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| ***3GPP***Postal address3GPP support office address650 Route des Lucioles - Sophia AntipolisValbonne - FRANCETel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16Internethttp://www.3gpp.org |
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Contents

Foreword 9

1 Scope 11

2 References 11

3 Definitions, symbols and abbreviations 11

3.1 Definitions 11

3.2 Symbols 15

3.3 Abbreviations 16

4 General 17

4.1 Relationship with other core specifications 17

4.2 Relationship between minimum requirements and test requirements 17

4.3 Requirement reference points 17

4.3.1 SAN type 1-H 17

4.3.2 SAN type 1-O 18

4.4 Satellite Access Node classes 19

4.5 Regional requirements 19

4.6 Applicability of minimum requirements 19

5 Operating bands and channel arrangement 20

5.1 General 20

5.2 Operating bands 20

5.3 Satellite Access Node channel bandwidth 20

5.3.1 General 20

5.3.2 Transmission bandwidth configuration 21

5.3.3 Minimum guardband and transmission bandwidth configuration 21

5.3.4 RB alignment 22

5.3.5 SAN channel bandwidth per operating band 22

5.4 Channel arrangement 23

5.4.1 Channel spacing 23

5.4.1.1 Channel spacing for adjacent carriers 23

5.4.2 Channel raster 23

5.4.2.1 NR-ARFCN and channel raster 23

5.4.2.2 Channel raster to resource element mapping 24

5.4.2.3 Channel raster entries for each *operating band* 24

5.4.3 Synchronization raster 24

5.4.3.1 Synchronization raster and numbering 24

5.4.3.3 Synchronization raster entries for each operating band 25

6 Conducted transmitter characteristics 26

6.1 General 26

6.2 Satellite Access Node output power 26

6.2.1 General 26

6.2.2 Minimum requirement for *SAN type 1-H* 26

6.3 Output power dynamics 26

6.3.1 General 26

6.3.2 RE power control dynamic range 27

6.3.2.1 General 27

6.3.2.2 Minimum requirement for *SAN type 1-H* 27

6.3.3 Total power dynamic range 27

6.3.3.1 General 27

6.3.3.2 Minimum requirement for *SAN type 1-H* 27

6.4 Transmit ON/OFF power 27

6.5 Transmitted signal quality 28

6.5.1 Frequency error 28

6.5.1.1 General 28

6.5.1.2 Minimum requirement for *SAN type 1-H* 28

6.5.2 Modulation quality 28

6.5.2.1 General 28

6.5.2.2 Minimum Requirement for *SAN type 1-H* 28

6.5.2.3 EVM frame structure for measurement 28

6.5.3 Time alignment error 29

6.6 Unwanted emissions 29

6.6.1 General 29

6.6.2 Occupied bandwidth 29

6.6.2.1 General 29

6.6.2.2 Minimum requirement for Satellite Access Node 29

6.6.3 Adjacent Channel Leakage Power Ratio 29

6.6.3.1 General 29

6.6.4 Operating band unwanted emissions 29

6.6.4.1 General 29

6.6.5 Transmitter spurious emissions 29

6.6.5.1 General 29

6.6.5.2 Basic Limits 30

6.6.5.2.1 General transmitter spurious emissions requirements 30

6.6.5.2.2 Protection of the own Satellite Access Node receiver 30

6.6.5.2.3 Additional spurious emissions requirements 30

6.6.5.2.4 Co-location with other Satellite Access Nodes 30

6.6.5.3 Minimum requirement for Satellite Access Node 30

6.7 Transmitter intermodulation 30

7 Conducted receiver characteristics 31

7.1 General 31

7.2 Reference sensitivity level 31

7.2.1 General 31

7.2.2 Minimum requirements for Satellite Access Node 31

7.3 Dynamic range 32

7.3.1 General 32

7.3.2 Minimum requirements for Satellite Access Node 32

7.4 In-band selectivity and blocking 33

7.4.1 Adjacent Channel Selectivity (ACS) 33

7.4.1.1 General 33

7.4.1.2 Minimum requirements for Satellite Access Node 33

7.4.2 In-band blocking 34

7.4.2.1 General 34

7.4.2.2 Minimum requirements for Satellite Access Node 34

7.5 Out-of-band blocking 34

7.5.1 General 34

7.5.2 Minimum requirements for Satellite Access Node 35

7.6 Receiver spurious emissions 35

7.6.1 General 35

7.6.2 Minimum requirement for *SAN type 1-H* 35

7.7 Receiver intermodulation 36

7.8 In-channel selectivity 36

7.8.1 General 36

7.8.2 Minimum requirements for Satellite Access Node 36

8 Conducted performance requirements 37

8.1 General 37

8.2 Performance requirements for PUSCH 37

8.3 Performance requirements for PUCCH 37

8.4 Performance requirements for PRACH 37

9 Radiated transmitter characteristics 38

9.1 General 38

9.2 Radiated transmit power 38

9.2.1 General 38

9.2.2 Minimum requirement for *SAN type 1-H* and *SAN type 1-O* 39

9.3 OTA Satellite Access Node output power 39

9.3.1 General 39

9.3.2 Minimum requirement for *SAN type 1-O* 40

9.4 OTA output power dynamics 40

9.4.1 General 40

9.4.2 OTA RE power control dynamic range 40

9.4.2.1 General 40

9.4.2.2 Minimum requirement for *SAN type 1-O* 40

9.4.3 OTA total power dynamic range 40

9.4.3.1 General 40

9.4.3.2 Minimum requirement for *SAN type 1-O* 41

9.5 OTA transmit ON/OFF power 41

9.6 OTA transmitted signal quality 41

9.6.1 OTA frequency error 41

9.6.1.1 General 41

9.6.1.2 Minimum requirement for *SAN type 1-O* 41

9.6.2 OTA modulation quality 41

9.6.2.1 General 41

9.6.2.2 Minimum requirement for *SAN type 1-O* 41

9.6.3 OTA time alignment error 41

9.7 OTA unwanted emissions 42

9.7.1 General 42

9.7.2 OTA occupied bandwidth 42

9.7.2.1 General 42

9.7.2.2 Minimum requirement for *SAN type 1-O* 42

9.7.3 OTA Adjacent Channel Leakage Power Ratio (ACLR) 43

9.7.3.1 General 43

9.7.3.2 Minimum requirement for *SAN type 1-O* 43

9.7.4 OTA operating band unwanted emissions 43

9.7.4.1 General 43

9.7.4.2 Minimum requirement for *SAN type 1-O* 43

9.7.5 OTA transmitter spurious emissions 43

9.7.5.1 General 43

9.7.5.2 Minimum requirement for *SAN type 1-O* 44

9.7.5.2.1 General 44

9.7.5.2.2 General OTA transmitter spurious emissions requirements 44

9.7.5.2.3 Protection of the SAN receiver of own 44

9.8 OTA transmitter intermodulation 44

10 Radiated receiver characteristics 45

10.1 General 45

10.2 OTA sensitivity 45

10.2.1 General 45

10.2.2 Minimum requirement 46

10.3 OTA reference sensitivity level 46

10.3.1 General 46

10.3.2 Minimum requirement for *SAN type 1-O* 46

10.4 OTA dynamic range 47

10.4.1 General 47

10.4.2 Minimum requirement for *SAN type 1-O* 47

10.5 OTA in-band selectivity and blocking 48

10.5.1 OTA adjacent channel selectivity 48

10.5.1.1 General 48

10.5.1.2 Minimum requirement for *SAN type 1-O* 48

10.6 OTA out-of-band blocking 49

10.6.1 General 49

10.6.2 Minimum requirement for *SAN type 1-O* 49

10.6.2.1 General minimum requirement 49

10.7 OTA receiver spurious emissions 50

10.7.1 General 50

10.7.2 Minimum requirement for *SAN type 1-O* 50

10.8 OTA receiver intermodulation 50

10.9 OTA in-channel selectivity 51

10.9.1 General 51

10.9.2 Minimum requirement for *SAN type 1-O* 51

11 Radiated performance requirements 53

11.1 General 53

11.2 Performance requirements for PUSCH 53

11.3 Performance requirements for PUCCH 53

11.4 Performance requirements for PRACH 53

Annex A (normative): Reference measurement channels 54

A.1 Fixed Reference Channels for RF Rx requirements in FR1 (QPSK, R=1/3) 54

A.2 Fixed Reference Channels for dynamic range (16QAM, R=2/3) 55

Annex B (normative): Error Vector Magnitude (FR1) 57

B.1 Reference point for measurement 57

B.2 Basic unit of measurement 57

B.3 Modified signal under test 58

B.4 Estimation of frequency offset 58

B.5 Estimation of time offset 58

B.5.1 General 58

B.5.2 Window length 59

B.6 Estimation of TX chain amplitude and frequency response parameters 60

B.7 Averaged EVM 61

Annex C (normative): Error Vector Magnitude (FR2) 62

Annex D (informative): Change history 64

# Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

In the present document, modal verbs have the following meanings:

