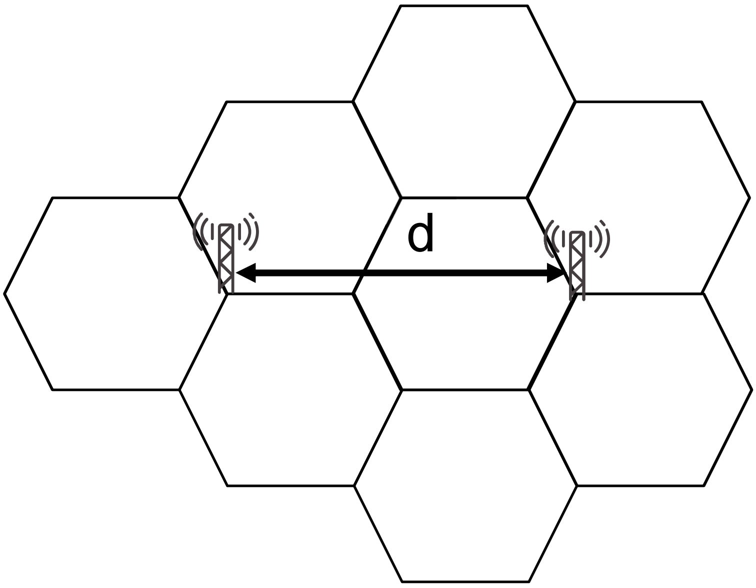


Figure 9.5.1.3-1: The inter site interference propagation case

Assume the Total Radiated Power OFF Power, TRP_{Off} , from an interfering site traverse a path loss L_P to reach the victim receiver. The power at the victim receiver array is then:

$$TRP_{Off} - L_P$$

The OFF power into each victim transceiver equipped with an element receive gain of $G_{E_{RX}}$,becomes:

$$TRP_{Off} - L_P + G_{E_{RX}}$$

The total OFF power fed into the whole array of *N* transceivers, then becomes:

$$TRP_{Off} - L_P + G_{E_{RX}} + 10\log(N) \quad (1)$$

If we assume the margin for a given noise increase in the system is *M* dB and the applicable bandwidth of *B* Hz, we get the total noise in the system as:

$$-174 + 10log(B) + NF - M \quad (2)$$

From equations (1) and (2) we get

$$TRP_{Off} = -174 + 10log(B) + NF - M - 10\log(N) + L_P - G_{E_{RX}}$$

The path loss L_P can be estimated using the 3GPP model for NLOS case:

Where:

- d is in km, and f in GHz

$$L_P = 31.3 - \left(15.07 - \frac{1480}{h_b^2}\right) log(h_b) + (43.42 - 3.1log(h_b)) log(d) + 20log(f) - 0.6(h_m - 1.5)$$

By assuming the following parameters for the path loss L_P:

- B = 1 MHz
- NF = 10 dB

- M = 6 dB, for 1 dB noise rise
- N = 128 transceivers
- $G_{E_{TX}} = G_{E_{RX}}$ = 6 dB
- f = 28 GHz
- d = 100 m
- h_b = 25 m
- h_m = 1.5 m

We get a value for L_P = 117 dB. However, when considering interference, the NLOS case is not the limiting factor but rather the LOS case. In 3GPP we have 2 LOS models LOS1 and LOS2. The path loss L_P for each of these LOS models can be expressed as follows:

$$L_P = 28 + 22log(d) + 20log(f)\text{, at LOS1}$$

$$L_P = 28 + 22log(d) + 20log(f) - 9log\left(d_{brk}^2 + (h_b - h_m)^2\right)\text{, at LOS2}$$

LOS1 model is used for the Urban environment which is characterized by shorter distance.

We get L_P = 101 dB and the corresponding OFF power TRP_{Off} = - 36 dBm/MHz.

This value of -36dBm/MHz can then be the requirement for the transmitter OFF power for BS type 2-O.

This value can be measured either as TRP or at the output of the colocation reference antenna.

In case of transmit power OFF measurement as a TRP, the transient time is measured as a relative EIRP measurement.

For the colocation interference scenario corresponds to when the base stations of two operators mutually interfere with each other simultaneously. A typical configuration is shown in Figure 9.5.1.3-2 where both antennas are mounted on the same vertical plane. The most difficult case is when both operators coexist in the same band.

The TDD network is synchronized to within a T_{Sync}, Cell Phase Sync requirement and the Guard Period T_{GUARD} is dimensioned to cope with the cell size and the transient times:

$$T_{GUARD} \geq 2^* T_{Sync} + 2^*T_{prop\_cell\ edge} + \max((T_{BS\ on \rightarrow off}), (T_{UE\ off \rightarrow on})) + \max((T_{BS\ off \rightarrow on}), (T_{UE\ on \rightarrow off}))$$

The synchronization assumption, the guard period and the assumptions that UL and DL TDD configurations are coordinated so that only the TDD OFF power needs to be considered.

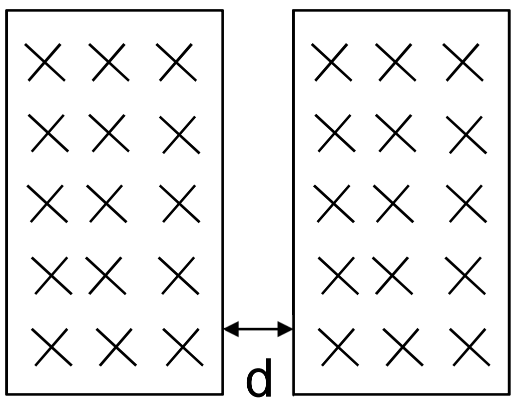


Figure 9.5.1.3-2: Colocation interference scenario

This colocation scenario is governed by the OTA reference sensitivity. Equipment not conforming to reference sensitivity requirements would self desense their own transceiver array and its neighboring sectors, even in its own channel. In this colocation case we would have some additional protection, since this is a neighbor carrier, even if it is in the same band.

For the scenario of sector site example, different sectors are installed within one site. This scenario is also governed by the OTA reference sensitivity. Equipment not conforming to reference sensitivity requirements would self desense their own transceiver array and its neighboring.

In summary, the transmit OFF power spectral density for NR BS type 2-O can be specified as TRP with a value less than -36 dBm/MHz and adopted as the core requirement.

For conformance testing, when verifying TX OFF power and ON/OFF transient period, it is only necessary to measure that the power level is below the TX OFF limit value after the specified time. The absolute TX OFF power level is not explicitly measured because compliance to the OFF power level is inferred by the transient period test.

The conformance power level is measured as the maximum EIRP value assuming on-state directivity (i.e. the difference between the maximum EIRP and TRP during transmitter ON power in dB). The EIRP conformance level during TX OFF power is measured in the beam peak direction within a reference beam direction pair for the declared beam identifier with the highest EIRP.

The transmitter OFF power antenna directivity is not known explicitly and hence an assumption must be made in order to translate the transmitter OFF power TRP core requirement to an EIRP OFF conformance requirement. At the same time the test system sensitivity restrictions due to the measurement being EIRP means it is difficult to measure very low power levels.

It has been shown that it is feasible to measure TX OFF power as EIRP if it is assumed that the transmitter ON antenna directivity is equal to the transmitter OFF antenna directivity. If a lower directivity is assumed then it is not possible to measure the power. Hence it is agreed that the transmitter ON antenna directivity will be used to calculate the EIRP of transmitter OFF level. This is reasonable as the transmitter ON directivity was used as a worst case when calculating the core TRP level in equation (1) above.

As the transmitter OFF level is fixed and there is no upper bound on the TX output power there is effectively no cap on the difference between ON power and OFF power level. Currently the measurement receiver can provide a dynamic range of approximately 70 dB. As the transmitter OFF level is -36 dBm/MHz this sets an upper TRP limit of approximately +34 dBm/MHz or +51 dBm/50MHz. It is not likely that an FR2 BS will have an output power at this power level. Hence, the dynamic range is not likely to be an issue. The ON antenna directivity can be calculated using the declared values of:

- rated carrier output EIRP, $P_{Rated,c,EIRP}$, (clause 4.6, D.11 of TS 38.141-2 [18])
- rated carrier TRP output power, $P_{Rated,c,TRP}$, (clause 4.6, D.37 of TS 38.141-2 [18]),

where $P_{Rated,c,EIRP}$ is in the value associated with the reference beam direction pair for the beam identifier with the highest EIRP.

The transmitter OFF power level for conformance testing as an EIRP TX OFF limit, $P_{EIRP\ OFF,}$ is calculated as:

$$P_{EIRP\ OFF} = TRP_{OFF} + P_{Rated,c,EIRP} - P_{Rated,c,TRP} + Test\,Tolerance$$

9.5.2 OTA Transmitter transient period

For OTA, the transmitter transient period is defined the same as for the conducted case. That is, it is defined as the time period during which the transmitter is changing from the OFF period to the ON period or vice versa. The transmitter transient period is illustrated in Figure 9.5.2-1.

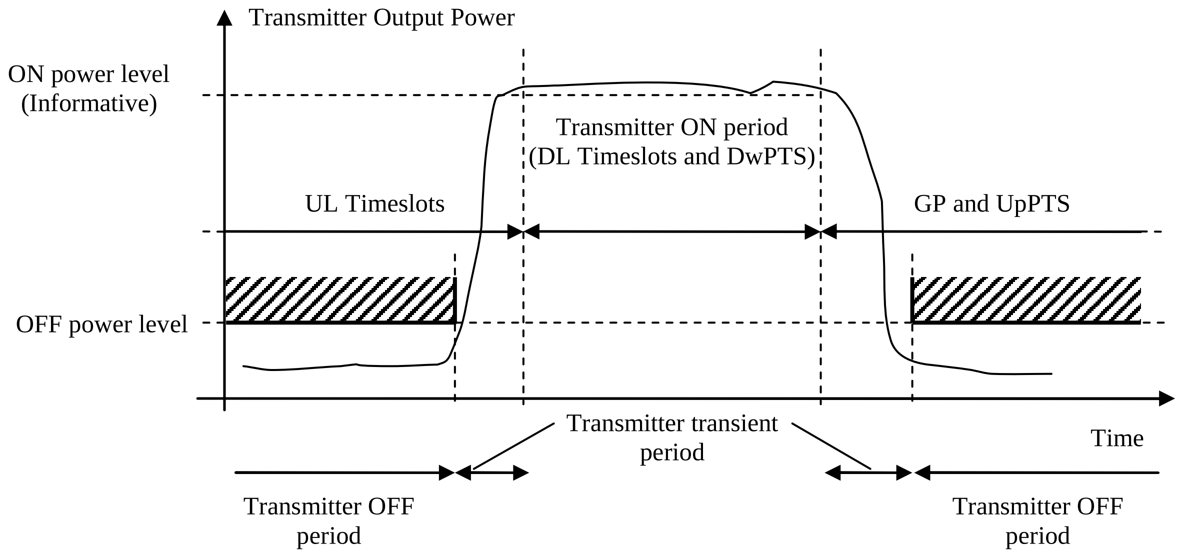


Figure 9.5.2-1: Illustration of the relations of transmitter ON period, transmitter OFF period and transmitter transient period.

In E-UTRA BS, the transmitter transient period for both OFF to ON and ON to OFF are specified to be shorter than 17us.

For NR, since larger sub-carrier spacing are introduced, such as 30kHz, 60kHz and 120kHz, the length of symbol is reduced significantly. It means if the same transient period is kept and the same number of symbol is configured for gap period (GP), the cell coverage will be reduced and BS to BS distance without interference will also be reduced. This may bring the risk of introducing BS to BS interference in the network. Balance needs to be considered between transient period requirements and BS to BS interference in the network. So NR BS transient periods need to be optimized.

Based on the above argument, it is agreed to adopt shorter transient periods for NR BS than the values specified for E-UTRA BS by considering the capabilities of current hardware. A value of 10 µs is agreed and accepted for the transmitter transient periods for FR1 as specified in Table 9.5.3.2-1 of 3GPP TS 38.104 [3].

For FR2, a value of 3 µs is agreed for the transmitter transient period as specified in Table 9.5.3.3-1 of 3GPP TS 38.104 [3].

9.6 OTA Transmitted signal quality

9.6.1 General

Unless otherwise stated, the requirements in clause 9.6 apply during the *transmitter(s) ON period*.

9.6.2 OTA frequency error for FR1

The OTA frequency error requirement is defined to capture the maximum allowable difference between an assigned frequency and the actual generated frequency. The frequency error requirement is a regulatory requirement in some regions.

Based on the motivation captured in 3GPP TS 37.843 [9], the OTA frequency error will be correlated among all TRX units forming the beam, hence the frequency error is coherent, 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.

The measurement time contributes to the frequency error. A short measurement time induces an intrinsic uncertainty of what the frequency error is. A measurement time like 1 ms in LTE is short and one has to go all the way to a one second measurement time is long enough to clear a frequency error measurement from the influence of phase noise and spurs, leaving only the contributions from the reference signal, frequency slip due to non-phase-locks and hold-over frequency drift. A frequency error requirement at ppb accuracy level must have a defined measurement duration. A 1 ms measurement time is sufficient.

As the frequency error is flat in the spatial domain it is only necessary to show conformance in a single direction. Therefore, the OTA frequency error requirement is defined as a directional requirement at the RIB and shall be met within the OTA coverage range. The requirement needs to be defined so that all transmitter units are active and the system is operating at the declared maximum rated total radiated power.

Based on considerations for conducted frequency error requirement in clause 6.5.2, conducted frequency error requirement will be reused for OTA frequency error requirement in FR1.

For the sake of minimising the number of spatial declarations and as frequency error testing is generally done at the same time as OTA EVM testing the 'reference direction' of the OTA compliance peak directions set is the most suitable direction to define for the conformance testing.

For conformance testing purposes, the OTA frequency error shall be tested at the maximum and minimum power settings (together with the EVM test).

9.6.3 OTA time alignment error for FR1

Similar to the conducted TAE requirement motivation captured in sub-clause 6.5.3, the OTA TAE requirement is defined as the largest timing difference between any two different NR signals belonging to different reference symbols in the radiated domain. The OTA TAE requirement is defined as a directional requirement at the RIB and shall be met within the OTA coverage range.

This requirement applies to frame timing in MIMO transmission, *carrier aggregation* and their combination in FR1.

The same general comments apply for carrier aggregation, as already stated in 6.5.3.1 carrier aggregation.

9.6.4 OTA time alignment error for FR2

The same general comments apply for carrier aggregation, as already stated in 6.5.3.1 carrier aggregation.

9.6.5 OTA frequency error for FR2

The Doppler shift dominates over any static frequency error at high speed when it comes to UE HO requirements for mobility and it is the UE RX Doppler performance that matters at handover. Moreover, NR FR2 will in the same way as NR FR1 benefit from using existing synchronization infrastructure. Oscillators in NR FR2 cannot be expected to be better than for NR FR1 and a strict base station frequency error would reduce the base station holdover margin and thereby the holdover duration when losing an external synchronization source. Given this one can conclude that there is nor a need or any motivation from an implantation view to have stricter base station frequency requirements for FR2 than for FR1. The same comments regarding measurement time apply to FR2 as stated for FR1 in clause 9.6.2.

9.6.6 OTA modulation quality for FR1

OTA transmit modulation signal quality is measured in terms of error vector magnitude (EVM). EVM captures a maximum allowed distortion due to degradations in the BS transmitter.

For NR EVM is defined similar to that of E-UTRA in that the measurement device contains a equalization algorithm and the EVM is assessed after equalization. For 2-O, common phase error compensation algorithm is also needed to be applied in addition to the simple equalization algorithm. EVM is also measured over a root mean square average over 10 sub-frames.

Although EVM is expressed in terms of a percentage it is a ratio, that of the error vector and the reference power. Whilst the reference (or wanted) signal may be subjected to beam forming the error vector power has unknown correlation level between transmitter units and hence may be beam formed or not.

The EVM requirement is important only between the BS and its intended UE. Hence the EVM is only of importance in directions where the BS intends to communicate with the UE's. It is therefore in a set of specific directions from the AAS BS which is of interest rather than the average or total EVM over the entire sphere. Based upon the method captured in 3GPP TR 37.843 [9], the EVM requirement is defined over a declared OTA coverage range. The range of directions which the NR BS meets the EVM requirement is declared by the manufacturer as *OTA coverage range*.

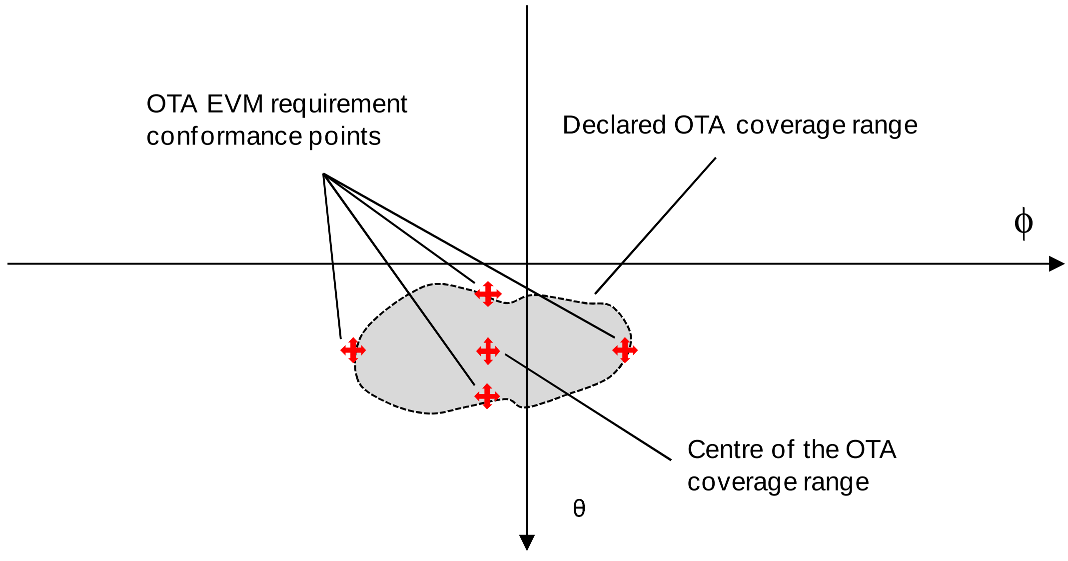


Figure 9.6.6-1. Example of *OTA coverage range* and 5 conformance points

The EVM is required to be met across the *OTA coverage range*. Physical layer specifics such as DM-RS patterns needed are discussed in more detail in 6.5.4 for conducted requirements, can also be applied to OTA for FR1.