**shall** indicates a mandatory requirement to do something

**shall not** indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

**should** indicates a recommendation to do something

**should not** indicates a recommendation not to do something

**may** indicates permission to do something

**need not** indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

**can** indicates that something is possible

**cannot** indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

**will** indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**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 establishes the minimum RF characteristics and minimum performance requirements of NR NTN Satellite Access Node (SAN)

# 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] 3GPP TS 38.181: "NR; Satellite Node conformance testing ".

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

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[x] <doctype> <#>[ ([up to and including]{yyyy[-mm]|V<a[.b[.c]]>}[onwards])]: "<Title>".

It is preferred that the reference to 21.905 be the first in the list.

# 3 Definitions, symbols and abbreviations

## 3.1 Definitions

For the purposes of the present document, the terms 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 transmitter unit:** transmitter unit which is ON, and has the ability to send modulated data streams that are parallel and distinct to those sent from other transmitter units to one or more *SAN type 1-H* *TAB connectors* at the *transceiver array boundary*

**SAN RF Bandwidth**: RF bandwidth in which a SAN transmits and/or receives single or multiple carrier(s) within a supported *operating band*

NOTE: In single carrier operation, the *SAN RF Bandwidth* is equal to the *SAN channel bandwidth*.

**SAN RF Bandwidth edge:** frequency of one of the edges of the *SAN RF Bandwidth*.

**basic limit:** emissions limit relating to the power supplied by a single transmitter to a single antenna transmission line in ITU-R SM.329 [2] used for the formulation of unwanted emission requirements for FR1

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

NOTE: For certain *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

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

NOTE 1: The *SAN channel bandwidth* is measured in MHz and is used as a reference for transmitter and receiver RF requirements.

NOTE 2: It is possible for the SAN to transmit to and/or receive from one or more satellite UE bandwidth parts that are smaller than or equal to the *SAN transmission bandwidth configuration*, in any part of the *SAN transmission bandwidth configuration*.

**SAN transmission bandwidth configuration**: set of resource blocks located within the *SAN channel bandwidth* which may be used for transmitting or receiving by the SAN

**Channel edge:** lowest or highest frequency of the NR carrier, separated by the *SAN channel bandwidth*.

**directional requirement:** requirement which is applied in a specific direction within the *OTA coverage range* for the Tx and when the AoA of the incident wave of a received signal is within the *OTA REFSENS RoAoA* or the *minSENS RoAoA* as appropriate for the receiver

**equivalent isotropic radiated power:** equivalent power radiated from an isotropic directivity device producing the same field intensity at a point of observation as the field intensity radiated in the direction of the same point of observation by the discussed device

NOTE: Isotropic directivity is equal in all directions (i.e. 0 dBi).

**equivalent isotropic sensitivity:** sensitivity for an isotropic directivity device equivalent to the sensitivity of the discussed device exposed to an incoming wave from a defined AoA

NOTE 1: The sensitivity is the minimum received power level at which specific requirement is met.

NOTE 2: Isotropic directivity is equal in all directions (i.e. 0 dBi).

**feeder link:** Wireless link between satellite-Gateway and satellite

**Geostationary Earth Orbit:** Circular orbit at 35,786 km above the Earth's equator and following the direction of the Earth's rotation. An object in such an orbit has an orbital period equal to the Earth's rotational period and thus appears motionless, at a fixed position in the sky, to ground observers.

**geosynchronous orbit:** Earth-centered orbit at approximately 35786 kilometres above Earth's surface and synchronised with Earth's rotation. A geostationary orbit is a non-inclined geosynchronous orbit, i.e. in the Earth’s equator plane.**Low Earth Orbit:** Orbit around the Earth with an altitude between 300 km, and 1500 km.

**Highest Carrier:** The carrier with the highest carrier frequency transmitted/received in a specified frequency band.

**Inter RF Bandwidth gap:** frequency gap between two consecutive *SAN RF Bandwidths* that are placed within two supported *operating bands*

**Lowest Carrier:** The carrier with the lowest carrier frequency transmitted/received in a specified frequency band.

**maximum carrier output power:** mean power level measured per carrier at the indicated interface, during the *transmitter ON period* in a specified reference condition

**maximum carrier TRP output power:** mean power level measured perRIB during the *transmitter ON period* for a specific carrier in a specified reference condition and corresponding to the declared *rated carrier TRP output* power (Prated,c,TRP)

**maximum total output power:** mean power level measured within the *operating band* at the indicated interface, during the *transmitter ON period* in a specified reference condition

**maximum total TRP output power:** mean power level measured perRIB during the *transmitter ON period* in a specified reference condition and corresponding to the declared *rated total TRP output* power (Prated,t,TRP)

**measurement bandwidth**: RF bandwidth in which an emission level is specified

**minSENS:** the lowest declared EIS value for the OSDD's declared for OTA sensitivity requirement.

**minSENS RoAoA:** The *reference RoAoA* associated with the OSDD with the lowest declared EIS

**minimum elevation angle**: Minimum angle under which the satellite or HAPS can be seen by a UE.

**non-geostationary satellites:** Satellites (LEO) orbiting around the Earth with a period that varies approximately between 1.5 hour and 10 hours. It is necessary to have a constellation of several Non-Geostationary satellites associated with handover mechanisms to ensure a service continuity.

**non-terrestrial networks:** Networks, or segments of networks, using an airborne or space-borne vehicle to embark a transmission equipment relay node or SAN.

**satellite-gateway:** An earth station or gateway is located at the surface of Earth, and providing sufficient RF power and RF sensitivity for accessing to the satellite (resp. HAPS).

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

NOTE: The *operating band*(s) for a SAN is declared by the manufacturer according to the designations in tables 5.2-1 and 5.2-2.

**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 requirement* are intended to be met

**OTA peak directions set:** set(s) of *beam peak directions* within which certain TX OTA requirements are intended to be met, where 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:** 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 assuming that for any AoA, the receiver gain is optimized for that AoA

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

**OTA sensitivity directions declaration:** set of manufacturer declarations comprising at least one set of declared minimum EIS values (with *SAN channel bandwidth*), and related directions over which the EIS applies

NOTE: All the directions apply to all the EIS values in an OSDD.