9.6.7 OTA modulation quality for FR2

9.6.7.1 General

The EVM requirement for FR2 shall apply also to the range of directions which is described in clause 9.6.6.

The intention of the following description is to summarize the parameters used to determine appropriate EVM levels.

A DM-RS pattern will be transmitted, and a standardized receiver will be used to mitigate some linear aspects of the EVM. Additionally, common phase error compensation algorithm is also needed to be applied in addition to the simple equalization algorithm. For this, an additional reference signal is needed, the so-called phase tracking reference signal (PT-RS).

To balance between reference signal overhead and throughput a balance of DM-RS and PT-RS along with achievable EVM levels were studied.

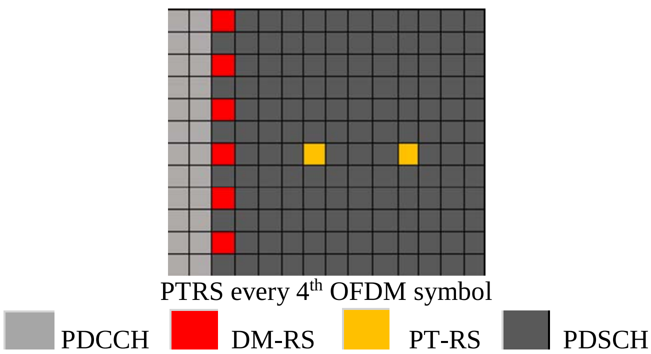


Figure 9.6.7-1: TYPE-1 Pattern front loaded DM-RS (1 DM-RS symbol)

In the following clause, background on the EVM measurement are introduced in details.

9.6.7.2 Example N_{RB} values

For NR specification, it is agreed to use 100 MHz channel bandwidth with 30 kHz SCS for FR1 and 400 MHz channel bandwidth with 120 kHz SCS for FR2 as example cases.

9.6.7.3 RSTP and OSTP

The considerations in clause 6.5.4.3 could be applied for FR2.

9.6.7.4 TDD EVM measurements

Moving average length 19 from E-UTRA specification is to be used for FR2 in NR.

9.6.7.5 EVM window

For the $\Delta\tilde{c}$ configurations, the example case for FR2 is 400 MHz BW with 120 kHz SCS, then sampling rate should be 491.52 Msps, therefore μ is 3 where κ is 64 for Tc (1/480kHz * 4096).

$\Delta\tilde{c}$ is on T_f = 144 ($72\kappa \cdot 2^{-\mu} \cdot T_c \cdot 491.52e6$) within the CP of length 288 ($144\kappa \cdot 2^{-\mu} \cdot T_c \cdot 491.52e6$) (in OFDM symbol $l \neq 0$ or $l \neq 56(7 \cdot 2^{\mu})$).

$\Delta\tilde{c}$ is on T_f = 400 ($(144\kappa \cdot 2^{-\mu} + 16\kappa - 72\kappa \cdot 2^{-\mu}) \cdot T_c \cdot 491.52e6$) within the CP of length 352 ($(144\kappa \cdot 2^{-\mu} + 16\kappa) \cdot T_c \cdot 491.52e6$) (in OFDM symbol $l = 0$ or $l = 56(7 \cdot 2^{\mu})$).

9.7 OTA Unwanted emissions

9.7.1 General

An overview of unwanted emissions and the relation and frequency boundary between the OBUE and spurious emissions is given in clause 9.7.1 of 3GPP TS 38.104 [3].

9.7.2 OTA Occupied bandwidth

The OTA occupied BW requirement is the same as the conducted occupied BW requirement in sub-clause 6.6.2.1. For frequency range1 and frequency range 2 the spatial requirements are the same as those used of an OTA AAS BS [9], occupied BW is a directional requirement

9.7.3 OTA Adjacent Channel Leakage Power Ratio (ACLR)

9.7.3.1 General

OTA ACLR is the ratio of the filtered mean power centred on the assigned channel frequency to the filtered mean power centred on an adjacent channel frequency. TRP is used a metric for the power measured on the assigned channel frequency and the adjacent channel frequency.

9.7.3.2 AAS radiated ACLR requirement for FR1

The OTA ACLR limit requirement for 1-O applies per RIB interface during the *transmitter ON period*. The OTA ACLR limit requirement for 1-O is based on the basic limits without the emission scaling applied as defined in sub-clause 6.3.3. The OTA ACLR absolute limit requirement for 1-O is based on the *basic limits* defined in sub-clause 6.3.3, with the emissions scaling applied to the basic limit as described in sub-clause 5.9.

9.7.3.3 AAS radiated ACLR requirement for FR2

For the frequency ranging from 24.25 GHz to 33.4 GHz, the OTA ACLR1 limit is 28 dB.

For the frequency ranging from 37 GHz to 52.6 GHz, the OTA ACLR1 limit is 26 dB.

The OTA ACLR2 limit is not specified since the emission level at the ACLR2 range will be close to noise floor.

The same *BS channel bandwidth* with the wanted signal can be assumed as the adjacent channel bandwidth.

The transmission bandwidth configuration of wanted channel (it would differ depending on SCS and/or *BS channel bandwidth*) should be used as a measurement bandwidth for the wanted signal power measurement.

Maximum transmission bandwidth configuration of the *BS channel bandwidth* (between subcarrier spacing) specified in Release 15 should be used as a measurement bandwidth for adjacent channel power measurement, i.e. the measurement bandwidth should also apply to future releases regardless of whether new SU is introduced or not.

The minimum radiated requirement for 2-O NR BS for FR2 is specified in Table 9.7.3.3-1 of 3GPP TS 38.104 [3].

It has also been agreed to define absolute ACLR limits for FR2, thus the following is agreed. In case the absolute ACLR requirement is not compatible with Japanese regulation, a regional requirement for Japan can be introduced. The absolute ACLR limits for FR2 are specified in Table 9.7.3.3-2 of 3GPP TS 38.104 [3].

It has also been agreed to apply the 50 MHz adjacent channel carrier to NR channel bandwidth <200 MHz and the 200 MHz adjacent channel carrier to NR channel bandwidth ≥200 MHz for OTA CACLR requirement in FR2. Accordingly, the CACLR requirement and the ACLR requirement in non-contiguous spectrum in FR2 are specified as shown in tables 9.7.3.3-3 to 9.7.3.3-5 of 3GPP TS 38.104 [3].

9.7.4 OTA Operating band unwanted emissions

9.7.4.1 Radiated OBUE Requirement in FR1

Minimum radiated requirement for 1-O NR BS in FR1 is defined based on basic limit with the emissions scaling applied, with reference to the basic limits in clause 6.6.4.2 of 3GPP TS 38.104 [3].

9.7.4.2 Radiated OBUE Requirement in FR2

The NR BS mmWave spectrum emission mask is defined taking into account following assumptions for Category A OBUE requirement:

- Boundary between OOB and spurious domain limits should be applied according ITU-R SM.1539 recommendation.
- Masks in the Out-of-band domain should be band centric OBUE mask
- The NR emission mask should use the emission limits submitted to WP5D as a baseline
- Agreed ACLR values should be considered
- Spurious emission limits should be taken into account (when agreed)
- BS mmWave output power should be taken into account
- Frequency range up to 52.6 GHz should be covered
- The mask is linked with the total transmission bandwidth (the sum of *BS channel bandwidth*s in case of multicarrier transmission).

The BS spectrum emission mask tables will need to cover the following variations:

- Power levels
- Frequency ranges
- BS classes (see further discussion below)

For the LS response to WP5D LS on “Characteristics of terrestrial IMT systems for frequency sharing/interference analysis in the frequency range between 24.25 GHz and 86 GHz” [10], there were spectrum masks developed that were based on similar principles as listed above. The masks in [10] used the FCC limits in 30.203 [11] as a baseline and that defined a mask with lower limits for BS Total transmitted power levels (P_{Tx}) below certain levels, aligned with the ACLR defined for different frequency ranges.

For LTE, there are different masks defined for different BS classes. The BS classes are fundamentally defined for different deployment scenarios (identified by Minimum Coupling Loss MCL), but also with different BS output powers. The spectrum masks for “smaller” BS (Medium Range and Local Area) have a dependence on the BS power level.

For NR, the spectrum masks for Medium Range and Local Area would also have dependence on power level. The dependence could similar between the different BS classes, making it possible to use the same spectrum mask definition for different BS classes. That would for example be the case if similar transceiver implementation was used for the different sized BS and with the implementation scaled with the BS power level in terms of the number of transmitting elements.

For this reason, a generic set of NR Operation Band Category A Unwanted Emission Masks is defined based on the same principles as for the WP5D LS response [10], applicable to all BS classes:

- A fixed mask, same as FCC limit applies to the highest BS power levels.
- Variable masks scaled with power level apply to BS with power level below certain thresholds:
  - One mask for 24.25 – 33.4 GHz, based on ACLR = 28 dBc.
  - One mask for 37 – 52.6 GHz, based on ACLR = 26 dBc.
- Masks are limited to an absolute lowest emission limit of -20 dBm as in the WP5D LS response [10]

The masks cover the frequency ranges within the present scope of the work item. It is specified in Table 9.7.4.3.2-1 to Table 9.7.4.3.2-2 of 3GPP TS 38.104 [3].

The BS power level used to distinguish and derive the FR2 OTA OBUE mask is agreed as rated total TRP output power ($P_{rated,t,TRP}$), which is mean power level that the manufacturer has declared to be available at the RIB during the *transmitter ON period.* Furthermore, it is consensus that the “rated total TRP output power” means both polarizations and includes all sub-blocks in case of non-contiguous operation.

For Category B OBUE requirement is based on the same principle of category A OBUE as much as possible with necessary modification to align with regulation in [35] as below:

- A single Δf_{OBUE} of 1.5GHz applies for FR2 BS type 2-O as well for Category B OBUE
- Wide bandwidth and narrow bandwidth is considered with the breakout point at $BW_{contiguous}$ of 500MHz according to SM.1539

9.7.5 OTA Transmitter spurious emissions

9.7.5.1 General

The metric used to capture OTA transmitter spurious emissions is total radiated power (TRP).

OTA transmitter spurious emissions co-location requirements shall not be specified for BS type 2-O co-located with BS type 2-O. Regional requirements are FFS.

Measurement bandwidths and frequency limits of the spurious emissions range are defined according to SM.329 [4].

9.7.5.2 AAS radiated Tx spurious emissions requirement for FR1

The OTA Tx spurious emission requirement for 1-O type NR BS is defined at RIB interface for the spurious range from 30 MHz (as opposed to the 9 kHz limit for the conducted requirement) up to the 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 sub-clause 6.6.4. For *operating bands* for which the 5^{th} harmonics reaches beyond the 12.75 GHz, the upper limit of the spurious range is extended up to the 5^{th} harmonic of the fundamental range, but not higher than 26 GHz.

Spurious emissions limits for 1-O are based on the *basic limits* defined for Cat. A and for Cat. B in Table 6.6.5-1 and Table 6.6.5-2, with the fixed emissions scaling applied based on the basic limit as described in sub-clause 5.9.

Minimum radiated requirement for *BS type 1-O* is defined based on basic limit with the emissions scaling applied. The basic limits are in clause 6.6.5.2 of 3GPP TS 38.104 [3].

9.7.5.3 AAS radiated Tx spurious emissions requirement for FR2

The Tx spurious emission requirement for *BS type 2-O* is defined at RIB for the spurious range from 30 MHz up to the 2nd harmonics of the upper frequency edge of the *operating band.*

Category A limits are defined for FR2 and are the same as limits defined for *basic limits* in subclause 6.6.5.2. The limits are specified in table 9.7.5.3.2-1 of TS 38.104 [3].

Category B limits are defined for FR2 with regional regulation defined in [35] as baseline. The limits are specified in table 9.7.5.3.2.3-1 with step frequencies defined in table 9.7.5.3.2.3-2. Currently, step frequencies are only defined for one band, i.e. n258, for Category B spurious emissions. If the applicability of Category B limit is confirmed for other FR2 operating band in future, corresponding step frequencies for that band will be defined accordingly. The step frequencies are calculated as shown in table 9.7.5.3-0.

Table 9.7.5.3-0: Step frequencies for defining the radiated Tx spurious emission limits for FR2

Operating band (GHz)	$F_{step,1}$ (GHz)	$F_{step,2}$ (GHz)	$F_{step,3}$ (GHz) (Note 3)	$F_{step,4}$ (GHz) (Note 3)	$F_{step,5}$ (GHz)	$F_{step,6}$ (GHz)
n258 (24.25 – 27.5)	max (18, 24.25 - max (10, 4 × W_B)) = 18	24.25 - max (2, W_B) = 21	24.25 - 1.5 = 22.75	27.5 + 1.5. = 29	27.5 + max (2, W_B) = 30.75	27.5 + max (10, 4 × W_B) = 40.5
NOTE 1: max () is the maximum operation of the two operands. NOTE 2: W_B is the bandwidth of the operating band. NOTE 3: $F_{step,3}$ and $F_{step,4}$ are aligned with the values for Δf_{OBUE}.						

For conformance testing of the Tx spurious emissions requirement for *BS type 2-O*, the upper frequency limit of the spurious range might be limited to 60 GHz value, considering practical OTA measurement capabilities of the OTA test ranges in the spurious range.

Table 9.7.5.3-1: (Void)

9.8 OTA Transmitter intermodulation

9.8.1 General

The 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.

The requirement applies during the *transmitter ON period* and the *transmitter transient period*. The interfering signal level is derived based on the co-location assumption that the co-located BS is of the same class and output power level as the BS under test. The OTA TX IMD interferer level can hence be regarded as a co-location requirement.

Due to high isolation between co-located base stations at FR2 frequencies there is no relevance for a transmitter intermodulation requirement for base stations operating at FR2 bands specified by requirement set 2-O.

9.8.2 Core requirement

The minimum requirement for the transmitter intermodulation requirement is that the emissions output level shall not exceed the unwanted emission limits specified for operating band unwanted emission in sub-clause 9.7.4, transmitter spurious emission in sub-clause 9.7.5, and ACLR in sub-clause 9.7.3 in the presence of a wanted signal and an interfering signal specified in Table 9.8.2-1 of 3GPP TS 38.104 [3] in an OTA environment.

When OTA ACLR, OTA OBUE and OTA spurious emission is defined, the relevance for having a separate intra-system requirement disappears. The intra-system case is covered by OTA unwanted emission requirement including the unwanted emission for the whole system, hence a separate intra-system IMD requirement is not needed when considering OTA.

9.9 Transmitter spatial emissions

9.9.1 General

Traditional antenna data sheets provide information on not only the antenna gain in the intended direction but also the gain in unwanted directions. Traditional metrics are:

- Front to back ration (FBR) – which captured the ratio of emissions behind the antenna compared to those in the forward direction.

- Side Lobe Ratio (SLR) – ratio of the side lobe antenna gain to the main lobe antenna gain.

For an AAS it is clear that these traditional metrics of antenna gain are not directly applicable, as an AAS has the ability to manipulate the shape of the spatial emissions to maintain optimum network throughput it is unlikely that the spatial pattern of the emissions will relate to a specific beam pattern with identifiable side and back lobes. An example of a realistic AAS beam pattern in an operational environment is shown in Figure 9.9.1-1.

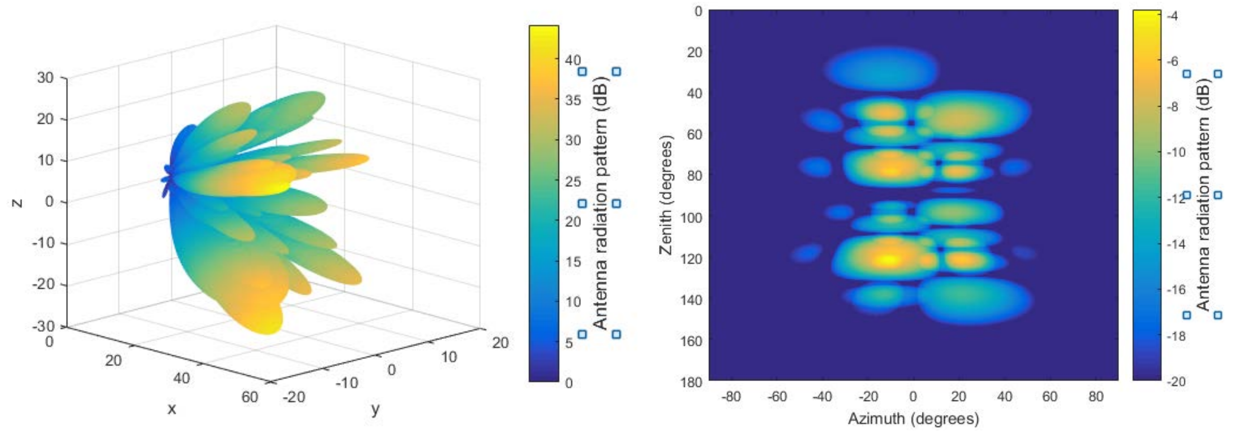


Figure 9.9.1-1: Example of a realistic AAS beam pattern in an operational environment (with DFT subband precoding)

The influence that the shape of the antenna pattern (and wanted and unwanted cell emission) has depends on the number of simultaneously operating beams, which could be depending on the operational state of the beamforming algorithm and operator configurations. The wanted and in the same time the unwanted spatial emissions strongly depends on the number of simultaneously beams and their shapes and directions.

The antenna pattern also depends on beamforming architectures and algorithms, amplitude tapering level, antenna structure, etc. and is affected by realistic propagation channel as described below in example.

In practice, several multipaths may exist to the UE, and radiation along each of the multipaths comprises useful radiation.