**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

**radiated interface boundary**: *operating band* specific radiated requirements reference where the radiated requirements apply

NOTE: For requirements based on EIRP/EIS, the *radiated interface boundary* is associated to the far-field region

**Radio Bandwidth:** frequency difference between the upper edge of the highest used carrier and the lower edge of the lowest used carrier

**rated beam EIRP:** For a declared beam and *beam direction pair*, the *rated beam EIRP* level is the maximum power that the SAN is declared to radiate at the associated *beam peak direction* during the *transmitter ON period*

**rated carrier output power:** mean power level associated with a particular carrier the manufacturer has declared to be available at the indicated interface, during the *transmitter ON period* in a specified reference condition

**rated carrier TRP output power:** mean power level declared by the manufacturer per carrier, for SAN operating in single carrier, multi-carrier, or carrier aggregation configurations that the manufacturer has declared to be available at the RIB during the *transmitter ON period*

**rated total output power:** mean power level associated with a particular *operating band* the manufacturer has declared to be available at the indicated interface, during the *transmitter ON period* in a specified reference condition

**rated total TRP output power:** mean power level declared by the manufacturer, that the manufacturer has declared to be available at the RIB during the *transmitter ON period*

**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 *OTA peak directions set*

**receiver target:** AoA in which reception is performedby *SAN types 1-H* or *SAN type 1-O*

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

**receiver target reference direction:** direction inside the *OTA sensitivity directions declaration* declared by the manufacturer for conformance testing. For an OSDD without *receiver target redirection range*, this is a direction inside the *sensitivity RoAoA*

**reference RoAoA**: the *sensitivity RoAoA* associated with the *receiver target reference direction* for each OSDD.

**requirement set:** one of the NR SAN requirement's set as defined for *SAN type 1-H*, *SAN type 1-O*

**SAN type 1-H:** Satellite Access Node operating at FR1 with a requirement set consisting of conducted requirements defined at individual *TAB connectors* and OTA requirements defined at RIB

**SAN type 1-O:** Satellite Access Node operating at FR1 with a requirement set consisting only of OTA requirements defined at the RIB

**satellite:** A space-borne vehicle embarking a bent pipe payload or a regenerative payload telecommunication transmitter, placed into Low-Earth Orbit (LEO) or Geostationary Earth Orbit (GEO).

**sensitivity RoAoA:** RoAoA within the *OTA sensitivity directions declaration*, within which the declared EIS(s) of an OSDD is intended to be achieved at any instance of time for a specific SAN direction setting

**service link:** Radio link between SAN and satellite UE

**superseding-band**: A *superseding-band* of an operating band includes the whole of the uplink and downlink frequency range of the operating band.

**TAB connector:** *transceiver array boundary* connector

**total radiated power:** is the total power radiated by the antenna

NOTE: The *total radiated power* is the power radiating in all direction for two orthogonal polarizations. *Total radiated power* is defined in both the near-field region and the far-field region

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

**transmission bandwidth:** RF Bandwidth of an instantaneous transmission from a satellite UE or SAN, measured in resource block units

**transparent payload:** Payload that changes the frequency carrier of the UL/DL RF signal, filters and amplifies it before transmitting it on the DL/UL, respectively.

**UE transmission bandwidth configuration:** set of resource blocks located within the satellite UE channel bandwidth which may be used for transmitting or receiving by the UE

**user throughput:** data rate provided to a terminal

## 3.2 Symbols

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

 Percentage of the mean transmitted power emitted outside the occupied bandwidth on the assigned channel

BeWθ,REFSENS Beamwidth equivalent to the *OTA REFSENS RoAoA* in the θ-axis in degrees. Applicable for FR1 only.

BeWφ,REFSENS Beamwidth equivalent to the *OTA REFSENS RoAoA* in the φ-axis in degrees. Applicable for FR1 only.

SANChannel *SAN channel bandwidth*

BWConfig *Transmission bandwidth configuration*, where BWConfig = *N*RB x SCS x 12

BWContiguous Contiguous *transmission bandwidth*, i.e. *SAN channel bandwidth* for single carrier

BWGB,low The minimum guard band defined in clause 5.3.3 for lowest assigned component carrier

BWGB,high The minimum guard band defined in clause 5.3.3 for highest assigned component carrier

Δf Separation between the *channel edge* frequency and the nominal -3 dB point of the measuring filter closest to the carrier frequency

ΔFGlobal Global frequency raster granularity

Δfmax f\_offsetmax minus half of the bandwidth of the measuring filter

ΔfOBUE Maximum offset of the *operating band* unwanted emissions mask from the downlink *operating band* edge

ΔfOOB Maximum offset of the out-of-band boundary from the uplink *operating band* edge

ΔminSENS Difference between conducted reference sensitivity and minSENS

ΔOTAREFSENS Difference between conducted reference sensitivity and OTA REFSENS

ΔFRaster Channel raster granularity

EISminSENS The EIS declared for the *minSENS RoAoA*

EISREFSENS OTA REFSENS EIS value

FFBWhigh Highest supported frequency within supported *operating band*, for which *fractional bandwidth* support was declared

FFBWlow Lowest supported frequency within supported *operating band*, for which *fractional bandwidth* support was declared

FC *RF reference frequency* on the channel raster, given in table 5.4.2.2-1

FC,low The Fc of the *lowest carrier*, expressed in MHz.

FC,high The Fc of the *highest carrier*, expressed in MHz.

FDL,low The lowest frequency of the downlink *operating band*

FDL,high The highest frequency of the downlink *operating band*

Ffilter Filter centre frequency

Foffset,high Frequency offset from FC,high to the upper *SAN RF Bandwidth edge*

Foffset,low Frequency offset from FC,low to the lower *SAN RF Bandwidth edge*

f\_offset Separation between the *channel edge* frequency and the centre of the measuring

f\_offsetmax The offset to the frequency ΔfOBUE outside the downlink *operating band*

FREF RF reference frequency

FREF-Offs Offset used for calculating FREF

FUL,low The lowest frequency of the uplink *operating band*

FUL,high The highest frequency of the uplink *operating band*

GBChannel Minimum guard band defined in clause 5.3.3

 Physical resource block number

NRB *Transmission bandwidth configuration*, expressed in resource blocks

NREF NR Absolute Radio Frequency Channel Number (NR-ARFCN)

NREF-Offs Offset used for calculating NREF

scaling per cell, as calculated in clause 6.1

PEIRP,N EIRP level for channel N

Pmax,c,AC*Maximum carrier output power* measuredper *antenna connector*

Pmax,c,TABC The *maximum carrier output power per TAB connector*

Pmax,c**,**TRP*Maximum carrier TRP output power* measuredat the RIB(s), and corresponding to the declared *rated carrier TRP output power* (Prated,c,TRP)

Pmax,c,EIRP The maximum carrier EIRPwhen the SAN is configured at the maximum rated carrier output TRP (Prated,c,TRP)

Prated,c,AC The *rated carrier output power per antenna connector*

Prated,c,sys The sum of Prated,c,TABC for all *TAB connectors* for a single carrier

Prated,c,TABC The *rated carrier output power per TAB connector*

Prated,c,TRP *Rated carrier TRP output power* declaredper RIB

Prated,t,AC The *rated total output power* declared at the *antenna connector*

Prated,t,TABC The *rated total output power* declared at *TAB connector*

Prated,t,TRP *Rated total TRP output power* declaredper RIB

PREFSENS Conducted Reference Sensitivity power level

SSREF SS block reference frequency position

## 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 Active Antenna System

ACLR Adjacent Channel Leakage Ratio

ACS Adjacent Channel Selectivity

AoA Angle of Arrival

AWGN Additive White Gaussian Noise

BW Bandwidth

CA Carrier Aggregation

CACLR Cumulative ACLR

CPE Common Phase Error

CP-OFDM Cyclic Prefix-OFDM

CW Continuous Wave

DFT-s-OFDM Discrete Fourier Transform-spread-OFDM

DM-RS Demodulation Reference Signal

EIRP Effective Isotropic Radiated Power

EIS Equivalent Isotropic Sensitivity

EVM Error Vector Magnitude

FR Frequency Range

FRC Fixed Reference Channel

GEO Geostationary Earth Orbiting

GSCN Global Synchronization Channel Number

ICS In-Channel Selectivity

LEO Low Earth Orbiting

MCS Modulation and Coding Scheme

NR New Radio

NR-ARFCN NR Absolute Radio Frequency Channel Number

OBUE Operating Band Unwanted Emissions

OOB Out-of-band

OSDD OTA Sensitivity Directions Declaration

OTA Over-The-Air

PRB Physical Resource Block

PT-RS Phase Tracking Reference Signal

QAM Quadrature Amplitude Modulation

RB Resource Block

RDN Radio Distribution Network

RE Resource Element

REFSENS Reference Sensitivity

RF Radio Frequency

RIB Radiated Interface Boundary

RMS Root Mean Square (value)

RoAoA Range of Angles of Arrival

RX Receiver

SAN Satellite Access Node

SCS Sub-Carrier Spacing

SSB Synchronization Signal Block

TAB Transceiver Array Boundary

TAE Time Alignment Error

TRP Total Radiated Power

TX Transmitter

UCI Uplink Control Information

# 4 General

## 4.1 Relationship with other core specifications

The present document is a single-RAT specification for a SAN, covering RF characteristics and minimum performance requirements. Conducted and radiated core requirements are defined for the SAN architectures and SAN types defined in clause 4.3.