For example:

It can be possible that a multipath reflection may result in a beam radiated into the direction of a neighbor cell may be reflected back towards the wanted UE and be useful as shown in Figure 9.9.1-2 (A). Furthermore, in a multipath environment it may also be possible that radiation is both useful for the scheduled UE and interference to other UEs with a different multipath profile. In the example illustrated in figure 3, the beams are reflected back to the wanted UE. However, the beam also causes interference to another UE, as shown in Figure 9.9.1-2(B)

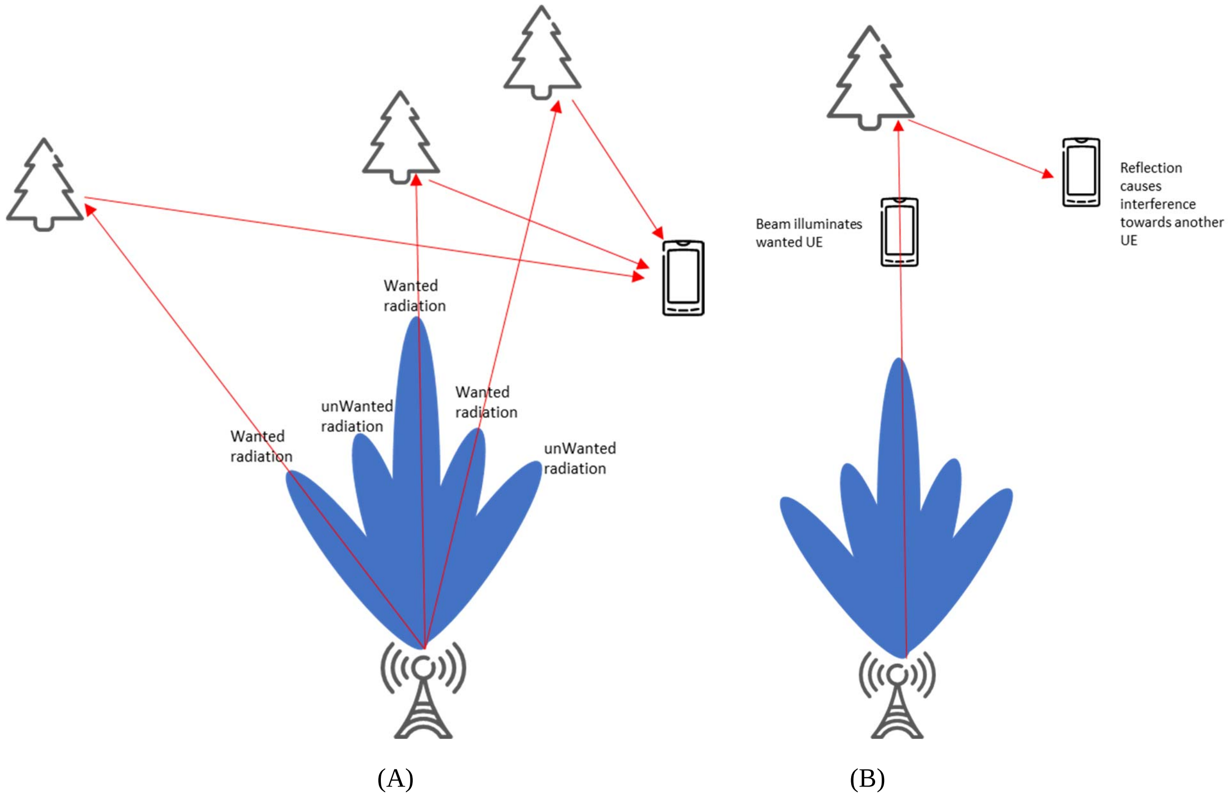


Figure 9.9.1-2: Example of how radiation may be both wanted and unwanted are difficult to differentiate.

Furthermore, techniques such as beam tapering may reduce the side lobe levels but at the cost of widening the beam and hence lowering EIRP. It has been shown that under some circumstances this has a negative effect on network throughput and hence a low side lobe level is not a beneficial target.

Hence the declaration of unwanted spatial emission may in many circumstances not directly relate to system performance on its own. This is because it is often not possible to differentiate wanted and unwanted radiation, and furthermore because the benefits of optimizing beamforming performance may outweigh the impacts of "unwanted" radiation, leading to systems with apparently higher unwanted radiation also providing superior throughput performance. System performance should additionally be characterized taking all factors into account.

However there remains some benefit in having a means to indicate the ratio of emissions in the intended directions to the unintended directions.

An option declaration of the spatial emissions has therefore been defined, this does not form part of the BS minimum requirements but a means for BS vendors to have a common understanding of a means to declare and measure the spatial emissions. This optional declaration should be also defined to limit the evaluation complexities and take into account that not all antenna pattern options could be evaluated due to many possibilities of AAS configuration in term of beamforming techniques, number of beams, amplitude tapering level, radiation pattern shaping for interference management, etc.

9.9.2 Declaration definition

The spatial emissions requirement can be separated into 2 ranges of directions, those in the intended set of directions (in cell) and those in the unwanted set of directions (out of cell). The intended set of directions (in cell) is defined only for the *OTA peak directions set* that corresponds to the maximum expected steering angles of the AAS in azimuth and elevation. The unwanted emissions unwanted directions are therefore defined as follows:

Out of cell direction set – The set of directions which are outside the intended directions of radiation or outside the wanted cell. Declared per operating band. The out of cell direction set is defined when intended set of directions (in cell) is specified for the *OTA peak directions set* that corresponds to the maximum expected steering angles of the AAS in azimuth and elevation.

As it is not possible to predict the spatial pattern of the emissions when the AAS is operational (as it depends on the channel, the UE' location and allocation etc.) the declaration only applies to the AAS when it is transmitting the conformance test directions where the beam pattern is defined. The declaration is defined only for single beam emissions and one declared operating condition.

The directions sets of transmitter directional requirements are defined by the *OTA coverage range* and the *OTA peak directions set(s).* The EIRR accuracy requirement uses a set of conformance directions based on the OTA peak directions set(s) as shown in Figure 9.9.2-1.

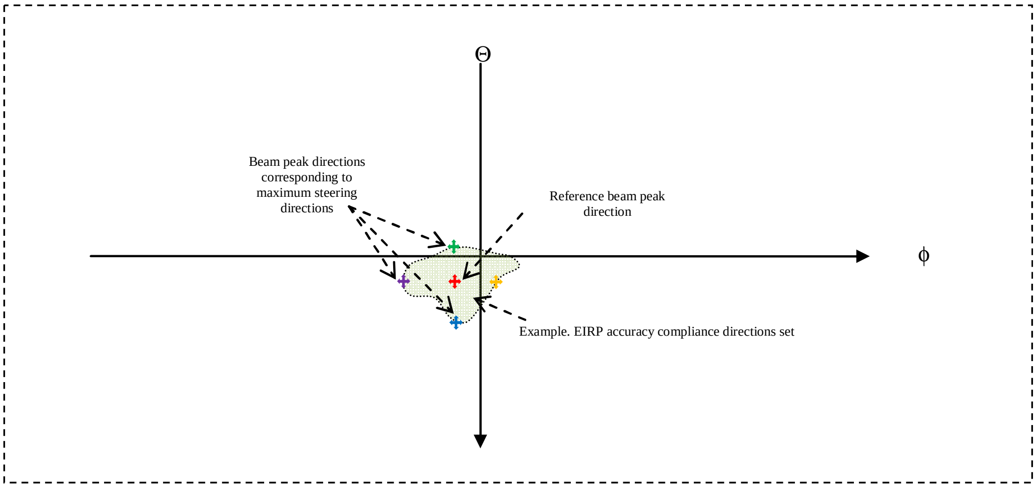


Figure 9.9.2-1: Diagram showing an example of requirement declaration

The OTA peak directions set is a subset of the OTA coverage range. So clearly the out of cell directions set must be outside the OTA coverage range and the OTA peak directions set. AN example id given in Figure 9.9.2-2

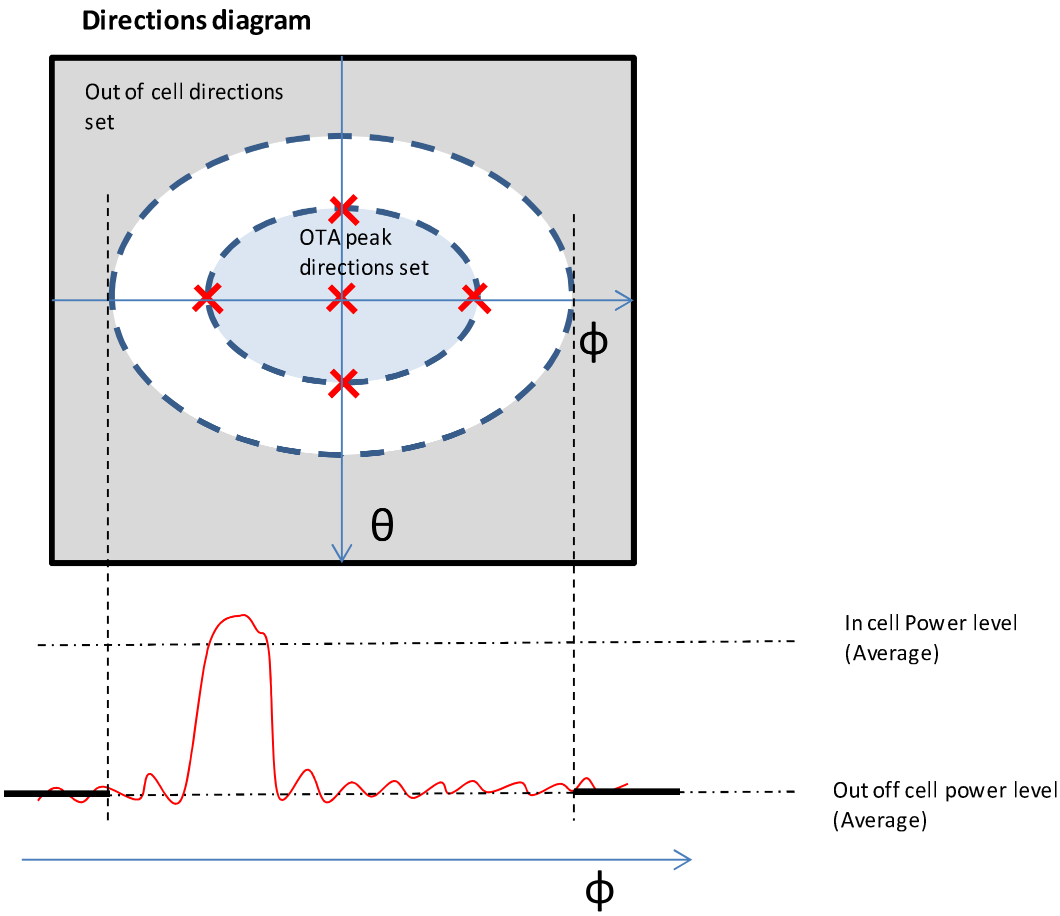


Figure 9.9.2-2: Example of out of cell directions set and declared single beam at a single extreme steering direction.

Having described the spatial aspects of the declaration the power levels of the power in the wanted direction (i.e. not in the out of cell direction set) and the power in the unwanted direction set need to be declared.

There are 5 conformance directions out of cell power level is the average power over these 5 conformance directions. For each of the conformance directions the power level is the average power in the specified out of cell directions set.

The out of cell power level and in cell power levels are declared for each of the 5 conformance directions. In addition, the average in cell power level and out of cell power level averaged over all 5 directions is declared. The reason that the average is declared is that the average more accurately reflects the impact of out of cell radiation to other cells.

The in-cell power level is the average power outside the out of cell directions set (i.e. in the intended direction) averaged over the 5 conformance directions.

So the optimal declarations are:

Table 9.9.2-1: Optional Manufacturer declarations

Declaration identifier	Declaration	Description
DE.1	Out of cell directions set	The set of directions which are outside the intended directions of radiation or outside the wanted cell. Declared per operating band.
DE.2	Out of cell power level	Declared in band average power inside each of the out of cell directions set(s) (DE.1) declared for each of the 5 conformance directions (D9.x)
DE.3	In cell power level	Declared in band average power outside the out of cell directions set(s) (DE.1) declared for each of the 5 conformance directions (D9.x)
DE.4	Average out of cell power level	Declared in band average power inside each of the out of cell directions set(s) (DE.1) averaged over the 5 conformance directions (D9.x).
DE.5	Average in cell power level	Declared in band average power inside each of the out of cell directions set(s) (DE.1) averaged over the 5 conformance directions (D9.x)

NOTE 1: The declaration of unwanted spatial emission may in many circumstances not directly relate to system performance on its own. This is because it is often not possible to differentiate wanted and unwanted radiation, and furthermore because the benefits of optimizing beamforming performance may outweigh the impacts of “unwanted” radiation, leading to systems with apparently higher unwanted radiation also providing superior throughput performance. System performance should additionally be characterized taking all factors into account.

NOTE 2: The Average out of cell power level reflects the impact of out of cell radiation on other cells more accurately than the out of cell power level for individual test beams.

9.10 Beam switching speed

9.10.1 General

The necessity of Beam switching speed requirement was discussed in RAN4. Beam forming (BF) is one of the essential capabilities for NR FR2 to compensate for large path-loss (BF is not required as a mandatory in legacy RAT and NR FR1). If the beam is not pointing in the direction of the target UE, DL performance may be affected. If multiple UEs are scheduled in different directions, the beam must be able to switch between them. It will be necessary that the BS can change steering direction in time which will not negatively impact DL performance. The steering speed capability is guaranteed by existing requirements such as EIRP accuracy or EVM while the requirements relevant to beam forming such as EIRP accuracy are specified in specific directions within the declared Range by the manufacture.

Based on RAN1 agreed OFDM symbol design, BS needs to switch own beam to different directions of different UEs at next OFDM symbol without any guard time. In this case, in order to prevent the DL performance degradation, the switching time should be at least less than cyclic prefix (CP) length (normal CP length unless otherwise stated). Following Table 9.10.1-1 shows CP length for each SCS.

Table 9.10.1-1: CP length for each SCS

SCS [kHz]	CP length
15	4.69 µs
30	2.34 µs
60	1.17 µs
120	586 ns
240	293 ns

9.10.2 Estimated switching speed

The direction of the beam from a phased array is changed by adjusting the phase of the signal applied to each of the elements in the antenna array. This may be implemented in a number of ways:

- Digital beam forming – in this case the phase is adjusted in the baseband – it can be considered that the time taken to adjust beam direction is so fast it is negligible.
- Analogue beam forming
  - Analogue phase shifters – devices which implement a controllable phase shift such as PIN diodes. This is probably the slowest reacting method of phase shift, such circuits have a reaction time in the 10s of ns and a worst case of 100ns can be considered.
  - Switched phase shifters – RF switches are used to switch different transmission line delays, such circuits will react based on the RF switching time, GaAs switches react in approximately 10ns.
- Hybrid beam forming – mixture of analogue and digital beam forming, worst case will have similar switching time to the analogue part.

The worst-case beam switching time is hence based on the analogue implementation and is estimated as < 100ns.

9.10.3 Simulation results

9.10.3.1 General

To clarify required beam switching time smaller than CP length, RAN4 carried out link level simulation evaluations based on a number of different assumptions. The final assumptions listed in Table 9.10.3-1 represent what is considered the worst-case set.

Table 9.10.3-1: Simulation assumption

Parameters	Values
Evaluated channel	PSS/PBCH/PDCCH/PDSCH
Carrier frequency	28GHz
BS CBW	400MHz
SS block SCS	240kHz
Data CH SCS	120kHz
Beam Switching Time	0%, 20%, 40%, 60%, 80%, 100% of CP
Channel Type	TDL_C
Delay spread	300ns(, 100ns)

9.10.3.2 PSS

Simulation assumption and results for PSS are shown in Table 9.10.3.2-1 and Figure 9.10.3.2-1 respectively [R4-1711428, Nokia]. There is almost no impact to error detection probability according to CP loss by difference of beam switching times under the same delay spread assumption.

Table 9.10.3.2-1: Simulation assumption for PSS [R4-1711428, Nokia]

Parameters	Values
Evaluated channel	PSS
Carrier frequency	28GHz
BS CBW	100MHz
SCS	240kHz
Beam Switching Time	0%, 50%, 100% of CP
Channel Type	TDL_A, TDL_D
Delay spread	100ns, 300ns, 1000ns

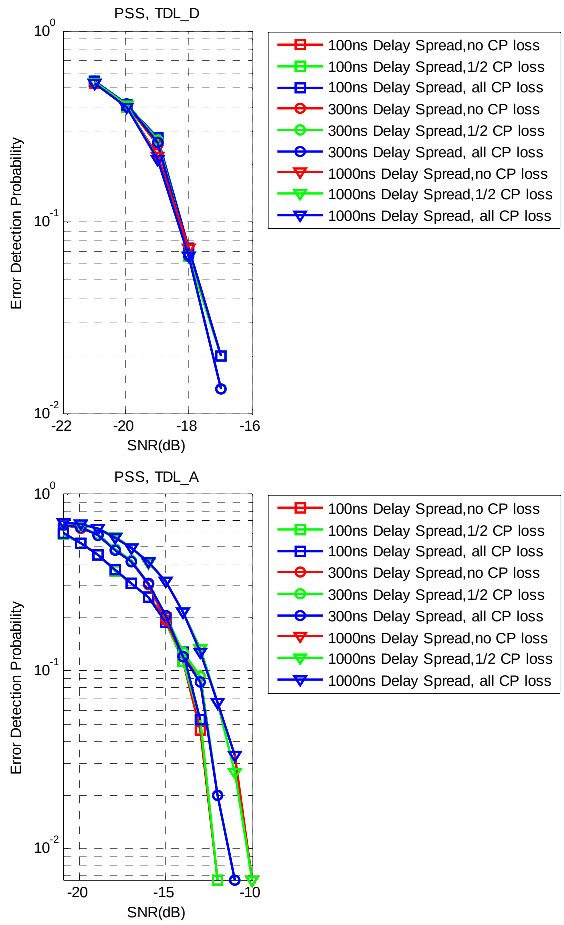


Figure 9.10.3.2-1: Error detection probability for PSS vs. SNR simulation results

9.10.3.3 PDCCH

Simulation assumption and results for PDCCH are shown in Table 9.10.3.3-1, and Figure 9.10.3.3-1 and 9.10.3.3-2 respectively [R4-1711428, Nokia]. There is almost no impact to performance according CP loss by difference of beam switching times.

Table 9.10.3.3-1: Simulation assumption for PDCCH [R4-1711428, Nokia]

Parameters	Values
Evaluated channel	PDCCH
Carrier frequency	28GHz
BS CBW	100MHz
SCS	120kHz
Beam Switching Time	0%, 50%, 100% of CP
Channel Type	TDL_C
Delay spread	100ns, 300ns

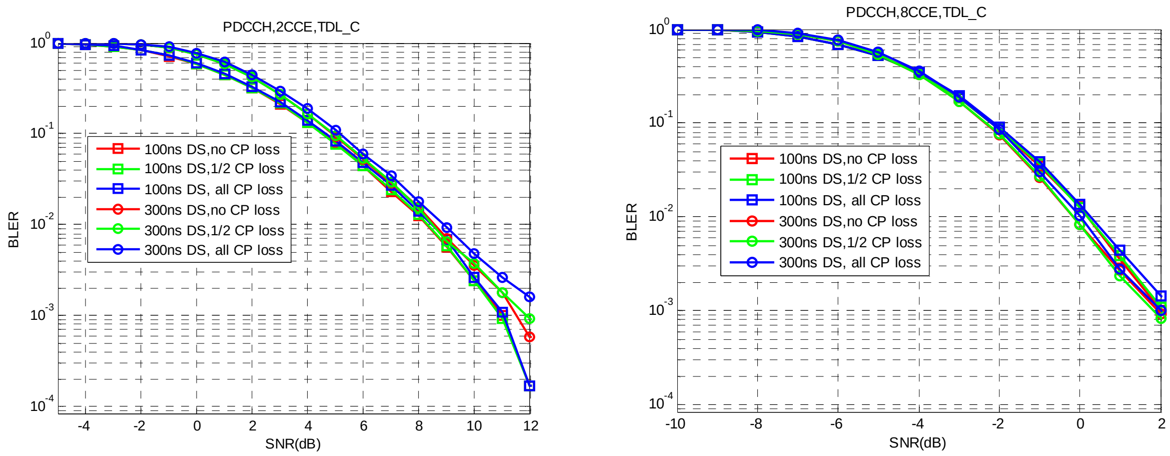


Figure 9.10.3.3-1: BLER for PDCCH vs. SNR simulation results with PDCCH allocated after PUCCH

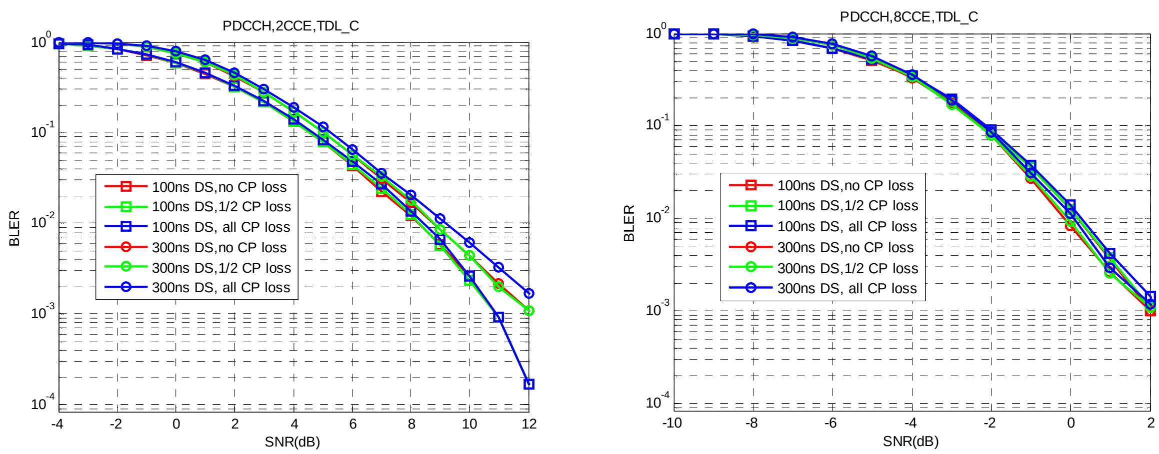


Figure 9.10.3.3-2: BLER for PDCCH vs. SNR simulation results with PDCCH allocated after PDSCH

Simulation assumption and results for PDCCH are shown in Table 9.10.3.3-2 and Figure 9.10.3.3-3 respectively [R4-1711164, Ericsson]. The simulation results for 400MHz CBW are shown in Figure 9.10.3.3-4. There is almost no impact to performance according CP loss by difference of beam switching times up to 40% of CP. Note that results on 60, 80, 100% of CP are not provided.

Table 9.10.3.3-2: Simulation assumption for PDCCH [R4-1711164, Ericsson]

Parameters	Values
Evaluated channel	PDCCH
Carrier frequency	28GHz
BS CBW	20 MHz, 400 MHz
SCS	120kHz
Beam Switching Time	0%, 20%, 40% of CP
Channel Type	TDL_C
Delay spread	300ns

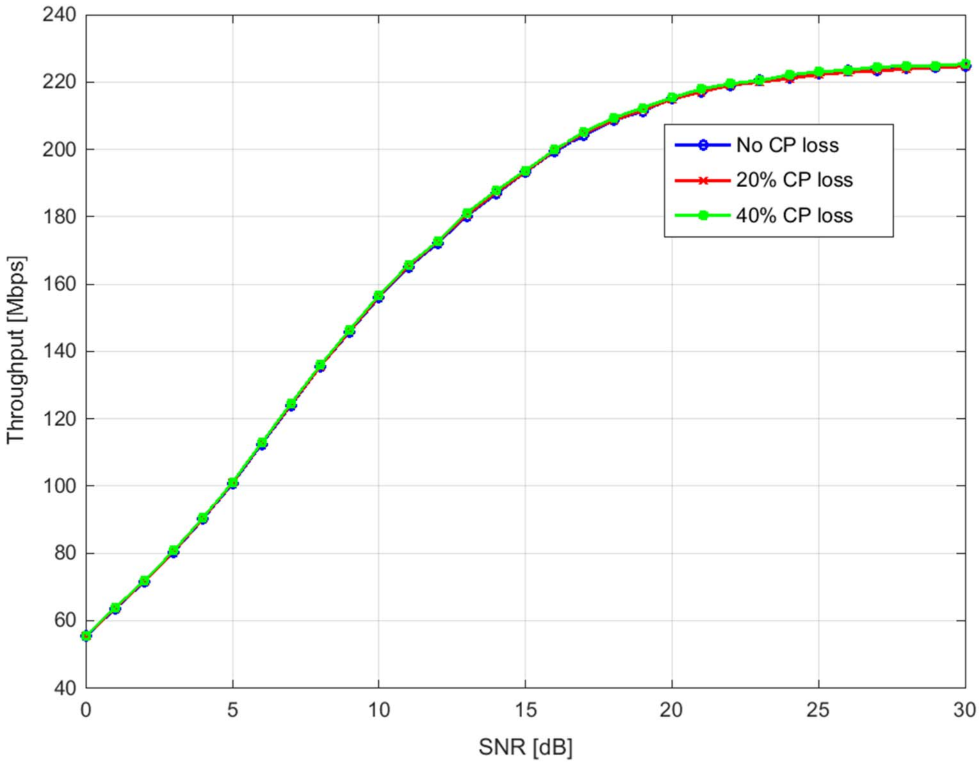


Figure 9.10.3.3-3: Throughput for PDCCH vs. SNR simulation results (20MHz CBW)

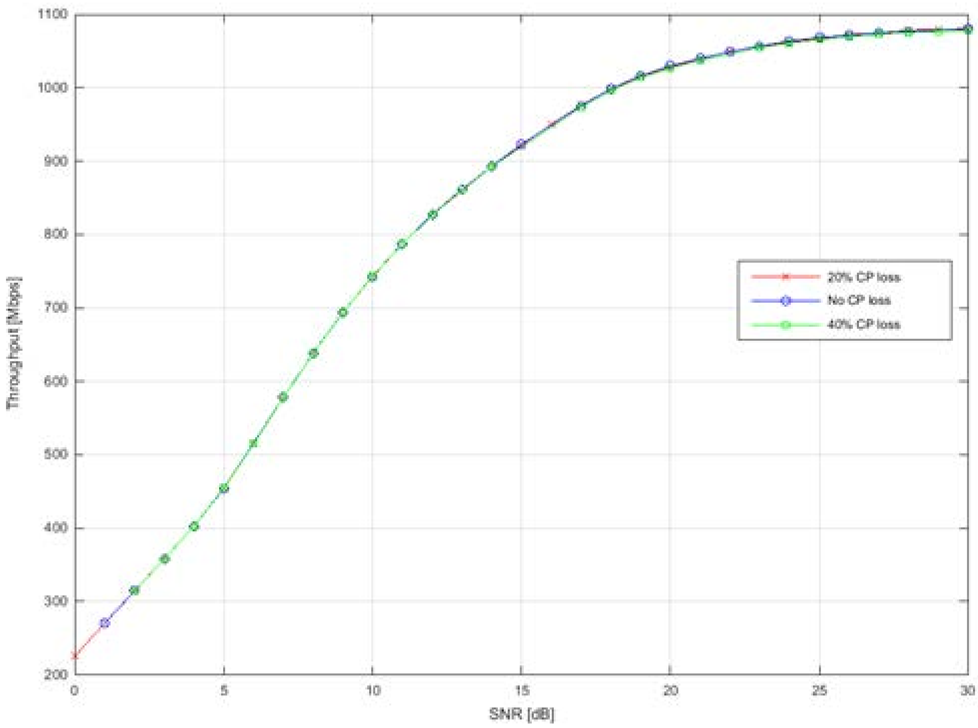


Figure 9.10.3.3-4: Throughput for PDCCH vs. SNR simulation results (400MHz CBW)

9.10.3.4 PDSCH

Simulation assumption and results for PDSCH are shown in Table 9.10.3.4-1 and Figure 9.10.3.4-1 to 9.10.3.4-3 respectively [R4-1711428, Nokia]. The degradation of throughput and BLER are found under the condition of 80% CP loss by beam switching speed delay, 100 ns delay spread and MCS 3 (code rate = 0.6092). In the case of 300ns delay spread, so that the code rate is too high to decode, the lower code rate (0.25) was used.

Table 9.10.3.4-1: Simulation assumption for PDSCH [R4-1711428, Nokia]

Parameters	Values
Evaluated channel	PDCCH
Carrier frequency	28GHz
BS CBW	100MHz
SCS	120kHz
Beam Switching Time	0%, 20%, 40%, 60%, 80%, 100% of CP
Channel Type	TDL_C
Delay spread	300ns, 100ns
MCS	MCS 0, MCS 3

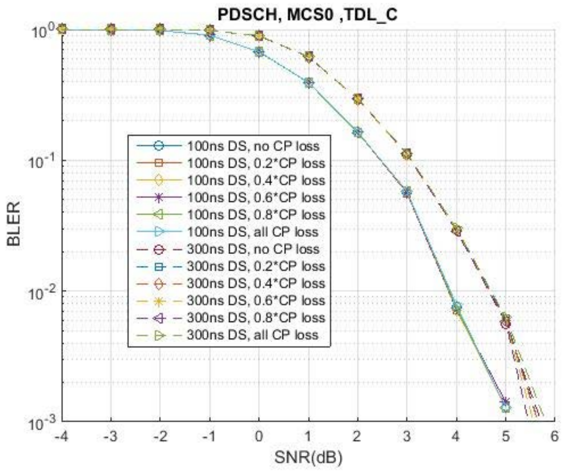


Figure 9.10.3.4-1: BLER for PDSCH vs. SNR simulation results with MCS0 (QPSK, Coding Rate = 0.2285) and 100ns delay spread

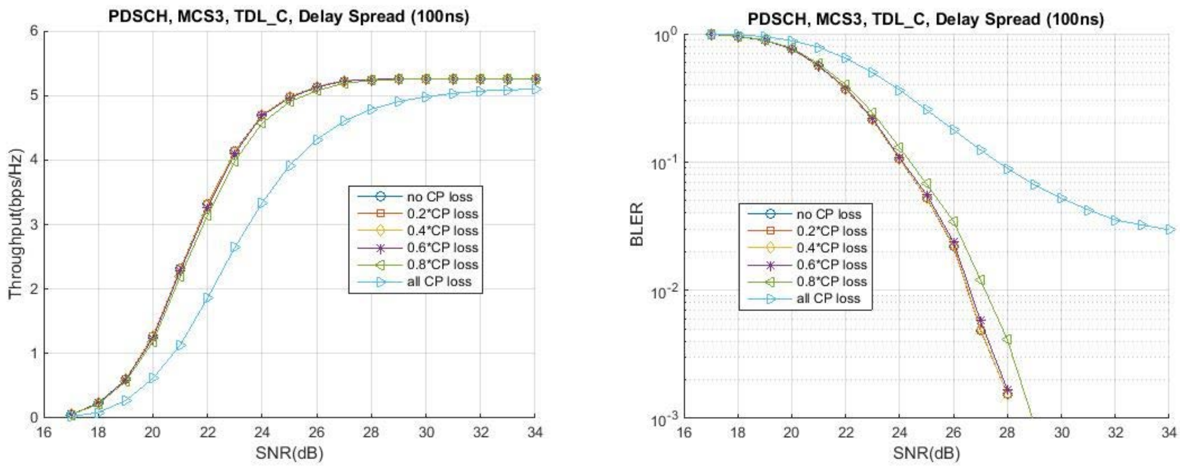


Figure 9.10.3.4-2: Throughput and BLER for PDSCH vs. SNR simulation results with MCS3 (64QAM, Coding Rate = 0.6092) and 100ns delay spread

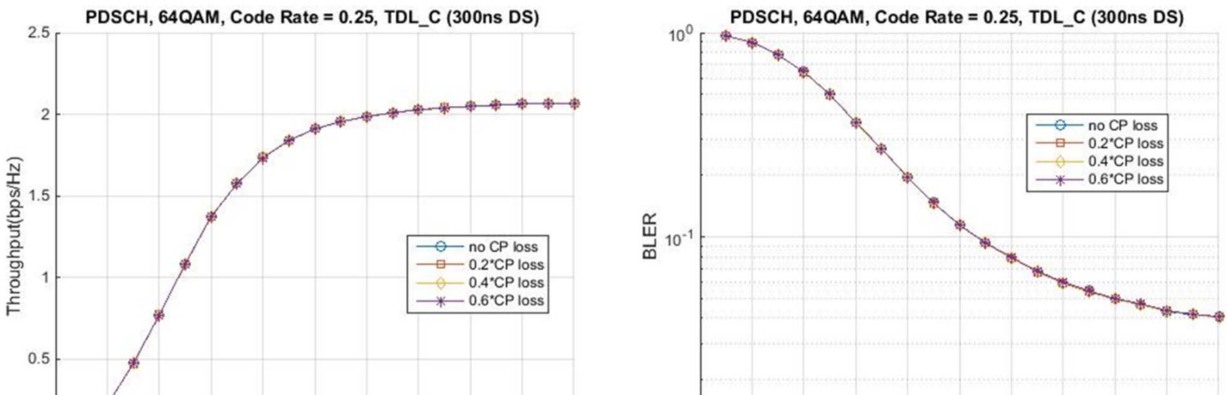


Figure 9.10.3.4-3: Throughput and BLER for PDSCH vs. SNR simulation results with MCS3 (64QAM, Coding Rate = 0.25) and 300ns delay spread

9.10.4 Test feasibility

Test feasibility is not identified yet in RAN4. Generally, two receive test antennas within OTA camber are required in order to confirm. However, it is not a typical OTA testing environment.

Beam switching definition arises a problem that although the beam switching duration can be specified the variation in power can cause a false failing of the requirement.

Studies had also been performed to understand the performance impact, results showed that if beam switch delay fell within the CP length then little to no impact was made on the overall link.

Discussions of complexity of the requirement description and the testability aspects of the requirement had also been discussed. One approach for the requirement description was to describe the beam switch time of the signal envelope. In the following table the number of samples contained within a 100nsec switching time for different SCS. The number of samples is small then power levels could depend as much on the modulation envelope of the signal itself as the beam switching.

Table 9.10.4-1: Number of samples during a 100 ns switching time for several example sampling rates

SCS	Example bandwidth	Example sampling rate	Samples of signal during 100nsec switching time
15 kHz	10MHz	15.36MHz	1.5
30 kHz	10MHz	15.36MHz	1.5
60 kHz	20MHz	20.48MHz	2
120 kHz	50MHz	61.44MHz	6
240 kHz	100MHz	122.88MHz	12

9.10.5 Conclusion

Based on simulation results, to prevent degradation to system performance the switching time must be less than 80% of the CP length. However, RAN4 decided not to introduce the requirement in Rel-15 3GPP TS 38.104 [3] as the estimated maximum switching time was smaller than 80% of the CP length. Additionally, some companies had concerns to introduce the requirement whose test feasibility was not clear, though it was agreed that a test feasibility does not affect the decision on whether to introduce the requirement to core spec or not. If further evidence is identified in the future it is not excluded to reconsider the conclusion and add a requirement in the future release of 3GPP TS 38.104 [3].

10 Radiated BS receiver characteristics

10.1 General

For BS type 1-H and BS type 1-O the same spatial definitions are used as for the AAS BS, as described in TR 37.941 [36].

For BS type 2-O spatial definitions defined for BS type 1-O are reused, with few exceptions described in table 10.1-1.

For NR BS type 1-O OTA sensitivity is valid over the RoAoA(s) in the declared OSDD(s), where any number of OSDD's may be declared by the manufacturer to describe the receiver capabilities.

Minimum sensitivity (minSENS) is defined as the lowest declared EIS value from all the declared OSDD's and is valid over the *minSENS RoAoA*.

Absolute levels which are based on performance at minSENS are offset from the appropriate conducted absolute power level by the following:

$$\Delta_{minSENS} = P_{REFSENS} – EIS_{minSENS}$$

OTA REFSENS is valid over the OTA REFSENS RoAoA which is declared by the manufacturer, absolute levels which are based on performance at OTA REFSENS are offset from the appropriate conducted absolute power level by the following:

$$\Delta_{REFSENS} = P_{REFSENS} – EIS_{REFSENS}$$

In table 10.1-1 classification of the radiated Rx requirements is provided with brief justification.