The applicability of each requirement is described in clause 4.6.

## 4.2 Relationship between minimum requirements and test requirements

Conformance to the present specification is demonstrated by fulfilling the test requirements specified in the conformance specification TS 38.181 [2].

The minimum requirements given in this specification make no allowance for measurement uncertainty. The test specifications TS 38.181 [2] define test tolerances. These test tolerances are individually calculated for each test. The test tolerances are used to relax the minimum requirements in this specification to create test requirements. For some requirements, including regulatory requirements, the test tolerance is set to zero.

The measurement results returned by the test system are compared - without any modification - against the test requirements as defined by the shared risk principle.

The shared risk principle is defined in recommendation ITU‑R M.1545 [3].

## 4.3 Requirement reference points

### 4.3.1 SAN type 1-H

For *SAN type 1-H*, the requirements are defined for two points of reference, signified by radiated requirements and conducted requirements.



Figure 4.3.1-1: Radiated and conducted reference points for *SAN type 1-H*

Radiated characteristics are defined over the air (OTA), where the radiated interface is referred to as the *Radiated Interface Boundary* (RIB). Radiated requirements are also referred to as OTA requirements. The (spatial) characteristics in which the OTA requirements apply are detailed for each requirement.

Conducted characteristics are defined at individual or groups of *TAB connectors* at the *transceiver array boundary*, which is the conducted interface between the transceiver unit array and the composite antenna.

The transceiver unit array is part of the composite transceiver functionality receiving and transmitting modulated signal to ensure radio links with ground base stations and users.

The satellite payload is composed by a transceiver unit array and a composite antenna array. The transceiver unit array contains an implementation specific number of transmitter units and an implementation specific number of receiver units.

The composite antenna contains a radio distribution network (RDN) and an antenna array. The RDN is a linear passive network which distributes the RF power generated by the transceiver unit array to the antenna array, and/or distributes the radio signals collected by the antenna array to the transceiver unit array, in an implementation specific way.

How a conducted requirement is applied to the *transceiver array boundary* is detailed in the respective requirement clause.

### 4.3.2 SAN type 1-O

For *SAN type 1-O*, the radiated characteristics are defined over the air (OTA), where the *operating band* specific radiated interface is referred to as the *Radiated Interface Boundary* (RIB). Radiated requirements are also referred to as OTA requirements. The (spatial) characteristics in which the OTA requirements apply are detailed for each requirement.



Figure 4.3.2-1: Radiated reference points for *SAN type 1-O*

Co-location requirements are specified at the conducted interface of the *co-location reference antenna*, the c*o-location reference antenna* does not form part of the BS under test but is a means to provide OTA power levels which are representative of a co-located system, further defined in clause 4.9. For a *SAN type 1-O* the transceiver unit array must contain at least 8 transmitter units and at least 8 receiver units. Transmitter units and receiver units may be combined into transceiver units. The transmitter/receiver units have the ability to transmit/receive parallel independent modulated symbol streams.

## 4.4 Satellite Access Node classes

The requirements in this specification apply to Satellite Access Node unless otherwise stated. The associated deployment scenarios are exactly the same for SAN with and without connectors.

For SAN *type 1-O* and *SAN type* 1-H, two SAN classes (LEO and GEO) are currently defined in Table 4.4-1.

Table 4.4-1 SAN classes

|  |  |
| --- | --- |
| SAN Class | Satellite Constellation |
| GEO class | GEO satellite |
| LEO class | LEO 600 km satelliteLEO 1200 km satellite |

## 4.5 Regional requirements

Some requirements in the present document 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.

Table 4.5-1 lists all requirements in the present specification that may be applied differently in different regions.

**Table 4.5-1: List of regional requirements**

| Clause number | Requirement | Comments |
| --- | --- | --- |
| 5.2 | *Operating bands* | NTN-NR *operating bands* may be applied regionally. |
| 6.6.4,9.7 | Operating band unwanted emission,OTA unwanted emissions | For n255 operation in US, Limits in FCC Title 47 apply. |
| 6.6.5 | Tx spurious emissions,OTA Tx spurious emissions | For n255 operation in US, Limits in FCC Title 47 apply. |

## 4.6 Applicability of minimum requirements

In table 4.6-1, the requirement applicability for each *requirement set* is defined. For each requirement, the applicable requirement clause in the specification is identified. Requirements not included in a *requirement set* is marked not applicable (NA).

Table 4.6-1: Requirement set applicability

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

# 5 Operating bands and channel arrangement

## 5.1 General

The channel arrangements presented in this clause are based on the *operating bands* and *SAN channel bandwidths* defined in the present release of specifications.

NOTE: Other *operating bands* and *SAN channel bandwidth*s may be considered in future releases.

Requirements throughout the RF specifications are in many cases defined separately for different frequency ranges (FR). The frequency ranges in which NTN satellite can operate according to the present version of the specification are identified as described in table 5.1-1.

Table 5.1-1: Definition of frequency ranges

|  |  |
| --- | --- |
| Frequency range designation | Corresponding frequency range  |
| FR1 | 410 MHz – 7125 MHz |

## 5.2 Operating bands

NTN satellite is designed to operate in the *operating bands* defined in table 5.2-1.

Table 5.2-1: NTN satellite *operating bands* in FR1

|  |  |  |  |
| --- | --- | --- | --- |
| NTN satellite *operating band* | Uplink (UL) *operating band*SAN receive / UE transmitFUL,low – FUL,high | Downlink (DL) *operating band*SAN transmit / UE receiveFDL,low – FDL,high | Duplex mode |
| n256 | 1980MHz – 2010 MHz | 2170 MHz – 2200 MHz | FDD |
| n255 | 1626.5 MHz – 1660.5 MHz | 1525 MHz – 1559 MHz | FDD |
| NOTE 1: NTN satellite bands are numbered in descending order from n256. |

## 5.3 Satellite Access Node channel bandwidth

### 5.3.1 General

The *SAN channel bandwidth* supports a single RF carrier in the uplink or downlink at the SAN. Different UE channel bandwidths may be supported within the same spectrum for transmitting to and receiving from UEs connected to the SAN. The placement of the UE channel bandwidth is flexible but can only be completely within the *SAN channel bandwidth*. The SAN shall be able to transmit to and/or receive from one or more UE bandwidth parts that are smaller than or equal to the number of carrier resource blocks on the RF carrier, in any part of the carrier resource blocks.

The relationship between the channel bandwidth, the guard band and the *transmission bandwidth configuration* is shown in figure 5.3.1-1.

.

Figure 5.3.1-1: Definition of channel bandwidth and *transmission bandwidth configuration* for one channel

### 5.3.2 Transmission bandwidth configuration

The *transmission bandwidth configuration* NRB for each *SAN channel bandwidth* and subcarrier spacing is specified in table 5.3.2.-1 for FR1.