Table 10.1-1: Classification of radiated Rx requirements

Rx requirement	Description and discussion	Classification
OTA sensitivity	Based on the Rel-13 EIS requirement declaration over the OSDD, the OTA sensitivity is directional requirement by definition. Conformance testing for OTA sensitivity is performed for the five directions same as the Rel-13 AAS OTA sensitivity requirements. This requirement is not applicable for BS type 2-O.	Directional
OTA reference sensitivity level	Conformance testing for OTA reference sensitivity is performed for five directions declared by the manufacturer.	Directional
OTA dynamic range	It was agreed that the requirement assumes that the wanted signal and interfering signal come from the same direction. Testing is defined in the receiver target reference direction, meaning that this is directional requirement. This requirement is not applicable for BS type 2-O.	Directional
OTA in-band selectivity and blocking	The OTA blocking requirement is tested as follows: - In the reference direction of the minSENS OSDD using the minSENS based requirement level - In each of the 4 conformance directions at the extremities of the OTA REFSENS RoAoA using the REFSENS based requirement level.	Directional
OTA out-of-band blocking	Out of band blocking is a long test and hence it is optimum to minimize the number of conformance test directions. The antenna gain can be assumed to be maximum at the reference direction, therefore it is sufficient to show conformance at the reference direction only.	Directional, except for co-location requirement applicable for BS type 1-O
OTA receiver spurious emission	The Rx spurious emissions requirement follows the approach for the Tx spurious emissions, i.e. the emissions in the spurious region needs to be measured as TRP due to unknown radiation pattern.	TRP
OTA receiver intermodulation	Since RX sensitivity and blocking already test at all conformance directions, it is sufficient to test RX IM only in a single direction.	Directional
OTA in-channel selectivity	In channel selectivity requirement is tested in a single direction.	Directional

Spatial definitions relevant for co-location requirements applicable for BS type 1-O are described in TR 37.941 [36].

10.2 OTA sensitivity

The minimum requirements for OTA sensitivity, are based on one or more manufacturer declared OSDD. For BS type 1-H and 1-O, the OTA sensitivity requirements will be as those for E-UTRA, except that NR specific FRCs required for NR. The background information for the minimum requirement is captured in 3GPP TR 37.842, sub-clause 7.3.2.

For BS type 2-O there are no equivalent conducted requirements and a certain minimum level of beam forming gain is required. As such it is not necessary to have both declared OTA sensitivity and reference sensitivity requirements. Hence there is only one sensitivity requirement for FR2, which is used as reference sensitivity and hence is called REFSENS.

10.3 OTA Reference sensitivity level

10.3.1 General

OTA reference sensitivity level is a directional requirement specified as an EIS level.

As OTA reference sensitivity is used as a reference for many of the interference requirements where it is important that the interferer is polarization matched to the receiver antenna it is also important that the wanted signal is polarization matched. Hence OTA reference sensitivity is specifically declared per polarization and the EIS values are under the assumption of *polarization match*.

10.3.2 BS type 1-O

For BS type 1-O OTA reference sensitivity is intended to provide equivalent protection and performance as the conducted reference sensitivity level. The OTA reference sensitivity level is calculated based on the conducted reference sensitivity level for BS type 1-C and 1-H and a hypothetical antenna gain of a passive antenna which would be used with a non-AAS BS in the same deployment scenario.

The requirement is valid over the OTA REFSENS RoAoA which is a declared by the vendor. The OTA REFSENS RoAoA is used to estimate the equivalent antenna gain using the Elliot's formula approximation, and a number of agreed margins as follows:

$$EIS_{REFSENS} = P_{REFSENS} - D_0 + D_{off-peak} + D_{RX\_OTA\_MARGIN}$$

Where:

- $P_{REFSENS}$ is the conducted reference sensitivity level in dBm.
- $D_{RX\_OTA+MARGIN}$ is an implementation margin to allow for errors associated with beam forming in the UL. The $D_{RX\_OTA\_MARGIN}$ value is 1dB.
- D_0 is the estimated antenna peak directivity in dBi of a non-AAS BS, which has a beam pattern related to the OTA REFSENS RoAoA region. D_0 is approximated by the Elliot's formula and expressed as,

$$D_0 \approx 10\log\left(\frac{32400}{BeW_{\theta,REFSEN} \cdot BeW_{\varphi,REFSENS}}\right)$$

  Where,

  - $BeW_{\theta,REFSENS}$ is the beamwidth equivalent to the OTA REFSENS RoAoA in the θ-axis in degrees.
  - $BeW_{\varphi,REFSENS}$ is the beamwidth equivalent to the OTA REFSENS RoAoA in the φ-axis in degrees.*OTA REFSENS RoAoA* is declared by the vendor.

- $D_{off-peak}$ is the peak directivity off-peak margin, it is defined as follows:
  - The OTA REFSENS RoAoA is defined as the contour where the EIS is 3dB higher than in the reference direction, therefore by definition $D_{off-peak}$ in the reference direction is 0dB. In all other directions within the OTA REFSENS RoAoA $D_{off-peak}$ is 3dB.

10.3.3 BS type 2-O

10.3.3.1 General

The OTA reference sensitivity requirement is the only sensitivity requirement used for BS type 2-0. OTA REFSENS RoAoA defines the region over which the $EIS_{REFSENS}$ value is valid. For BS type 2-O, it is not clear what beam forming gain is needed even if there is a single ideal beam forming gain because the channel scenarios for the same BS class can potentially vary significantly. Hence in order to allow for implementation in different deployment scenarios a range of antenna gain is identified for each BS class. This range of antenna gain can then be used along with the implementation margin and SINR requirements to calculate a range of potential minimum EIS values. The vendor declares the OTA reference sensitivity within this range, depending on their view on the needed array size considering the propagation scenarios under which they expect their BS to operate.

The FRC and hence the noise BW for the reference sensitivity FRC is 50MHz.

Hence for a wide area BS

$$EIS_{REFSENS} = P_{kT} + 10 * \log_{10}(BW) + NF + IM + SNR - G \quad (dBm)$$

Where: BW is the noise BW of the FRC, NF is the noise figure, IM is implantation margin not related to antenna array, SNR is the required SNR for demodulation and G is the antenna gain and RF losses.

The declared reference sensitivity value is per polarization under the assumption of *polarization matching*.

The declared FR2 OTA sensitivity applies when all receiver units in the BS per polarization are considered no matter the arrangement of the antenna elements and or antenna panels. As such it is not necessary to defined or discuss antenna panels in the specification.

10.3.3.2 Antenna gain and loss assumptions

For WA BS the antenna gain (G) has been identified for the 28GHz band to be the range 10 to 33 dB.

G includes the antenna directivity and the antenna loss.

Losses may arise from a number of factors, including array related aspects such as scan loss, mutual coupling, steering loss, RF phase error, beam straddling, allowances for beam shaping algorithms, drop towards the coverage edge, radome related losses, antenna mismatch, and any other antenna array related RF losses.

The antenna mismatch may be different between the Rx and Tx the antenna mismatch discussed here is for Rx only. If we need to discuss Tx antenna gain and mismatch, this can be discussed separately.

The current agreements assume there are no filter losses included, if band filtering is needed between the LNA and the antenna then additional loss may be added the value of this is FFS.

The exact distribution of directivity and loss is not formally agreed however the max and min values are based on the approximate extreme cases (based on 28GHz):

Low gain case:

> The minimum usable low gain for a wide area BS can be approximated based on the minimum cell size for a wide area BS. The minimum distance for a UE to the antenna for a wide area BS is 35m (assuming a 23.5m vertical separation). It is reasonable to expect that high throughput and hence high SINR should be achievable at distances greater than this. To achieve and UL SINR of 15 dBi for a 200MHz channel at 100m at least 10dB antenna gain is required.
>
> This is equivalent to antenna of approx. 4x4 elements (0.5λ spacing) with 3dB off peak margin and 4dB losses.

High gain case:

> The high gain is limited by practical implementation of the antenna, a 64x32 element (0.5λ spacing) antenna would consist of 2048 elements and have a directivity of 38.1dBi. With some many elements it is likely the losses would be higher than for a smaller antenna, hence 3dB off peak margin and 5dB losses result in a gain of 30 dBi. Two such panels are considered and hence the upper gain limits 33dBi.

For higher frequencies as the noise figure is higher (see sub-clause 10.3.3.3) the antenna gain required to maintain the same OTA REFSENS value is higher. As the low gain case is based on a reasonable minimum cell size it is reasonable that the OTA REFSENS is not reduced further for the higher frequencies, so for the 45GHz range the minimum expectation for G will be 12dB rather than 10dB.

Note this does not take into account the effect of higher FSPL on the cell size at higher frequencies.

Table 10.3.3.2-1: G assumptions for calculating FR2 WA OTA REFSENS range

BS class	G	
	30 GHz (24.25 – 33.4 GHz)	45GHz (37 – 52.6 GHz)
WA	10 to 33 dBi	12 to 35 dBi

Medium range and local area BS are intended to cover smaller cell sizes and hence the antenna gain requirements are lower, for medium range and local area BS the following assumptions for G have been agreed.

Table 10.3.3.2-2: G assumptions for calculating FR2 MR and LA OTA REFSENS range

BS class	G	
	30 GHz (24.25 – 33.4 GHz)	45GHz (37 – 52.6 GHz)
MR	[5 to 28] dBi	[7 to 30] dBi
LA	0 to 23 dBi	2 to 25 dBi

10.3.3.3 Noise figure assumptions

The noise figure for the receiver will increase as the frequency increases, the following values have been agreed for each frequency range:

Table 10.3.3.3-1: Noise Figure values for the WP5D response in TR 38.803 [24]

Frequency range	30 GHz (24.25 – 33.4 GHz)	45GHz (37 – 52.6 GHz)
BS	10 dB	12 dB

The same NF assumption is used for all BS classes.

10.3.3.4 SNR and IM

IM is the implementation margin associated with the RF parts and the BB, not including the antenna mismatch. It is the same for all frequency ranges and both conducted and OTA requirements. It has been agreed that:

- For REFSENS and ICS:
    - IM = 2 dB

The SNR values are found by simulation and are explained in annex B, for FR2 OTA sensitivity the values are as show in table 10.3.3.4-1.

Table 10.3.3.4-1: SNR values for FR2 OTA RF sensitivity

FRC	SNR (dB)
G-FR2-A1-1	-1.1
G-FR2-A1-2	-1.1
G-FR2-A1-3	-1.2

There is a 0.1dB difference between the SNR for the different FRC's, however as it has been agreed that the OTA sensitivity will be declared in integer values the difference between the FRC's is not significant, the SNR can be rounded down to -1dB, therefore a single range can be declared covering all FRC's

G-FR2-A1-3 has a CBW of 100MHz, assumption so far have been based on FRC with 50MHzCBW, how the 100MHz CBW of the FRC is handled is FFS.

10.3.3.5 OTA Reference sensitivity ranges

Considering the gain range is adjusted to account of the higher NF at the higher frequencies a single range is defined for all bands as follows:

OTA reference sensitivity level for FR2 is:

- 1 dB step within the range -96 to -119 dBm dB for WA
- 1 dB step within the range -91 to -114 dBm for MR
- 1 dB step within the range -86 to -109 dBm dB for LA

10.4 OTA Dynamic range

10.4.1 Dynamic range requirements for Range 2 NR BS

In the table below, we summarize investigations from different companies related to mmWave receiver noise floor rise requirements.

Table 10.4.1-1: Investigations related to mmWave receiver noise floor rise

R4-1706752: BS receiver dynamic range for mmWave bands Source: Huawei, HiSilicon	Proposal: The dynamic range simulation result for mmWave bands is small and no need to specify the requirement.
R4-1705097, Simulation results for receiver dynamic range of NR BS receiver with different deployment scenarios Source: Ericsson	Observation-1: Noise floor rise for dynamic range of NR receiver is ~0dB for all scenarios at 50 percentile UL interference. Observation-2: Noise floor rise for dynamic range of NR receiver is ~0dB for UMa and UMi scenarios at 90 percentile UL interference. Observation-3: Noise floor rise for dynamic range of NR receiver for InH scenario at 99 percentile UL interference is not substantial. Proposal: There is no need to specify dynamic range requirement for NR BS.
R4-1705430: Proposal on mmWave NR BS Receiver Dynamic Range Source: Nokia, Alcatel-Lucent Shanghai Bell	Proposal: To specify the mmWave NR BS receiver dynamic range requirement with the interference level of 15dB over the receiver thermal noise floor, and the wanted signal level calculated as the interference signal level plus the required UL 16QAM SNR and implementation margin. Here the SNR can be obtained at 95% relative throughput from link level simulations, and the implementation margin can be defined as 2.5dB.
R4-1706813: Simulation results for receiver dynamic range of NR BS receiver without array gain for different deployment scenarios, Source: Ericsson	Observation: Noise floor rise for dynamic range of NR receiver without including the array gain is ~0dB for all scenarios at 50 and 99 percentile UL interference. Proposal: There is no need to specify dynamic range requirement for NR BS.
R4-1706774: Discussion on receiver dynamic range and ICS requirement of range2 NR BS Source: ZTE Corporation	Proposal 1: not to specify the dynamic range requirement for rang2 NR BS.
R4-1704930: Discussion on NR BS dynamic range, Source: CATT	Observation 1: Due to the considerable path loss in mmW frequency range, the interference signals reach to the BS side will be much lower in NR system than in LTE system. Observation 2: The UE specific BF will bring on significant rejections to the interference signals in the directions other than the direction of wanted signal. Observation 3: The large *BS channel bandwidth* of NR will result in a higher noise floor. Observation 4: Considering that there has been the REFSENS requirement which is aims to measure the receiver capability to receive the wanted signal in the level of noise floor, it seems unnecessary to define a similar requirement, say dynamic range requirement. Observation 5: For sub-6GHz NR BS dynamic requirement, it's acceptable to reuse the same requirement of LTE except that the reference measurement channel may need to be further investigated for the new numerologies, *BS channel bandwidth* and coding schemes.
R4-1709427: Further simulation results for range2 NR BS Dynamic Range Source: CATT	Additional simulation results

As it is seen from the above summary, most of the investigations point to a common conclusion that there is no need to define NR BS receiver dynamic range requirement for mmWave base station, considering the noise floor rise for NR BS receiver dynamic range in the simulated scenarios.

In addition to the above investigations, it also been discussed whether other requirements implicitly demonstrate compliance to a small (e.g. 5dB) dynamic range.

For LTE, the demodulation requirements are set well above the noise floor. It is reasonable to assume that a similar approach may be adopted for NR demodulation, then the demodulation requirements will be set well above the receiver noise floor.

In case of LTE, with 5MHz channel bandwidth, the noise floor is -103dBm with a 5dB Noise Figure. So, the 5dB noise floor rise would result in -98dBm in AWGN. As seen in Table 8.2.1.4.2-1 of TS 36.141 [27], the AWGN power level at the BS input is specified as -80.4dBm/18MHz for 20MHz channel bandwidth. For receiver dynamic range test, 16-QAM is used, the SINR in that case is around 10.3dB, which results in absolute signal level around -75dBm. This is well above 5dB from the noise floor.

In NR, the AWGN noise level will be higher compared to LTE levels, due to channel bandwidth and noise figure levels. However, if we follow same approach in defining the demodulation requirements as it is done for LTE, the absolute levels for demodulation requirements will be well above the AWGN noise floor. Thus, we do not see any need for testing dynamic range requirements in the order of 5dB.

Based on the above discussions and based on proposals from multiple companies, the following is agreed:

Agreement: There is no need to specify dynamic range requirement for range2 NR BS.

The absolute levels for demodulation requirements shall be well above (e.g. at least ~5dB) the AWGN noise floor, thus the small dynamic range shall be handled via demodulation requirements.

10.4.2 OTA Dynamic range requirements for FR1

As agreed in eAAS WI, in order to provide a reasonable conformance test, the requirement assumes that the wanted signal and interfering signal come from the same direction. And since both wanted signal and AWGN will be transmitted from the test equipment in the same direction, the same combining gain will be achieved for both wanted signal and the AWGN. Hence the OTA dynamic range for FR1 can be defined based on conductive requirements plus an offset, i.e. $\Delta_{OTAREFSENS}$.

10.5 OTA In-band selectivity and blocking

10.5.1 General

The narrowband blocking specified for E-UTRA is based on single PRB interferer capturing the co-existence in bands with narrow band systems such as GSM. As FR2 bands would be dedicated to NR and minimum bandwidth is 50 MHz and even adjacent bands e.g. in 23.6-24 GHz has *BS channel bandwidth* of 100 MHz and 200 MHz, there is no need for narrowband blocking requirements for FR2 and thus a narrowband blocking requirement should not be specified.

10.5.2 Adjacent channel Selectivity (ACS)

Conformance of the OTA ACS requirements can be shown in the reference direction.

The following have been agreed for OTA ACS requirement in FR2:

- For *BS channel bandwidth*s of 50 MHz, the ACS requirement is agreed as 24 dB in 24.25 – 33.4 GHz BS and 23 dB in 37 – 52.6 GHz BS.
- For *BS channel bandwidth*s more than 50 MHz, apply the same interferer power as for *BS channel bandwidth*s equal to 50 MHz.
- The allowed REFSEN degradation is 6 dB.
- Additional frequency offset similar to E-UTRA should be considered to avoid orthogonality between sub-carriers of wanted and interfering signal.
- For all *BS channel bandwidth*s within the same frequency range (24.25 – 33.4 GHz or 37 – 52.6 GHz), to specify a 50 MHz DFT-s-OFDM NR signal (60 kHz SCS, 64 RB) for ACS requirements.

The wanted signal and interfering signal power level are calculated in the following way in FR2:

Wanted signal power level = REFSEN + 6 dB

Interfering signal power level = BS noise
floor + ACS + 4.7 dB = -174 dBm/Hz + $10*\log_{10}$(BW) + NF - G + ACS + 4.7 dB

Where:

- BW is wanted signal bandwidth in Hz, e.g. 66PRB for 50 MHz SCS: 60 kHz;
- NF is noise figure which is agreed as 10 dB within 24.25 – 33.4 GHz, 12 dB within 37 – 52.6 GHz;
- G is dependent on the mmWave receiver antenna gain and other factors for OTA REFSENS requirement;
- ACS for 50 MHz *BS channel bandwidth* is agreed as 24 dB within 24.25 – 33.4 GHz, 23 dB within 37 – 52.6 GHz;
- 4.7 dB is calculated from $10\log_{10}(10^{(6/10)}-1)$.

10.5.3 In-band Blocking

10.5.3.1 General

OTA blocking interference levels are based on statistical analysis of likely power levels in simulated networks. The interferer power levels are based on a statistical analysis and as such do not represent a worst case and cannot be attributed to a specific direction.

The OTA RF requirement places the interfere and the wanted signal in the same direction for simplicity, however this is not intended to represent a real scenario, where such an event is very low probability as interferers are large and tend to be lose to the antenna and wanted signals at sensitivity are small and tend to be far from the antenna. The RF requirement ensures however that if the hardware can demodulate the specified wanted signal in the presence of the specified interferer level (from the same direction), then it will provide sufficient performance to maintain the same probability-based blocking protection shown in the simulations, and expected in actual real world scenarios.

The OTA blocking requirement is tested using the same set of 5 conformance directions as the OTA sensitivity requirement. However, in each direction, only one of the two blocking requirements is tested. Each of the two requirements is tested in at least one direction.

10.5.3.2 FR1

In-band blocking for BS type 1-O uses the same approach as that used for E-UTRA AAS as described in 3GPP TR 37.843. Wanted signal and interferer levels are adjusted to be in line with NR channel BW and FRC's.

Both the in-band interferer and the wanted signal have requirements at 2 power levels associated with OTA REFSENS and minSENS.

10.5.3.3 FR2

BS type 2-O has a number of differences when considering the OTA blocking levels.

- There are no conducted requirements, so simulation of conducted interferer power levels do not give a final OTA power level.
- Beam forming is necessary in order to overcome the path loss.
- A wide range of implementations with varying antenna maximum beam forming gain are envisaged.
- Different beam forming architectures result in different statistical spread of interferer power at the active Rx input (i.e. the LNA).

Traditionally the in-band blocking level has been analysis on a statistical basis based on the 99.99% probability of an interferer being possible. This has been used since UTRA where WCDMA modulation was susceptible to blocking and the entire system would be blocked if such an event occurred. The NR OFDMA scheme does not suffer so greatly due to a blocking event hence such a high probability is not required, probabilities between 99% and 99.9% have also been considered.

In the past the wanted signal has not been considered when studying the interferer level, however with an OTA requirement and a beam forming system when considering a statistical worst case, it is important to consider both the wanted and the interfering signal. This is due to the fact that blocking arises when a low power wanted signal and a high-power blocking signal occur simultaneously (the likelihood of this occurring depends on instantaneous power control, scheduling and beam directions) Hence the difference between the wanted signal and the interferer is also important.

Initially the probability of the interferer alone was simulated looking at the same scenarios identified in the co-existence simulation in 3GPP TR 38.803 [24].

The probability of the blocking signal level and also the probability of simultaneous low wanted signal and high blocking signal were both considered. Simulations of both of these aspects suggested that the blocking signal is typically 33dB above the reference sensitivity level. This result was consistent when considering different architectures.

It was agreed that the specification for the interferer power level will be 33dB higher than the OTA REFSENS power level.

As for FR2 there is only a single sensitivity requirement, a 6dB offset from OTA reference sensitivity is used for the wanted signal and a 33dB offset from reference sensitivity is used for the interferer.

10.6 OTA Out-of-band blocking

10.6.1 FR1 OTA out-of-band blocking

The OTA out-of-band blocking requirement derivation for NR is the same as that for AAS and is documented in 3GPP TR 37.843 [9], in summary the OTA out of band blocking is difficult to translate directly from the conducted out of band blocking requirement as

- The gain characteristics of an antenna is not known in the out-of-band frequency region.
- The free space path-loss at high frequencies (i.e. up to 12.75 GHz) means that the radiated power levels required to provide -15 dBm at conducted point are unfeasibly high.

Clearly the interferers are present irrespective of the victim *antenna gain*, the original levels assumed that the victim *antenna gain* was the same as the in-band gain, this assumption is not required when considering an OTA requirement and the interferer levels can be represented as a field strength at the antenna array.

The field strength is derived from the conducted out of band interfere level and the in-band antenna gain assumptions:

EIRP(30m) = P_{rx} – Gant + FSPL(30m) = -15dBm – 17dBi + 68dB(frequency=2 GHz, FSPL 30m) = 36dBm

And

$$E = \frac{\sqrt{30EIRP}}{r} = \frac{\sqrt{30*10^{\frac{36-30}{10}}}}{30} = 0.36\,V/m$$

10.6.2 FR2 OTA out-of-band blocking

The blocking interferer for FR1 is defined from 30 MHz to 12.75 GHz at a level of 0.36 V/m, as the interferer level is based on the aggressors in the same geographical area rather than the victim the FR2 BS will be subjected to the same interference levels over this frequency range.

Out of band blocking requirements are based on analysis of interferers in the specified frequency region, for FR1 the largest interfering signals have been other 3GPP BS and hence out of band blocking levels are based on the co-existence in the same geographical area with other 3GPP systems.

FR1 requirements are based on the analysis done for UTRA BS the derivation of the -15 dBm conducted interferer level is based on interference from other BS at approximately the same frequency.

For FR2 there is no conducted level so the scenario is constructed from the interference itself under similar assumptions.

The aggressor out of band BS is considered to have a total power of 29 dBm, an antenna gain of 26 dBi hence an EIRP in the main beam of 55 dBm. As the beam has high gain and is pointed at UE's on the ground then when considering the interference at a victim BS there is a down tilt loss (L_{DT}) of 13 dB is considered.

With the interferer at a distance (d) of 200 m this gives an interfering field strength of:

$$E = \frac{\sqrt{30EIRP(W)}}{d} = \frac{\sqrt{30 * 10^{\frac{EIRP(dBW)-L_{DT}}{10}}}}{d} = \frac{\sqrt{30 * 10^{\frac{(55-30)-13}{10}}}}{200} = 0.1V/m$$

This core requirement is applied from 12.57 GHz to 2nd harmonic of the upper frequency edge of the *operating band* (excluding the operating band +/- 1.5 GHz).

For base station operating at the upper frequency region of FR2, it is relevant to discussion the possibility to limit the upper frequency for conformance testing in a similar manner as for FR2 spurious emission. For OTA spurious emission the upper frequency limit for FR2 is set to 60 GHz. The reason for why limiting the test to 60 GHz, is that essential test equipment such as cables and connectors gets very expensive and unreliable. Hence the upper conformance test frequency for OTA out-of-band blocking should also be set to 60 GHz.

The base station out-of-band blocking requirement is tested with a CW interferer and the wanted uplink signal. A spurious response occurs when the *m*-th harmonic of the interferer frequency mixes with the *n*-th harmonic of an internal signal, like a clock or a local oscillator signal, and this mixing product falls within the receive bandwidth of the wanted signal (or near the receive bandwidth, if the receiver selectivity is insufficient to suppress the spurious mixing product). The frequency of the unwanted mixing product equals $\pm m \cdot f_{CW} \pm n \cdot f_{internal}$, where f_{CW} is the interferer frequency and $f_{internal}$ is the frequency of the internal signal involved in the mixing product. *m* can assume the values 1, 2, 3, … and *n* can assume the values 0, 1, 2, …. Spurious responses for which the harmonic number *m* of the interferer signal equals 4 or more are usually not significant. Hence, the frequency step size should be chosen such that any spurious response due to a maximum third harmonic of the interferer will be captured within the receive bandwidth of the wanted signal.

To reduce the amount of time used for the time-consuming OTA conformance testing, while continue to ensure that any spurious response within the receive bandwidth will still be verified with sufficient granularity, the measurement step size for interfering signal at frequency above 6 GHz can be set according to the minimum supported BS channel bandwidth as shown in Table 10.6.2-1 in the NR BS type 2-O OTA out-of-band blocking conformance testing. For interfering signal at frequency below 6 GHz, the traditionally measurement step size of 1 MHz can be kept.

Table 10.6.2-1: Measurement step size for out-of-band blocking conformance testing

Minimum supported BS Channel bandwidth of wanted signal [MHz]	50	100	200	400
Measurement step size for interfering signal [MHz]	15	30	60	60

10.7 OTA Receiver spurious emissions

10.7.1 General

The metric used to capture receiver spurious emissions OTA is total radiated power (TRP).

OTA Tx spurious emissions co-location requirements and regional requirements are FFS.

Measurement bandwidths as well as the spurious range frequency limits are defined according to SM.329 [4].

The OTA receiver spurious emission requirement is subject to the following limitations:

1. For BS operating in FDD: OTA RX spurious emissions requirement will not apply to FDD duplex as being superseded by the OTA TX spurious emissions requirement. This is due to the fact that TX and RX spurious emissions cannot be distinguished in OTA domain.

NOTE: The OTA receiver spurious emission requirement applicability for the AAS BS with the RX-only capabilities is FFS.

2. For BS operating in TDD: the OTA receiver spurious emissions requirement applies during the *transmitter OFF period* only.

10.7.2 Radiated Rx spurious emissions requirement in FR1

The OTA Rx spurious emission requirement for BS type 1-O is defined at the RIB over the same spurious range as defined for the conducted Rx spurious requirement, as defined in sub-clause 7.6.1.

Rx spurious emissions limits for BS type 1-O are based on the *basic limits* defined in sub-clause 7.6, with the emissions scaling applied based on the *basic limit* as described in clause 5.9.

Definition of the emissions measurements for the conformance requirement will be based on the core requirement, subject to the TRP MU, where the MU definition should capture the whole spurious frequency range.

10.7.3 Radiated Rx spurious emissions requirement in FR2

The Rx spurious emission requirement for *BS type 2-O* is defined at RIB over the same spurious range as defined for the radiated Tx spurious requirement for *BS type 2-O*, i.e. from 30 MHz up to the 2nd harmonics of the upper frequency edge of the *operating band.*

Rx spurious emission limits for FR2 are reused from the FR1 range above 1GHz, i.e. - 47 dBm. Please note, that comparing to the FR1 spurious requirements, there is no emissions scaling applied for the spurious emissions in FR2.

Measurement BW is based on the value from SM.329 recommendation [4].

The step frequencies for defining the radiated spurious emission limits are calculated as shown in table 10.7.3-1 according to the frequency range of each operating band.

Table 10.7.3-1: Step frequencies for defining the radiated Rx spurious emission limits for FR2

Operating band (GHz)	$F_{step,1}$ (GHz)	$F_{step,2}$ (GHz)	$F_{step,3}$ (GHz) (Note 3)	$F_{step,4}$ (GHz) (Note 3)	$F_{step,5}$ (GHz)	$F_{step,6}$ (GHz)
n258 (24.25 – 27.5)	max (18, 24.25 - max (10, 4 × W_B)) = 18	24.25 - max (2, W_B) = 21	24.25 - 1.5 = 22.75	27.5 + 1.5. = 29	27.5 + max (2, W_B) = 30.75	27.5 + max (10, 4 × W_B) = 40.5
n260 (37 – 40)	max (18, 37 - max (10, 4 × W_B)) = 25	37 - max (2, W_B) = 34	37 - 1.5 = 35.5	40 + 1.5. = 41.5	40 + max (2, W_B) = 43	40 + max (10, 4 × W_B) = 52
n261 (27.5 – 28.35)	max (18, 27.5 - max (10, 4 × W_B)) = 18	27.5 - max (2, W_B) = 25.5	27.5 - 1.5 = 26	28.35 + 1.5. = 29.85	28.35 + max (2, W_B) = 30.35	28.35 + max (10, 4 × W_B) = 38.35
NOTE 1: max () is the maximum operation of the two operands. NOTE 2: W_B is the bandwidth of the operating band. NOTE 3: $F_{step,3}$ and $F_{step,4}$ are aligned with the values for Δf_{OBUE}.						

Considering that FR2 frequency bands are expected to be TDD only, the conformance testing of the OTA RX spurious emissions for *BS type 2-O* could be applied during TX OFF period only.

Similar to the OTA Tx spurious emissions, for conformance testing of the Rx spurious emissions requirement for *BS type 2-O*, the upper frequency limit of the spurious range might be limited to 60 GHz value, considering practical OTA measurement capabilities of the OTA test ranges in the spurious range.

10.8 OTA Receiver intermodulation

10.8.1 General Receiver intermodulation

The blocking requirements capture the selectivity of the receiver, whilst the receiver intermodulation given the two interferers condition would capture the linearity of the receiver.

For FR1, the RX IM wanted signal and interferer levels are re-used from E-UTRA. The interfering signal subcarrier spacing is the same as the wanted signal subcarrier spacing. The lowest supported wanted signal SCS is tested. The frequency offset of the CW is adjusted taking into account the NR spectrum utilization for each bandwidth such that the RX IM signal overlaps the wanted signal to within a few subcarriers.

For FR2, the RX IM levels are set re-using the same principles as FR1. In FR1, the general receiver intermodulation requirements with two interferers (one modulated and one CW) and corresponding joint probabilities between the two interferers which would be lower than one interferer, the relation between general blocking level and receiver intermodulation level is summarized in Table 10.8.1-1 which indicate an offset in level around 8-9 dB between general blocking and receiver intermodulation interferer levels of ~8-9 dB. Note that for receiver intermodulation, interferers having same level resemble the worst case compared to asymmetrical interferer levels.

Table 10.8.1-1: Existing general receiver blocking and intermodulation requirements

	UTRA 25.104	**E-UTRA 36.104**	**MSR 37.104**
General blocking level	-40 dBm	-43 dBm	-40 dBm
General receiver intermodulation level	-48 dBm	-52 dBm	-48 dBm
Level offset	8 dB	9 dB	8 dB

Given the involvement of statistics of two interferer and OTA spatial aspect for mm-waves and possible non-symmetrical interferer levels etc, to avoid lengthy investigation, a pragmatic approach similar to existing RATs is used to define the receiver intermodulation requirements for FR2 bands. Thus, simulations of interferer levels were carried out under the assumption that the requirement would be based on equal levels. The simulations demonstrated that the for 1% RX IM probability, the RX IM interferer levels are around 8-10dB lower than the in-band blocking level under this assumption.

Thus it was decided that for FR2, the interferer levels for general receiver intermodulation should be derived by applying an offset of 8 dB below OTA blocking levels.

In addition, for FR2, the modulated interferer bandwidth should be 50 MHz, but larger interferer bandwidths are not precluded in later releases when wide band operation is considered.

10.8.2 Narrowband Receiver intermodulation

The narrowband receiver intermodulation specified for E-UTRA is based on single PRB interferer and CW interferer capturing the co-existence in bands with narrow band systems such as GSM.

For FR1, the same interferer and wanted signal levels as for E-UTRA are applied. The IM SCS is the same as for the wanted signal. The CW position is calculated such that the IM product falls within the wanted signal FRC in most cases (taking into account the NR spectrum utilization).

As FR2 bands would be dedicated to NR and minimum bandwidth is 50 MHz and even adjacent bands e.g. in 23.6-24 GHz has *BS channel bandwidth* of 100 MHz and 200 MHz, there is no need for narrowband receiver intermodulation requirements for FR2 and thus requirements should not be specified.

10.9 OTA In-channel selectivity

10.9.1 General

In-channel selectivity (ICS) is a measure of the receiver ability to receive a wanted signal at its assigned resource block locations in the presence of another in-channel wanted signal received at a much larger power spectral density.

10.9.2 BS type 1-O

For BS type 1-O, power level of wanted signal and interfering signal should be offset by the value $\Delta_{minSENS,}$ other parameters could be reused from BS type 1-C.

10.9.3 BS type 2-O

Similar to E-UTRA BS, the UL signal is defined for just 2 users, one being the "wanted" signal and the other one being the "interfering" signal at elevated power. The wanted signal and interferingsignal power level can be calculated in the following way:

Interfering signal power level = -174dBm/Hz+10*$\log_{10}$(BW)+NF+ICS-G,
Where:

- BW is interfering signal bandwidth in Hz, e.g. 33PRB for 50MHz SCS:60 kHz;
- G is dependent on the mmWave receiver antenna gain and other factors for OTA REFSENS requirement
- ICS is agreed as 14dBc for all BS type, the specific reasons can be found in the following Table.;

R4-1710771,ZTE	The observed IoT level for mmWave BS is around [0-5] dB which is much less than 16dB assumed for legacy LTE BS. Considering the legacy *C/I* 9dB assumed for interfering signal, then maximum in-channel selectivity is 14dB which is still much less than 25dB assumed for legacy LTE BS.
R4-1711156, Nokia	Comparing the simulation results between mmWave and below 6GHz, it can be seen the UL IOT for below 6GHz NR BS is around 10 dB higher than that for mmWave NR BS. It has been agreed that the current 25dB E-UTRA BS receiver in-channel selectivity could be reuse for below 6GHz NR BS, hence (25-10=)15dB should be a suitable level for mmWave NR BS in-channel selectivity based on the agreed below 6GHz NR BS receiver in-channel selectivity

Similar as FR1 ICS requirement, it should be noted that DFT-s-OFDM has been adopted as the interfering signal of ICS requirement, the PRB number of interfering signal should comply with basic DFT process principle $2^{\alpha 1} g 3^{\alpha 2} g 5^{\alpha 3}$ specified in TS 38.211 [25].

Wanted signal power level for ICS requirement for BS type 2-O could be calculated as following:

Wanted signal power level = -174dBm/Hz+10*log10(BW)+NF+SNR+IM+3dB-G;
Where:

- BW is wanted signal bandwidth in Hz;
- G is dependent on the mmWave receiver antenna gain and other factors for OTA REFSENS requirement;
- SNR is dependent on the link level simulation results;
- IM is implementation margin which is assumed as 2dB;
- 3dB is reference sensitivity degradation which is reused from legacy E-UTRA requirement;

Regarding the interferer power level, the modulation scheme for interfering signal is assumed as 16QAM and modulation scheme for wanted signal is assumed as QPSK.