Table 5.3.2-1: Transmission bandwidth configuration NRB for FR1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SCS (kHz) | 5 MHz | 10 MHz | 15 MHz | 20 MHz |
| NRB | NRB | NRB | NRB |
| 15 | 25 | 52 | 79 | 106 |
| 30 | 11 | 24 | 38 | 51 |
| 60 | N/A | 11 | 18 | 24 |

NOTE: All Tx and Rx requirements are defined based on *transmission bandwidth configuration* specified in table 5.3.2-1 for FR1.

### 5.3.3 Minimum guardband and transmission bandwidth configuration

The minimum guard band for each *SAN channel bandwidth* and SCS is specified in table 5.3.3-1 for FR1.

Table 5.3.3-1: Minimum guard band (kHz) (FR1)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SCS (kHz) | 5 MHz | 10 MHz | 15 MHz | 20 MHz |
| 15 | 242.5 | 312.5 | 382.5 | 452.5 |
| 30 | 505 | 665 | 645 | 805 |
| 60 | N/A | 1010 | 990 | 1330 |

The number of RBs configured in any *SAN channel bandwidth* shall ensure that the minimum guard band specified in this clause is met.



Figure 5.3.3-1: SAN PRB utilization

In the case that multiple numerologies are multiplexed in the same symbol, the minimum guard band on each side of the carrier is the guard band applied at the configured *SAN channel bandwidth* for the numerology that is transmitted/received immediately adjacent to the guard band.



Figure 5.3.3-2: Guard band definition when transmitting multiple numerologies

NOTE: Figure 5.3.3-2 is not intended to imply the size of any guard between the two numerologies. Inter-numerology guard band within the carrier is implementation dependent.

### 5.3.4 RB alignment

For each *SAN channel bandwidth* and each numerology, *SAN transmission bandwidth configuration* must fulfil the minimum guard band requirement specified in clause 5.3.3.

For each numerology, its common resource blocks are specified in clause 4.4.4.3 in [9], and the starting point of its *transmission bandwidth configuration* on the common resource block grid for a given channel bandwidth is indicated by an offset to “Reference point A” in the unit of the numerology.

For each numerology, all *UE transmission bandwidth configurations* indicated to UEs served by the SAN by higher layer parameter *carrierBandwidth* defined in TS 38.331 [11] shall fall within the *SAN transmission bandwidth configuration*.

### 5.3.5 SAN channel bandwidth per operating band

The requirements in this specification apply to the combination of *SAN channel bandwidths*, SCS and *operating bands* shown in table 5.3.5-1 for FR1. The *transmission bandwidth configuration* in table 5.3.2-1 shall be supported for each of the *SAN channel bandwidths* within the SAN capability. The *SAN channel bandwidths* are specified for both the Tx and Rx path.

Table 5.3.5-1: *SAN channel bandwidths* and SCS per *operating band* in FR1

| SAN Operating Band | SCS (kHz) | *SAN channel bandwidth* (MHz) |
| --- | --- | --- |
| 5 | 10 | 15 | 20 |
|  | 15 | 5 | 10 | 15 | 20 |
| n256 | 30 |  | 10 | 15 | 20 |
|  | 60 |  | 10 | 15 | 20 |
|  | 15 | 5 | 10 | 15 | 20 |
| n255 | 30 |  | 10 | 15 | 20 |
|  | 60 |  | 10 | 15 | 20 |

## 5.4 Channel arrangement

### 5.4.1 Channel spacing

### 5.4.1.1 Channel spacing for adjacent carriers

The spacing between carriers will depend on the deployment scenario, the size of the frequency block available and the *SAN channel bandwidths*. The nominal channel spacing between two adjacent SAN carriers is defined as following:

- For SAN FR1 *operating bands* with 100 kHz channel raster,

▪ Nominal Channel spacing = (BWChannel(1) + BWChannel(2))/2

where BWChannel(1) and BWChannel(2) are the *SAN channel bandwidths* of the two respective SAN carriers. The channel spacing can be adjusted depending on the channel raster to optimize performance in a particular deployment scenario.

### 5.4.2 Channel raster

### 5.4.2.1 NR-ARFCN and channel raster

The global frequency raster defines a set of *RF reference frequencies* FREF. The *RF reference frequency* is used in signalling to identify the position of RF channels, SS blocks and other elements. The global frequency raster is defined for all frequencies from 0 to 100 GHz. The granularity of the global frequency raster is ΔFGlobal.

*RF reference frequencies* are designated by an NR Absolute Radio Frequency Channel Number (NR-ARFCN) in the range [0…3279165] on the global frequency raster. The relation between the NR-ARFCN and the *RF reference frequency* FREF in MHz is given by the following equation, where FREF-Offs and NRef-Offs are given in table 5.4.2.1-1 and NREF is the NR-ARFCN.

 FREF = FREF-Offs + ΔFGlobal (NREF – NREF-Offs)

Table 5.4.2.1-1: NR-ARFCN parameters for the global frequency raster

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Range of frequencies (MHz) | ΔFGlobal (kHz) | FREF-Offs (MHz) | NREF-Offs | Range of NREF |
| 0 – 3000 | 5 | 0 | 0 | 0 – 599999 |

The *channel raster* defines a subset of *RF reference frequencies* that can be used to identify the RF channel position in the uplink and downlink. The *RF reference frequency* for an RF channel maps to a resource element on the carrier. For each *operating band*, a subset of frequencies from the global frequency raster are applicable for that band and forms a channel raster with a granularity ΔFRaster, which may be equal to or larger than ΔFGlobal.

The mapping between the *channel raster* and corresponding resource element is given in clause 5.4.2.2. The applicable entries for each *operating band* are defined in clause 5.4.2.3.

#### 5.4.2.2 Channel raster to resource element mapping

The mapping between the *RF reference frequency* on the channel raster and the corresponding resource element is given in table 5.4.2.2-1 and can be used to identify the RF channel position. The mapping depends on the total number of RBs that are allocated in the channel and applies to both UL and DL. The mapping must apply to at least one numerology supported by the SAN.

Table 5.4.2.2-1: Channel Raster to Resource Element Mapping

|  |  |  |
| --- | --- | --- |
|  |  |  |
| Resource element index  | 0 | 6 |
| Physical resource block number  |  |  |

k,  and NRB are as defined in TS 38.211 [9].

#### 5.4.2.3 Channel raster entries for each *operating band*

The RF channel positions on the channel raster in each SAN *operating band* are given through the applicable NR-ARFCN in table 5.4.2.3-1 for FR1, using the channel raster to resource element mapping in clause 5.4.2.2.

- For SAN *operating bands* with 100 kHz channel raster, ΔFRaster = 20 × ΔFGlobal. In this case, every 20th NR-ARFCN within the *operating band* are applicable for the channel raster within the *operating band* and the step size for the channel raster in table 5.4.2.3-1 is given as <20>.

Table 5.4.2.3-1: Applicable NR-ARFCN per *operating band* in FR1

|  |  |  |  |
| --- | --- | --- | --- |
| SAN *operating band* | ΔFRaster(kHz)  | Uplinkrange of NREF(First – <Step size> – Last) | Downlinkrange of NREF(First – <Step size> – Last) |
| n256 | 100 | 396000 – <20> – 402000 | 434000 – <20> – 440000 |
| n255 | 100 | 325300 – <20> – 332100 | 305000 – <20> – 311800 |

### 5.4.3 Synchronization raster

#### 5.4.3.1 Synchronization raster and numbering

The synchronization raster indicates the frequency positions of the synchronization block that can be used by the UE for system acquisition when explicit signalling of the synchronization block position is not present.

A global synchronization raster is defined for all frequencies. The frequency position of the SS block is defined as SSREF with corresponding number GSCN. The parameters defining the SSREF and GSCN for all the frequency ranges are in table 5.4.3.1-1.

The resource element corresponding to the SS block reference frequency SSREF is given in clause 5.4.3.2. The synchronization raster and the subcarrier spacing of the synchronization block are defined separately for each band.

Table 5.4.3.1-1: GSCN parameters for the global frequency raster

|  |  |  |  |
| --- | --- | --- | --- |
| Range of frequencies (MHz) | SS block frequency position SSREF | GSCN | Range of GSCN |
| 0 – 3000 | N \* 1200 kHz + M \* 50 kHz,N = 1:2499, M ϵ {1,3,5} (Note) | 3N + (M-3)/2 | 2 – 7498 |
| NOTE: The default value for *operating bands* which only support SCS spaced channel raster(s) is M=3. |

5.4.3.2 Synchronization raster to synchronization block resource element mapping

The mapping between the synchronization raster and the corresponding resource element of the SS block is given in table 5.4.3.2-1.

**Table 5.4.3.2-1: Synchronization Raster to SS block Resource Element Mapping**

|  |  |
| --- | --- |
| Resource element index k | 120 |

*k* is the subcarrier number of SS/PBCH block defined in TS 38.211 clause 7.4.3.1 [9].

#### 5.4.3.3 Synchronization raster entries for each operating band

The synchronization raster for each band is given in table 5.4.3.3-1. The distance between applicable GSCN entries is given by the <Step size> indicated in table 5.4.3.3-1 for FR1.

Table 5.4.3.3-1: Applicable SS raster entries per *operating band* (FR1)

|  |  |  |  |
| --- | --- | --- | --- |
| SAN *operating band* | SS Block SCS | SS Block pattern(NOTE 1) | Range of GSCN(First – <Step size> – Last) |
| n256 | 15 kHz | Case A | 5429 – <1> – 5494 |
| n255 | 15 kHz | Case A | 3818 – <1> – 3892 |
| 30 kHz | Case B | 3824 – <1> – 3886 |
| NOTE 1: SS Block pattern is defined in clause 4.1 in TS 38.213 [10]. |

# 6 Conducted transmitter characteristics

## 6.1 General

<Text will be added.>

## 6.2 Satellite Access Node output power

### 6.2.1 General

The SAN conducted output power requirement applies at *TAB connector* for *SAN type 1-H*.

The *rated carrier output power* of the *SAN type 1-H* shall be as specified in table 6.2.1-2.

**Table 6.2.1-2: *SAN type 1-H* rated output power limits for SAN classes**

| **SAN class** | **Prated,c,sys** | **Prated,c,TABC** |
| --- | --- | --- |
| SAN GEO class | (Note) | (Note) |
| SAN LEO class | (Note) | (Note) |
| NOTE: Prated,c,sys or Prated,c,TABC of SAN shall be based on manufacture declaration and comply with regulation requirement. |

### 6.2.2 Minimum requirement for *SAN type 1-H*

In normal conditions, Pmax,c,TABC shall remain within +2 dB and -2 dB of the *rated carrier output power* Prated,c,TABC for each *TAB connector* as declared by the manufacturer.

In extreme conditions, Pmax,c,TABC shall remain within +2.5 dB and -2.5 dB of the *rated carrier output power* Prated,c,TABC for each *TAB connector* as declared by the manufacturer.

## 6.3 Output power dynamics

### 6.3.1 General

Transmitted signal quality (as specified in clause 6.5) shall be maintained for the output power dynamics requirements of this clause.

Power control is used to limit the interference level.

### 6.3.2 RE power control dynamic range

#### 6.3.2.1 General

The RE power control dynamic range is the difference between the power of an RE and the average RE power for a SAN at maximum output power (Pmax,c,TABC) for a specified reference condition.

For *SAN type 1-H* this requirement shall apply at each *TAB connector* supporting transmission in the *operating band*.

#### 6.3.2.2 Minimum requirement for *SAN type 1-H*

RE power control dynamic range:

Table 6.3.2.2-1: RE power control dynamic range

|  |  |
| --- | --- |
| Modulation scheme used | RE power control dynamic range (dB) |
| on the RE | (down) | (up) |
| QPSK (PDCCH) | -6 | +4 |
| QPSK (PDSCH) | -6 | +3 |
| 16QAM (PDSCH) | -3 | +3 |
| 64QAM (PDSCH) | 0 | 0 |
| NOTE: The output power per carrier shall always be less or equal to the maximum output power of the satellite access node. |

### 6.3.3 Total power dynamic range

#### 6.3.3.1 General

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

For *SAN type 1-H* this requirement shall apply at each *TAB connector* supporting transmission in the *operating band*.

NOTE 1: The upper limit of the dynamic range is the OFDM symbol power for a SAN when transmitting on all RBs at maximum output power. The lower limit of the total power dynamic range is the average power for single RB transmission. The OFDM symbol shall carry PDSCH and not contain RS or SSB.

#### 6.3.3.2 Minimum requirement for *SAN type 1-H*

The downlink (DL) total power dynamic range for each SAN carrier shall be larger than or equal to the level in table 6.3.3.2-1.

Table 6.3.3.2-1: Total power dynamic range

|  |  |
| --- | --- |
| *SAN channel*  | Total power dynamic range (dB) |
| *bandwidth* (MHz) | 15 kHz SCS | 30 kHz SCS | 60 kHz SCS |
| 5 | 13.9 | 10.4 | N/A |
| 10 | 17.1 | 13.8 | 10.4 |
| 15 | 18.9 | 15.7 | 12.5 |
| 20 | 20.2 | 17 | 13.8 |

## 6.4 Transmit ON/OFF power

The requirement is not applicable in Release-17.

This requirement is not needed for Satellite Access Node due to FDD operation.

## 6.5 Transmitted signal quality

### 6.5.1 Frequency error

#### 6.5.1.1 General

Frequency error is the measure of the difference between the actual SAN transmit frequency and the assigned frequency. The same source shall be used for RF frequency and data clock generation.

For *SAN type 1-H* this requirement shall be applied at each *TAB connector* supporting transmission in the *operating band.*

#### 6.5.1.2 Minimum requirement for *SAN type 1-H*

The modulated carrier frequency of each carrier configured by the SAN shall be accurate to within 0.05 ppm observed over 1 ms.

### 6.5.2 Modulation quality

#### 6.5.2.1 General

Modulation quality is defined by the difference between the measured carrier signal and an ideal signal. Modulation quality can e.g. be expressed as Error Vector Magnitude (EVM). The Error Vector Magnitude is a measure of the difference between the ideal symbols and the measured symbols after the equalization. This difference is called the error vector. Details about how the EVM is determined are specified in Annex B.

For *SAN type 1-H* this requirement shall be applied at each *TAB connector* supporting transmission in the *operating band.*

#### 6.5.2.2 Minimum Requirement for *SAN type 1-H*

The EVM levels of each carrier for different modulation schemes on PDSCH outlined in table 6.5.2.2-1 shall be met using the frame structure described in clause 6.5.2.3.

Table 6.5.2.2-1: EVM requirements for *SAN type 1-H* carrier

|  |  |
| --- | --- |
| Modulation scheme for PDSCH | Required EVM |
| QPSK | 17.5 % |
| 16QAM | 12.5 % |
| 64QAM (NOTE) | 8 % |
| NOTE: EVM requirement for 64QAM is optional. |

####

#### 6.5.2.3 EVM frame structure for measurement

EVM shall be evaluated for each carrier over all allocated resource blocks and downlink subframes. Different modulation schemes listed in table 6.5.2.2-1 shall be considered for rank 1.

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

### 6.5.3 Time alignment error

The requirement is not applicable in this version of the specification.

## 6.6 Unwanted emissions

### 6.6.1 General

<Text will be added.>

### 6.6.2 Occupied bandwidth

#### 6.6.2.1 General

<Text will be added.>

#### 6.6.2.2 Minimum requirement for Satellite Access Node

<Text will be added.>

### 6.6.3 Adjacent Channel Leakage Power Ratio

#### 6.6.3.1 General

<Text will be added.>

### 6.6.4 Operating band unwanted emissions

#### 6.6.4.1 General

<Text will be added.>

### 6.6.5 Transmitter spurious emissions

#### 6.6.5.1 General

<Text will be added.>

#### 6.6.5.2 Basic Limits

<Text will be added.>

##### 6.6.5.2.1 General transmitter spurious emissions requirements

<Text will be added.>

##### 6.6.5.2.2 Protection of the own Satellite Access Node receiver

<Text will be added.>

The protection of the Satellite Access Node receiver of different Satellite Access Node is not needed.