The values of the wanted signal and the interferer have been specified based on the declared sensitivity $EIS_{REFSENS\_50M}$. This declared sensitivity is based on an FR2 signal of 50 MHz channel bandwidth (66 PRBs – 60kHz SCS), while the FRCs (used for the wanted signal) and the interferers have different channel bandwidth, bandwidth adaptation needs to be done then for each requirement. The wanted signal and interferingsignal power level can be calculated as follows:

$$EIS_{REFSENS\_wanted} = EIS_{REFSENS\_50M} + 10*\log10(BW_{wanted}/ BW_{50M}) + (SNR_{wanted} - SNR_{50M}) + 3$$

$$EIS_{REFSENS\_interfer} = EIS_{REFSENS\_50M} + 10*\log10(BW_{interfer}/ BW_{50M}) + ICS - 0.9$$

Note: ICS in above equation = 14 dBc

For example, for 50 MHz and 60 kHz SCS:

- The wanted signal is specified based on G-FR2-A1-4 FRC which is 33 PRBs wide and 60 kHz SCS, so its value should be:

$EIS_{REFSENS\_50M}$ + 3 + 10 * log10(33*12*60*1000/66*12*60*1000) = $EIS_{REFSENS\_50M}$ + 3 -3.01

- The interferer signal is specified based on 32 PRBs and 60 kHz SCS, so its value should be:

$EIS_{REFSENS\_50M}$ + 13 + 10 * log10(32*12*60*1000/66*12*60*1000) = $EIS_{REFSENS\_50M}$ + 13 - 3.14

11 EMC requirements

11.1 General

For the NR BS EMC specification drafting purposes, the following approach was agreed:

- Text of the 3GPP TS 38.113 [15] specification for single RAT NR aims not to refer to the legacy EMC specifications and to capture full text of the EMC specification with the required updates and corrections.
- For the purpose for RAN4 specification transparency, any EMC requirements and limits required from the external EMC specifications (e.g. IEC, CISPR) shall be referred (i.e. not copied over), if possible.
- Any potential NR updates shall be considered for MSR BS EMC specification 3GPP TS 37.113 [23] and AAS BS EMC specification 3GPP TS 37.114 [16], once the Single RAT NR EMC specification 3GPP TS 38.113 [15] is stable.

For NR update of the MSR BS EMC specification 3GPP TS 37.113 [23], the following main clauses were considered to belong to the core and conformance parts, due to June 2018 and December 2018, respectively:

- Core part: clauses 2, 3, 4.4 (exclusion bands), 7 (Applicability overview), 8 (Emission; all clauses except 8.1), 9 (Immunity; all clauses except 9.1)
- Conformance part: clauses 4 (Test conditions, all except 4.4), 5 (Performance assessment), 6 (Performance criteria), 8.1 (Test configurations), 9.1 (Test configurations)

For NR update of the AAS BS EMC specification 3GPP TS 37.114 [16], the following main clauses were considered to belong to the core and conformance parts, due to June 2018 and December 2018, respectively:

- Core part: clauses 2, 3, 4.1 (exclusion bands), 7 (Applicability overview), 8 (Emission; all clauses except 8.1), 9 (Immunity; all clauses except 9.1)
- Conformance part: clauses 4 (Test conditions, all except 4.1), 5 (Performance assessment), 6 (Performance criteria), 8.1 (Test configurations), 9.1 (Test configurations)

NOTE: In case of further clauses identified to be belonging to the core or to conformance part, their content shall be specified within the deadlines listed above.

11.2 NR BS ports for the EMC purposes

Based on the legacy EMC specification approach to the definition of the antenna ports, the updated figures for the NR BS architectures are presented for the EMC requirements purposes, including the BS type 1-C and BS type 1-H equipped with the antenna ports, and the BS type 1-O and BS type 2-O, which are not equipped with the antenna ports and which rely on the radiated interface only.

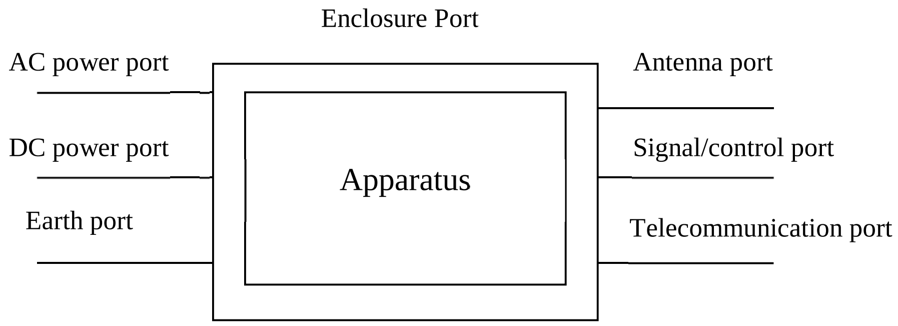


Figure 11.2-1: Examples of ports for BS type 1-C and BS type 1-H

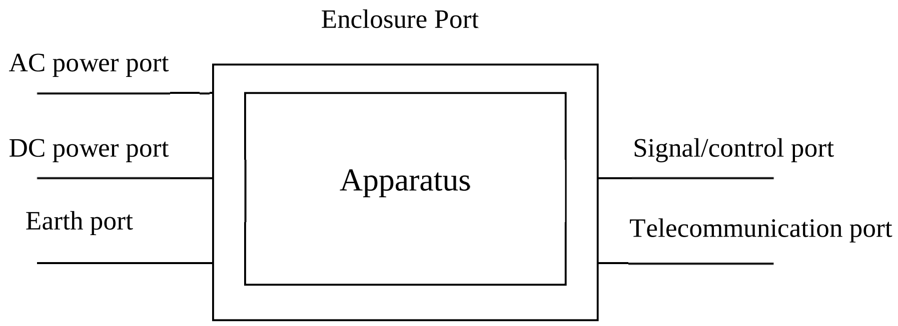


Figure 11.2-2: Examples of ports for BS type 1-O and BS type 2-O

11.3 Emission requirements

For the EMC emissions requirement, the following approach was agreed for the NR BS types:

1. BS type 1-C and BS type 1-H:

- The emissions requirement will reuse the legacy approach base on the antenna ports termination.

    i. RF spurious emission requirement will be captured in the RF core specification 3GPP TS 38.104 [3], conforming to the 3GPP TS 38.141-1 [17].

    ii. EMC radiated emissions requirement will be captured in the EMC specification 3GPP TS 38.113 [15]

- The emission requirement will apply to BS and the ancillary equipment.

2. BS type 1-O and BS type 2-O:

- For BS type 1-O and BS type 2-O the RF radiated spurious emission includes the EMC radiated emissions. In this case RF radiated spurious emissions and EMC radiated emissions cannot be distinguished in the OTA measurement setup.

- Follow the single limit approach for the RF RSE and EMC RE emission requirement.

    i. The core requirement will be captured in the RF core specification 3GPP TS 38.104 [3], conforming to the 3GPP TS 38.141-2 [18].

    ii. Remove the corresponding EMC radiated emission requirements from 3GPP TS 38.113 [15].

- The emission requirement will apply to the ancillary equipment only.

11.4 Radiated immunity requirements

For the measurement aspects of the radiated immunity requirements, refer to TR 37.941 [36].

11.4.1 Measurement set-up for testing radiated immunity

NOTE: In Rel-15, content of this clause was shifted to the OTA BS testing TR 37.941 [36].

Figure 11.4.1-1: Void

11.4.2 Alternatives to protect BS type 1-O during RI test

NOTE: In Rel-15, content of this clause was shifted to the OTA BS testing TR 37.941 [36].

11.4.2.1 Void

11.4.2.2 Void

12 Conformance testing aspects

12.1 General

This clause captures conformance testing aspects related to the measurement uncertainty of test system for conducted requirements.

For measurement uncertainty of test system for radiated requirements, refer to TR 37.941 [36].

12.2 Conformance testing for conducted requirements

12.2.1 Measurement uncertainty of test system

For the frequency range up to 4.2 GHz, the same measurement uncertainty as E-UTRA in TS 36.141 [27] were adopted for conducted requirements.

For frequency range 4.2 - 6 GHz, for measurement of transmitter, all uncertainty factors including instrumentation related MU were judged to the same as for the 3 – 4.2 GHz range and thus the total MU for 4.2 – 6 GHz is the same as for 3 - 4.2 GHz.

For frequency range 4.2 - 6 GHz, for measurement of receiver, both the wanted signal level error and interferer level error may differ for frequency ranges. Hence the MU for the frequency range is defined separately. The derivation of maximum test system uncertainty for 4.2 – 6 GHz receiver tests is shown in table 12.2.1-1.

This assessment was made under the assumption of testing BS designed for licensed spectrum; for unlicensed spectrum the MU may differ.

Table 12.2.1-1: Maximum test system uncertainty for 4.2 – 6 GHz conducted receiver tests

Requirement	Derivation of Test System Uncertainty	MU (dB)				
		Wanted signal level error	Modulated Interferer level error	CW Interferer level error	ACLR effect or Broadband noise effect	Total
7.2 Reference sensitivity level	wanted_level_error	1.22	N/A	N/A	N/A	1.2
7.4.1 Adjacent channel selectivity	[SQRT (wanted_level_error^2 + interferer_level_error^2)] + leakage effect	1.22	1.22	N/A	0.4	2.1
7.4.2 In-band blocking (General blocking)	[SQRT (wanted_level_error^2 + interferer_level_error^2)] + leakage effect	1.22	1.39	N/A	0.4	2.2
7.4.2 In-band blocking (Narrow band blocking)	[SQRT (wanted_level_error^2 + interferer_level_error^2)] + leakage effect	1.22	1.22	N/A	0.4	2.1
7.5.5.1 Out-of-band blocking (General requirements) 1MHz < $f_{interferer}$ ≤ 3 GHz	[SQRT (wanted_level_error^2 + interferer_level_error^2)] + Broadband noise effect	1.22	N/A	1	0.1	1.7
7.5.5.1 Out-of-band blocking (General requirements) 3.0GHz < $f_{interferer}$ ≤ 4.2 GHz	[SQRT (wanted_level_error^2 + interferer_level_error^2)] + Broadband noise effect	1.22	N/A	1.2	0.1	1.8
7.5.5.1 Out-of-band blocking (General requirements) 4.2GHz < $f_{interferer}$ ≤ 12.75 GHz	[SQRT (wanted_level_error^2 + interferer_level_error^2)] + Broadband noise effect	1.22	N/A	3	0.1	3.3
7.5.5.2 Out-of-band blocking (Co-location requirements)	[SQRT (wanted_level_error^2 + interferer_level_error^2)] + Broadband noise effect	1.22	N/A	2	0.4	2.7
7.7 Receiver intermodulation	SQRT [(2 x CW_level_error)^2 +(mod interferer_level_error)^2 +(wanted signal_level_error)^2] + ACLR effect	1.22	1.22	0.98	0.4	3
7.8 In-channel selectivity	[SQRT (wanted_level_error^2 + interferer_level_error^2)] + leakage effect	1.22	1.22	N/A	0.4	2.1

12.3 Conformance testing for OTA TX directional requirements

NOTE: In Rel-15, content of this clause was shifted to the OTA BS testing TR 37.941 [36].

12.3.1 Void

12.3.2 Void

12.3.3 Void

12.3.4 Void

12.3.5 Void

12.3.6 Void

12.4 Conformance testing for OTA RX directional requirements

NOTE: In Rel-15, content of this clause was shifted to the OTA BS testing TR 37.941 [36].

12.4.1 Void

12.4.2 Void

12.4.3 Void

12.5 Conformance testing for OTA RX out of band blocking

NOTE: In Rel-15, content of this clause was shifted to the OTA BS testing TR 37.941 [36].

12.5.1 Void

12.5.2 Void

12.5.3 Void

12.6 Conformance testing for OTA in band TRP requirements

NOTE: In Rel-15, content of this clause was shifted to the OTA BS testing TR 37.941 [36].

12.6.1 Void

12.6.2 Void

12.6.3 Void

12.7 Conformance testing for OTA out of band TRP requirements

NOTE: In Rel-15, content of this clause was shifted to the OTA BS testing TR 37.941 [36].

12.7.1 Void

12.7.2 Void

12.7.3 Void

12.8 Conformance testing for OTA co-location requirements

NOTE: In Rel-15, content of this clause was shifted to the OTA BS testing TR 37.941 [36].

12.8.1 Void

12.8.2 Void

12.8.3 Void

12.8.4 Void

12.8.5 Void

12.9 Conformance testing for performance requirements

NOTE: In Rel-15, content of this clause was shifted to the OTA BS testing TR 37.941 [36].

12.9.1 Void

12.9.2 Void

12.9.3 Void

12.10 TRP measurements

NOTE: In Rel-15, content of this clause was shifted to the OTA BS testing TR 37.941 [36].

12.10.1 Void

Annex A: Aspects related to measurement of OTA unwanted emission

NOTE: In Rel-15, content of this annex was shifted to the OTA BS testing TR 37.941 [36].

A.1 Void

A.2 Void

A.3 Void

A.4 Void

Annex B: Simulation assumptions and results summary for RF Fixed Reference Channels

Table B.1 Simulation assumptions for RF Fixed Reference Channels

Parameter	Assumption (common)
DMRS pattern	Type 1: 1 symbol front loaded (symbol 2) + 1 additional (symbol 11), no FDM data in DMRS symbols
DMRS power boosting	3 dB
Receiver type	MMSE
PTRS	None
Propagation	AWGN
Modulation	QPSK for REFSENS and ICS 16QAM for Dynamic Range
Expected coding rate	1/3 for REFSENS and ICS 2/3 for Dynamic Range
Symbol type	CP-OFDM
HARQ	None
Number of receive antenna	1
Channel estimation	Practical
Criteria	SNR at 95%-tile throughput
MCS index	4 for REFSENS and ICS 16 for Dynamic Range

Table B.2 Simulation parameters according to RAN1 agreements

Parameter	Assumption (common)
Base graph	For coding rate ≤ 0.25, base graph 2 is selected For 0.25 ＜coding rate ≤ 0.67, base graph 2 is selected if transport block size ≤ 3824（payload only, without CRC） For transport block size ≤ 292, base graph 2 is selected Otherwise, base graph 1 is selected
Transport block CRC	24bits if transport block size > 3824 16bits if transport block size ≤ 3824
Code block CRC	24bits (if more than 1 code block)
Target coding rate	308/1024 for REFSENS and ICS 658/1024 for Dynamic Range

Table B.3 Simulation results summary for RF Fixed Reference Channels

			Ericsson R4-1802310 R4-1802311 R4-1802312 R4-1802313 R4-1802314	Huawei R4-1801675 R4-1801676 R4-1801677 R4-1801678 R4-1601679	ZTE R4-1802412 R4-1802414 R4-1802415 R4-1802416 R4-1802417	CATT R4-1801447 R4-1801448 R4-1801450	Nokia R4-1802737 R4-1802738 R4-1802742	Average	Standard Deviation
REFSENS	FR1	G-FR1-A1-1	-1.1	-1.5	-1.3	-1.1	-1.1	-1.2	0.2
		G-FR1-A1-2	-0.6	-1	-1	-0.8	-0.8	-0.8	0.2
		G-FR1-A1-3	-0.7	-1	-1	-0.8	-0.8	-0.9	0.1
		G-FR1-A1-4	-1.1	-1.2	-1.2	-1	-1.1	-1.1	0.1
		G-FR1-A1-5	-1.2	-1.2	-1.3	-1.2	-1.2	-1.2	0
		G-FR1-A1-6	-1	-1.3	-1.2	-1.1	-0.9	-1.1	0.2
ICS	FR1	G-FR1-A1-7	-0.8	-1	-1.1	-1	-0.8	-0.9	0.1
		G-FR1-A1-8	-0.4	-0.4	-0.8	-1	-0.6	-0.6	0.3
		G-FR1-A1-6	-0.4	-0.4	-0.8	-1	-0.6	-0.6	0.3
Dyn Range	FR1	G-FR1-A2-1	8.9	10.1	9.1	9.1	9.2	9.3	0.5
		G-FR1-A2-2	8.9	9.7	9	9	9	9.1	0.3
		G-FR1-A2-3	8.9	9.7	9	9	9	9.1	0.3
		G-FR1-A2-4	8.8	10.1	9	9	9.1	9.2	0.5
		G-FR1-A2-5	8.9	10.6	9.1	9.2	9.2	9.4	0.7
		G-FR1-A2-6	9.1	9.6	9.2	9.3	9.3	9.3	0.2
REFSENS	FR2	G-FR2-A1-1	-1.2	-1.3	-1.3	-0.8	-1.1	-1.1	0.2
		G-FR2-A1-2	-1.1	-1.5	-1.2	-1	-0.9	-1.1	0.2
		G-FR2-A1-3	-1.2	-1.3	-1.3	-0.8	-1.2	-1.2	0.2
ICS	FR2	G-FR1-A1-4	-1.1	-1.6	-1.3	-1	-1	-1.2	0.3
		G-FR1-A1-5	-0.8	-1.3	-1.1	-0.8	-0.8	-1	0.2

Annex C:
Change history

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2017-09	RAN4#84	R4-1709364				Report skeleton	0.0.1
2017-09	RAN4-NR AH #3	R4-1709365				Agreed Text Proposals in RAN4 NR AH #2: **R4-1708836**, "Draft TR 38.XXX: General aspects for RF, RRM and demodulation for NR" **R4-1708860**, "TP to general TR 38.XXX relationships with other core specifications" **R4-1708869**, "TP to TR 38.xxx (NR WI TR): Unwanted Emissions Mask (UEM) for Frequency Range 1" **R4-1708965**, "TP to TR 38.xxx (NR WI TR): NR band numbering" **R4-1709137**, "TP to draft general TS 38.xxx: Conducted Tx spurious requirements for NR BS, Range 1"	0.1.0
2017-09	RAN4-NR AH #3	R4-1709990				Updated done during RAN4 NR AH#3, including revised structure for clauses 8-10.	0.1.1
2017-09	RAN4-NR AH#3	R4-1710085				Agreed Text Proposals in RAN4 NR AH #3: **R4-1709991**, "TP for TR 38.xyz: Applicability of NR BS requirements" **R4-1709992**, "TR to TR 38.xxx capturing BS architectures and interfaces" **R4-1709994**, "TP to TR 38.xxx (BS RF): NR BS classes" **R4-1709995**, "TP for TR 38.xyz: Anchor points for NR BS requirements" **R4-1709999**, "TP to TR 38.xxx (BS RF): Basic limit and emissions scaling" **R4-1710000**, "TP to TR 38.xxx (BS RF): BS output power" **R4-1710001**, "TP for TR 38.xyz: Adding background information for radiated transmit power" **R4-1710002**, "TP for TR 38.xyz: Addition of background information for conducted TX IMD" **R4-1710003**, "TP of frequency error for range1 NR BS" **R4-1710006**, "TP to TR 38.xxx: OBW for NR BS" **R4-1710007**, "TP to TR 38.xxx (BS RF): Tx spurious emissions requirements for 1-O and 2-O" **R4-1710008**, "TP to TR 38.xxx (BS RF): TAE requirement" **R4-1710009**, "TP for TR BS RF on Transmit ON/OFF power for TDD NR BS" **R4-1710011**, "TP to TR 38.xxx (BS RF): Rx spurious emissions requirement for NR BS" **R4-1710012**, "TP to TR 38.xxx: Receiver spurious emission for FR1" **R4-1710014**, "TP to TR 38.xxx - range 1 spatial parameters" **R4-1710016**, "TP to TR 38.xxx (BS RF): introduction of the EMC requirements section for the NR BS" **R4-1710024**, "Correction TP of Conducted Tx spurious requirements for NR BS, Range 1" **R4-1710038**, "TP dynamic range requirements for Range 2 NR BS to TR 38.xxx" **R4-1710074**, "TP to TR 38.xxx definition of spatial emissions declarations" **R4-1710075**, "TP to TR 38.xxx: Spectrum emission mask (SEM) for FR2"	0.2.0

2017-10	RAN4#84 bis	R4-1711981				Agreed Text Proposals in RAN4 #84bis: **R4-1710585**, "TP for TS 38.817-02: Relationship between minimum requirements and test requirements; Regional requirements" **R4-1710586**, "TP for TS 38.817-02: Receiver spurious emissions and the boundary to spurious domain" **R4-1710735**, "Occupied bandwidth for Frequency Range 2" **R4-1711019**, "TP to TR 38.817-2: on NB blocking for mm-waves" **R4-1711327**, "TP to TR38.817 (BS RF): conducted NR BS output power" **R4-1711328**, "TP to TR38.817 (BS RF): Radiated NR BS transmit power, FR1" **R4-1711329**, "TP to TR38.817 (BS RF): OTA base station output power, FR1" **R4-1711604**, "TP to TR 38.817-02 v0.1.0: Transient time for NR UE" **R4-1711739**, "TP to 38.817-02: Requirements for contiguous and non-contiguous spectrum" **R4-1711740**, "TP to TR 38.817-2: Base station and UE bandwidth allocation" **R4-1711742**, "TP to 38.817-02: Requirements for BS capable of multi-band operation" **R4-1711743**, "TP for TR 38.817-02: out of band blocking (7.5)" **R4-1711774,** "Test Proposal for BS RF TR 38.718-02: NR BS beam switching speed requirement" **R4-1711776**, "TP to TR 38.817-02 for Unwanted spatial emission declaration - update" **R4-1711781**, "TP to TR 38.817-02: NR BS conducted ACLR requirement in FR1 (6.6.3)" **R4-1711810**, "TP to TR 38.817-02: NR BS conducted in-band selectivity and blocking requirements in FR1 (7.4)" **R4-1711813**, "TP to TR 37.817-2: receiver intermodulation requirements for mm-waves" **R4-1711827**, "TP to TR 38.817-02: EMC agreements" **R4-1711851**, "TP to TR 38.817-2 to add the subclause for BS general RF requirements for SUL and LTE-NR co-existence" **R4-1711928**, "TP to TR 38.817-02 - OTA ACLR (9.7.3)"	0.3.0
2017-11	RAN4#85	R4-1712124				Agreed Text Proposal in RAN4 #84bis: **R4-1710818**, "TP for TR 38.xyz: Adding background information for OTA sensitivity for FR1" **R4-1711783**, "TP for TR 38.xyz: Adding background information on FR1 TX IMD" **R4-1711814**, "TP for TR 38.xyz: Adding OTA unwanted emission test aspects"	0.4.0
2017-12	RAN4#85	R4-1714547				Agreed Text Proposal in RAN4 #85: **R4-1712652**, "TP to TR 38.817-02: Directional and TRP requirements identification (directional vs. TRP)" **R4-1712962**, "TP for TR 38.817-02: out of band blocking (7.5)" **R4-1712963**, "TP for TS 38.817-02: OTA Dynamic range (10.4)" **R4-1713025**, "TP for TR 38.817-02: Adding background information for OTA unwanted emission testing in sub-clause 3.1 and Annex A" **R4-1713814**, "TP to TR 38.817-02: OTA receiver spurious emissions, FR2 (10.7.3)" **R4-1714123**, "TP for TR 38.817-2 Transmit OFF level for NR BS 1-O (9.5.1)" **R4-1714124**, "TP for TR 38.817-2 Transmitter OFF Power for NR BS 2-O (9.5.1)" **R4-1714128**, "TP to TR 38.817-02 v0.4.0: Frequency error" **R4-1714130**, "TP to TR 38.817-02: NR BS conducted CACLR requirements in FR1 (6.6.3)" **R4-1714156**, "TP for TR 38.817-02: NR BS beam switching speed requirement" **R4-1714298**, "TP to TR 38.817-02: Output power dynamics for FR1 (conducted)" **R4-1714311**, "TP to TR 38.817-02 v0.4.0: Directional and TRP requirements identification (directional vs. TRP)" **R4-1714431**, "TP to TR 38.817-02 v0.4.0: Absolute levels for FR2 ACLR absolute levels for NR BS" **R4-1714440**, "TP for TR 38.817-02: Base station classes (5.4)" **R4-1714519**, "TP to TR 38.817-2: ACS & blocking further detail" **R4-1714521**, "TP to TR 38.817-02: NR BS conducted receiver intermodulation requirements in FR1 (7.7)"	0.5.0

2018-05	RAN4-AH 1801	R4-1800270				Agreed Text Proposal in RAN4 AH 1801: **R4-1800593**, "pCR to TR 38.817-2: Corrections to RX IM text" **R4-1800917**, "TP to TR 38.817-02: Channel bandwidth corrections (7.4.1, 10.5.1, 10.8.2)" **R4-1801027**, "TP for TR 38.817-02: NR BS beam switching speed requirement" **R4-1801028**, "TP to TR 38.817 -02 and Rx Spatial declarations (10.1)" **R4-1801038**, "TP to TR 37.817 capturing agreement on FR2 in-band blocking (10.5)" **R4-1801241**, "TP to TR 38.817-02: NR BS in-band and out-of-band boundaries for FR1 (5.9)" **R4-1801242**, "TP to TR 38.817-02: Section 6.5 Transmitted Signal Quality" **R4-1801243**, "TP to TR 38.817-02: Section 9.6 OTA Transmitted Signal Quality" **R4-1801244**, "TP for TR 38.817-02: Editorial correction of headings and text in Annex A" **R4-1801273**, "TP to TR 38.817-02 clarifying spatial ranges for Tx requirements" **R4-1801282**, "TP to TR 38.817-02: Relations between single core and separate conducted/OTA test requirements (5.2)" **R4-1801322**, "TP to TR 38.817 - capturing agreements on FR2 antenna gain assumptions (10.2,10.3)"	0.6.0
03/2018	RAN4#86	R4-1802143				Agreed Text Proposal in RAN4 #86: **R4-1802015**, "TP to TR 38.817-02: BS classes (5.4)" **R4-1802316**, "TP to TR 38.817-02 - 7.2 REFSENS conducted" **R4-1802418**, "TP to TR38.817: ICS requirement (Section 7.8)" **R4-1802731**, "TP to TR 38.817-02: NR CACLR requirement for non-continuous allocation in FR1 (6.6.3)" **R4-1802745**, "TP to TR 38.817-02 v0.6.0: Conducted TAE for CA" **R4-1802746**, "TP to TR 38.817-02 v0.6.0: OTA TAE for CA" **R4-1802933**, "TP to TR 38.817-02: Upper limit of the spurious range for BS type 2-O (9.7.5.3, 10.7.3)" **R4-1803292**, "TP to TR 38.817-02: Base station output power (6.2)" **R4-1803300**, "TP to TR 38.817-02: Simulation Assumptions for NR BS RF FRCs (Annex B)" **R4-1803308**, "TP to TR 38.817-02: simplification of the BS EMC specification (11.1)" **R4-1803322**, "TP to TR 38.817-02: Conducted dynamic Range for BS type 1-C and BS type 1-H" **R4-1803323**, "TP to TR38.817 ICS requirement (Section 10.9)" **R4-1803527**, "TP to TR 38 817-2 - antenna gain mismatch"	0.7.0
2018-05	RAN4#86 bis	R4-1804041				Agreed Text Proposal in RAN4 #86: **R4-1804243**, "TP to TR 38.817-02: NR CACLR requirement for non-continuous allocation in FR2 (9.7.3.3)" **R4-1804569**, "TP to TR 38.817-02: Base station conducted output power (6.2)" **R4-1805208**, "TP to TR 38.817-2 - FR1 out of band blocking (10.6.1)" **R4-1805812**, "TP to TR 38.817-2 – corrections for FR2 OTA reference sensitivity (10.3.3)" **R4-1805818**, "TP to TR 37.817-02: timeline of the NR updates for MSR/AAS EMC"	0.8.0
2018-05	RAN4#87	R4-1806933				Agreed Text Proposal in RAN4 #87: **R4-1806930**, "Correction TP to TR38.817 Dynamic range requirement (Section 7.3)" **R4-1806931**, "Correction TP to TR38.817 ICS requirement (Section 7.8 and 10.9)" **R4-1806934**, "TP to TR 38.817-02: Removal of full requirements" **R4-1807188**, "TP to TR 38.817-02: Frequency range for OTA ACLR requirements in FR2 (9.7.3)" **R4-1807189**, "TP to TR 38.817-02: Frequency range for OTA OBUE requirement in FR2 (9.7.4)" **R4-1807739**, "TP to TR 38.817-02: Output power dynamics requirements completion" **R4-1808277**, "TP to TR 38.817-02: Improvement of RIB interface in Figures 5.3.4-1 and 5.3.5-1, in sub-clause 5.3" **R4-1808279**, "TP to TR 38.817-02: multi-band corrections" **R4-1808296**, "TP to TR 38.817-02: Update of clause 9.7.5.1 OTA Transmitter spurious emissions for co-location." **R4-1808430**, "TP to TR38.817-2: ICS requirement for FR2"	0.9.0
2018-06	RAN#80	RP-180795				Presentation to TSG RAN for approval.	1.0.0
2018-06	RAN#80					Approved by plenary – Rel-15 spec under change control	15.0.0
2018-09	RAN#81	RP-181896	0001	2	F	CR to TR 38.817-02: Update to OTA Modulation Quality	15.1.0

2018-09	RAN#81	RP-181896	0002		F	CR to TR 38.817-02: cleanup of the FR2 spurious emission requirements	15.1.0
2018-09	RAN#81	RP-181896	0003		F	CR to 38.817-02: OTA operating band unwanted emission (9.7.4)	15.1.0
2018-12	RAN#82	RP-182359	0004	1	F	Correction CR on OTA FR2 OBUE in TR38.817-02	15.2.0
2018-12	RAN#82	RP-182361	0005	1	F	CR to TR 38.817-02: Clarifications on background of Adjacent Channel Selectivity requirements (7.4.1, 10.5.2)	15.2.0
2018-12	RAN#82	RP-182361	0006		F	CR to TR 38.817-02: Corrections on background of In-Channel Selectivity requirements (2, 7.8, 10.9.3)	15.2.0
2018-12	RAN#82	RP-182361	0009		F	CR to TR 38.817-02: Finalizing the measurement step size for BS type 2-O out-of-band blocking conformance testing (new clause 10.6.2)	15.2.0
2018-12	RAN#82	RP-182359	0010	1	F	CR for TR 38.817-02: Adding missing background information for 2-O radiated transmit power in sub-clause 9.2.3	15.2.0
2018-12	RAN#82	RP-182359	0012	1	F	CR for TR 38.817-02: Improvements of applicability table in sub-clause 5.6	15.2.0
2018-12	RAN#82	RP-182359	0013	1	F	CR to TR 38.817-02: Improvement of sub-clasue 9.1 to include both FR1 and FR2	15.2.0
2018-12	RAN#82	RP-182359	0014	1	F	CR to TR 38.817-02: Improvement of sub-clasue 10.1 to include both FR1 and FR2	15.2.0
2018-12	RAN#82	RP-182359	0017	1	F	CR to TR 38.817-02: Addtion of FR2 extreme EIRP requirements in sub-clause 9.2	15.2.0
2018-12	RAN#82	RP-182359	0018	1	F	CR to TR 38.817-02: Adding technical background FBW declaration of EIRP in sub-clause 9.2.1	15.2.0
2018-12	RAN#82	RP-182361	0021		F	Correction to directions for FR1 OTA in-band blocking requirement	15.2.0
2018-12	RAN#82	RP-182361	0022		F	CR to TR 38.817-02 for Conformance testing (Ch 12) after RAN4#89	15.2.0
2018-12	RAN#82	RP-182361	0024	2	F	CR to TR 38.817-02 - polarisation wording improvements for OTA reference sensitivity	15.2.0
2018-12	RAN#82	RP-182359	0025	1	F	CR to TR 38.817-02:Improvements of applicability table (5.6)	15.2.0
2018-12	RAN#82	RP-182359	0026	1	F	CR to TR 38.817-02: Classification of radiated Tx requirements (9.1)	15.2.0
2019-03	RAN#83	RP-190402	0029	1	F	CR to TR 38.817-02: Clean-up of TRP measurement background in sub-clause 12.7 and Annex A	15.3.0
2019-03	RAN#83	RP-190401	0032	1	F	CR to 38.817-02; clarification of BS power limits	15.3.0
2019-03	RAN#83	RP-190401	0033		F	CR to 38.817-02: Background on MU for conducted testing	15.3.0
2019-03	RAN#83	RP-190401	0034	1	B	CR to TR 38.817-02 adding background of RX exclusion band	15.3.0
2019-06	RAN#84	RP-191237	0035	1	F	CR to TR 38.817-02: Addition of RC MU tables for FR2 spurious emission in subclause 12.7.1	15.4.0
2019-06	RAN#84	RP-191237	0037		F	CR to TR 38.817-02: on background for FR2 OFF power	15.4.0
2019-06	RAN#84	RP-191237	0039	1	F	CR to TR38.817-02 on TT and MU tables for FR2 OFF power	15.4.0
2019-06	RAN#84	RP-191237	0040	2	F	CR to TR 38.817-02: Addition of MU evaluation for testing output power, ACLR and OBUE in RC test method in subclause 12.6	15.4.0
2019-06	RAN#84	RP-191237	0041	1	F	CR to TR 38.817-02 removal of Tx Diversity for TAE testing	15.4.0
2019-06	RAN#84	RP-191237	0042	1	F	CR to TR 38.817-02: updating the FR2 OTA transmit ON/OFF column in Table 12.10.1-1 (12.10.1)	15.4.0
2019-06	RAN#84	RP-191237	0043	2	F	CR to TR38.817-02 Correction on beam based direcrtions	15.4.0
2019-06	RAN#84	RP-191237	0045		F	CR to TR 38.817-02 Editorial Corrections to TR 38.817-02	15.4.0
2019-09	RAN#85	RP-192048	0046	1	F	CR to TR 38.817-02 BS type correction subclause 11	15.5.0
2019-09	RAN#85	RP-192048	0047		F	CR to TR38.817-02: Correct on FR1 ?fOBUE	15.5.0
2019-09	RAN#85	RP-192048	0048	2	F	CR to TR 38.817-02: Background on the EVM	15.5.0
2019-09	RAN#85	RP-192048	0049		F	CR to TR 38.817-02 with correction of term 'reference signal" for EVM	15.5.0
2019-09	RAN#85	RP-192048	0050	2	F	CR to TR 38.817-02 updating the FR2 TAE limits	15.5.0
2019-09	RAN#85	RP-192048	0051	1	F	CR to 38.817-02 - correct TX OFF MU table	15.5.0
2019-09	RAN#85	RP-192048	0052		F	CR to 38.817-02 - derivation of FR2 out of band blocking limits	15.5.0
2019-12	RAN#86	RP-193036	0055		F	CR to TS 38.817-02: Clarification on interference level of receiver dynamic range requirement	15.6.0
2019-12	RAN#86	RP-193036	0056		F	CR to TS 38.817-02: Clarification on interfering signal frequency offsets of receiver in-band selectivity and blocking requirements	15.6.0
2019-12	RAN#86	RP-193036	0057		F	CR to TR 38.817-02: Clarification on interfering signal frequency offsets for receiver intermodulation requirements	15.6.0
2019-12	RAN#86	RP-193036	0058		F	CR to 38.817-02:In-band and out-of-band boundaries for FR1 (5.10)	15.6.0
2020-03	RAN#87	RP-200404	0061	1	F	CR to TR 38.817-02: Clarifications and corrections on receiver dynamic range and other requirements	15.7.0
2020-03	RAN#87	RP-200404	0062	1	F	CR for background on Category B unwanted emission requirement for BS type 2-O	15.7.0
2020-03	RAN#87	RP-200404	0065		F	CR to 38.817-02: Measurement uncertainty for FR2 OTA additional spurious emissions requirements	15.7.0
2020-06	RAN#88	RP-200986	0066		F	CR to TR 38.817-02: Corrections of CR implementation errors	15.8.0
2020-06	RAN#88	RP-201005	0067	1	F	CR to TR 38.817-02: internal TR references corrections and content redundancy removal (wrt. TR 37.941 for OTA BS testing), Rel-15	15.8.0
2020-09	RAN#89	RP-201512	0068	1	F	CR to TS 38.817-02: Clarification on calculation of step frequencies for defining the Category B radiated Tx spurious emission limits in FR2	15.9.0
2022-09	RAN#97	RP-222023	0069		F	Big CR for TR 38.817-02 Maintenance (Rel-15, CAT F)	15.10.0

2023-09	RAN#101	RP-232502	0070		F	[NR_newRAT-Core] CR to TR 38.817-02: Clarification on calculation of CW frequency offset for conducted narrowband receiver intermodulation requirement in FR1	15.11.0

History

Document history		
V15.11.0	October 2023	Publication