##### 6.6.5.2.3 Additional spurious emissions requirements

<Text will be added.>

##### 6.6.5.2.4 Co-location with other Satellite Access Nodes

The requirement is not applicable in Release-17.

This requirement is not needed since there is no co-location scenario foreseen for satellite.

#### 6.6.5.3 Minimum requirement for Satellite Access Node

<Text will be added.>

## 6.7 Transmitter intermodulation

The requirement is not applicable in this version of the specification.

# 7 Conducted receiver characteristics

## 7.1 General

Conducted receiver characteristics are specified at the *TAB connector* for *SAN type 1-H*, with full complement of transceivers for the configuration in normal operating condition.

Unless otherwise stated, the following arrangements apply for conducted receiver characteristics requirements in clause 7:

- Requirements shall be met for any transmitter setting.

- The requirements shall be met with the transmitter unit(s) ON.

- Throughput requirements do not assume HARQ retransmissions.

- When SAN is configured to receive multiple carriers, all the throughput requirements are applicable for each received carrier.

- For ACS, blocking and intermodulation characteristics, the negative offsets of the interfering signal apply relative to the lower *SAN RF Bandwidth* edge or *sub-block* edge inside a *sub-block gap*, and the positive offsets of the interfering signal apply relative to the upper *SAN RF Bandwidth* edge or *sub-block* edge inside a *sub-block gap*.

NOTE 1: In normal operating condition the SAN is configured to transmit and receive at the same time.

## 7.2 Reference sensitivity level

### 7.2.1 General

The reference sensitivity power level PREFSENS is the minimum mean power received at the TAB connector for SAN type 1-H at which a throughput requirement shall be met for a specified reference measurement channel.

### 7.2.2 Minimum requirements for Satellite Access Node

The throughput shall be ≥ 95% of the maximum throughput of the reference measurement channel as specified in annex A.1 with parameters specified in table 7.2.2-1 and 7.2.2-2 for SAN type 1-H in all operating band in FR1.

Table 7.2.2-1: SAN reference sensitivity levels (GEO class payload)

|  |  |  |  |
| --- | --- | --- | --- |
| *SAN channel bandwidth (MHz)* | *Sub-carrier spacing (kHz)* | *Reference measurement channel* | *Reference sensitivity power level, PREFSENS* *(dBm)* |
| 5, 10, 15  | 15 | G-FR1-A1-1 (Note 1) |  -99.3  |
| 10, 15  | 30 | G-FR1-A1-2 (Note 1) |  -99.4  |
| 10, 15 | 60 | G-FR1-A1-3 (Note 1) |  -96.5  |
| 20  | 15 | G-FR1-A1-4 (Note 1) |  -92.9  |
| 20  | 30 | G-FR1-A1-5 (Note 1) |  -93.2  |
| 20  | 60 | G-FR1-A1-6 (Note 1) |  -93.3  |
| NOTE 1: PREFSENS is the power level of a single instance of the reference measurement channel. This requirement shall be met for each consecutive application of a single instance of the reference measurement channel mapped to disjoint frequency ranges with a width corresponding to the number of resource blocks of the reference measurement channel each, except for one instance that might overlap one other instance to cover the full *SAN channel bandwidth*. |

Table 7.2.2-2: SAN reference sensitivity levels (LEO class payload)

|  |  |  |  |
| --- | --- | --- | --- |
| *SAN channel bandwidth (MHz)* | *Sub-carrier spacing (kHz)* | *Reference measurement channel* | *Reference sensitivity power level, PREFSENS* *(dBm)* |
| 5, 10, 15  | 15 | G-FR1-A1-1 (Note 1) |  -102.4  |
| 10, 15  | 30 | G-FR1-A1-2 (Note 1) |  -102.5  |
| 10, 15 | 60 | G-FR1-A1-3 (Note 1) |  -99.6 |
| 20  | 15 | G-FR1-A1-4 (Note 1) |  -96.0 |
| 20  | 30 | G-FR1-A1-5 (Note 1) |  -96.3  |
| 20  | 60 | G-FR1-A1-6 (Note 1) |  -96.4  |
| NOTE 1: PREFSENS is the power level of a single instance of the reference measurement channel. This requirement shall be met for each consecutive application of a single instance of the reference measurement channel mapped to disjoint frequency ranges with a width corresponding to the number of resource blocks of the reference measurement channel each, except for one instance that might overlap one other instance to cover the full *SAN channel bandwidth*. |

## 7.3 Dynamic range

### 7.3.1 General

The 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 at the TAB connector for SAN type 1-H inside the received SAN channel bandwidth. In this condition, a throughput requirement shall be met for a specified reference measurement channel. The interfering signal for the dynamic range requirement is an AWGN signal.

### 7.3.2 Minimum requirements for Satellite Access Node

The throughput shall be ≥ 95% of the maximum throughput of the reference measurement channel as specified in annex A.2 with parameters specified in table 7.3.2-1 for LEO.

Table 7.3.2-1: LEO SAN class dynamic range

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *SAN channel bandwidth* (MHz) | Subcarrier spacing (kHz) | Reference measurement channel | Wanted signal mean power (dBm) | Interfering signal mean power (dBm) / BWConfig | Type of interfering signal |
| 5 | 15 | G-FR1-A2-1 | -76.4  | -88.2  | AWGN |
|  | 30 | G-FR1-A2-2  | -77.1  |  |  |
| 10 | 15 | G-FR1-A2-1 | -76.4  | -85.0  | AWGN |
|  | 30 | G-FR1-A2-2  | -77.1  |  |  |
|  | 60 | G-FR1-A2-3  | -74.1  |  |  |
| 15 | 15 | G-FR1-A2-1 | -76.4  | -83.2  | AWGN |
|  | 30 | G-FR1-A2-2  | -77.1  |  |  |
|  | 60 | G-FR1-A2-3 | -74.1  |  |  |
| 20 | 15 | G-FR1-A2-4 | -70.2  | -81.9  | AWGN |
|  | 30 | G-FR1-A2-5 | -70.2  |  |  |
|  | 60 | G-FR1-A2-6 | -70.5  |  |  |
| NOTE: The wanted signal mean power is the power level of a single instance of the corresponding reference measurement channel. This requirement shall be met for each consecutive application of a single instance of the reference measurement channel mapped to disjoint frequency ranges with a width corresponding to the number of resource blocks of the reference measurement channel each, except for one instance that might overlap one other instance to cover the full *SAN channel bandwidth*. |

## 7.4 In-band selectivity and blocking

### 7.4.1 Adjacent Channel Selectivity (ACS)

#### 7.4.1.1 General

Adjacent channel selectivity (ACS) is a measure of the receiver's ability to receive a wanted signal at its assigned channel frequency at *TAB connector* for *SAN type 1-H* in the presence of an adjacent channel signal with a specified center frequency offset of the interfering signal to the band edge of a victim system.

#### 7.4.1.2 Minimum requirements for Satellite Access Node

The throughput shall be ≥ 95% of the maximum throughput of the reference measurement channel.

For SAN, the wanted and the interfering signal coupled to the *SAN type 1-H* *TAB connector* are specified in table 7.4.1.2-1 and the frequency offset between the wanted and interfering signal in table 7.4.1.2-2 for ACS. The reference measurement channel for the wanted signal is identified in table 7.2.2-1, 7.2.2-2 and 7.2.2-3 for each *SAN channel bandwidth* in any operating band and further specified in annex A.1. The characteristics of the interfering signal is further specified in annex D.

The ACS requirement is applicable outside the *SAN RF Bandwidth* or *Radio Bandwidth*. The interfering signal offset is defined relative to the *SAN RF Bandwidth* edges or *Radio Bandwidth* edges.

Minimum conducted requirement is defined at the *TAB connector* for *SAN type 1-H.*

Table 7.4.1.2-1: Satellite Access Node ACS requirement

|  |  |  |
| --- | --- | --- |
| *SAN channel bandwidth* of the lowest/*highest carrier* received (MHz) | Wanted signal mean power (dBm) | Interfering signal mean power (dBm) |
| 5, 10, 15, 20 (Note 1) | PREFSENS + 6 dB | GEO SAN class: -57LEO SAN class: -60 |
| NOTE 1: The SCS for the lowest/highest carrier received is the lowest SCS supported by the SAN for that bandwidth.NOTE 2: PREFSENS depends on the *SAN channel bandwidth* as specified in table 7.2.2-1.  |

Table 7.4.1.2-2: Satellite Access Node ACS interferer frequency offset values

|  |  |  |
| --- | --- | --- |
| *SAN channel bandwidth* of the *lowest/highest carrier* received (MHz) | Interfering signal center frequency offset from the lower/upper *SAN RF Bandwidth edge* (MHz) | Type of interfering signal |
| 5 | ±2.5025 |  |
| 10 | ±2.5075 | 5 MHz [DFT-s-OFDM] NR signal |
| 15 | ±2.5125 | 15 kHz SCS, 25 RBs |
| 20 | ±2.5025 |  |

### 7.4.2 In-band blocking

#### 7.4.2.1 General

The in-band blocking characteristics is a measure of the receiver's ability to receive a wanted signal at its assigned channel at the *TAB connector* for *SAN type 1-H* in the presence of an unwanted interferer, which is an NR signal for general blocking or an NR signal with one resource block for narrowband blocking.

#### 7.4.2.2 Minimum requirements for Satellite Access Node

In-band blocking requirement is not applicable for SAN.

## 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 at the *TAB connector* for *SAN type 1-H* in the presence of an unwanted interferer out of the *operating band*, which is a CW signal for out-of-band blocking.

### 7.5.2 Minimum requirements for Satellite Access Node

The throughput shall be ≥ 95% of the maximum throughput of the reference measurement channel, with a wanted and an interfering signal coupled to *SAN type 1-H* *TAB connector* using the parameters in table 7.5.2-1.

The reference measurement channel for the wanted signal is identified in clause 7.2.2 for each *SAN channel bandwidth* and further specified in annex A.1.

The out-of-band blocking requirement apply from 1 MHz to FUL,low - ΔfOOB and from FUL,high + ΔfOOB up to 12750 MHz, including the downlink frequency range of the FDD *operating band* for SAN. The ΔfOOB for *BS type 1-H* is defined in table [7.4.2.2-0].

Minimum conducted requirement is defined at the *antenna connector* at the *TAB connector* for *SAN type 1-H.*

**Table 7.5.2-1: Out-of-band blocking requirement for NR**

|  |  |  |
| --- | --- | --- |
| **Wanted Signal mean power (dBm)** | **Interfering Signal mean power (dBm)** | **Type of Interfering Signal** |
| PREFSENS +6 dB(Note) | -44  | CW carrier |
| NOTE 1: For SAN, PREFSENS depends on the *SAN channel bandwidth*.  |

## 7.6 Receiver spurious emissions

### 7.6.1 General

The receiver spurious emissions power is the power of emissions generated or amplified in a receiver unit that appear at the *TAB connector* of the *SAN* *type 1-H*. The requirements apply to all SAN with separate RX and TX *TAB connectors*.

NOTE: In this case for FDD operation the test is performed when both TX and RX are ON, with the TX *TAB connectors* terminated.

### 7.6.2 Minimum requirement for *SAN type 1-H*

The receiver spurious emissions *basic limits* are provided in table 7.6.2-1.

Table 7.6.2-1: General SANreceiver spurious emissions limits

| Spurious frequency range | *Basic limits* | *Measurement bandwidth* | Note |
| --- | --- | --- | --- |
| 30 MHz – 1 GHz | -57 dBm | 100 kHz | Note 1 |
| 1 GHz – 12.75 GHz | -47 dBm | 1 MHz | Note 1, Note 2 |
| NOTE 1: *Measurement bandwidth*s as in ITU-R SM.329 [x], s4.1.NOTE 2: Upper frequency as in ITU-R SM.329 [x], s2.5 table 1.NOTE 3: The frequency range from ΔfOBUE below the lowest frequency of the SAN transmitter *operating band* to ΔfOBUE above the highest frequency of the SAN transmitter *operating band* may be excluded from the requirement. ΔfOBUE is defined in clause 6.6.1. |

## 7.7 Receiver intermodulation

The requirement is not applicable in this version of the specification.

## 7.8 In-channel selectivity

### 7.8.1 General

In-channel selectivity (ICS) is a measure of the receiver ability to receive a wanted signal at its assigned resource block locations at *TAB connector* for *SAN type 1-H* in the presence of an interfering signal received at a larger power spectral density. In this condition a throughput requirement shall be met for a specified reference measurement channel. The interfering signal shall be an NR signal which is time aligned with the wanted signal.

### 7.8.2 Minimum requirements for Satellite Access Node

For *SAN type* *1-H*, the throughput shall be ≥ 95% of the maximum throughput of the reference measurement channel as specified in annex A.1 with parameters specified in table 7.8.2-1 for GEO SAN, in table 7.8.2-2 for LEO SAN. The characteristics of the interfering signal is further specified in annex D.

Table 7.8.2-1: GEO class SAN ICS requirement

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *SAN channel bandwidth* (MHz) | Subcarrier spacing (kHz) | Reference measurement channel | Wanted signal mean power (dBm) | Interfering signal mean power (dBm) | Type of interfering signal |
| 5 | 15 | G-FR1-A1-7 | -98.2  | -92.0  | DFT-s-OFDM NR signal, 15 kHz SCS,10 RBs |
| 10,15,20 | 15 | G-FR1-A1-1 | -96.3  | -88.1  | DFT-s-OFDM NR signal, 15 kHz SCS,25 RBs |
| 5 | 30 | G-FR1-A1-8 | -98.9  | -92.0  | DFT-s-OFDM NR signal, 30 kHz SCS,5 RBs |
| 10,15,20 | 30 | G-FR1-A1-2 | -96.4  | -89.0  | DFT-s-OFDM NR signal, 30 kHz SCS,10 RBs |
| 10,15,20 | 60 | G-FR1-A1-9 | -95.8  | -89.0  | DFT-s-OFDM NR signal, 60 kHz SCS,5 RBs |
| NOTE: Wanted and interfering signal are placed adjacently around Fc, where the Fc is defined for *SAN channel bandwidth* ofthe wanted signalaccording to the table 5.4.2.2-1. The aggregated wanted and interferer signal shall be centred in the *SAN channel bandwidth* of the wanted signal. |

Table 7.8.2-2: LEO class SAN ICS requirement

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *SAN channel bandwidth* (MHz) | Subcarrier spacing (kHz) | Reference measurement channel | Wanted signal mean power (dBm) | Interfering signal mean power (dBm) | Type of interfering signal |
| 5 | 15 | G-FR1-A1-7 | -101.3  | -83.1  | DFT-s-OFDM NR signal, 15 kHz SCS,10 RBs |
| 10,15,20 | 15 | G-FR1-A1-1 | -99.4  | -79.2  | DFT-s-OFDM NR signal, 15 kHz SCS,25 RBs |
| 5 | 30 | G-FR1-A1-8 | -102.0  | -83.1  | DFT-s-OFDM NR signal, 30 kHz SCS,5 RBs |
| 10,15,20 | 30 | G-FR1-A1-2 | -99.5  | -80.1  | DFT-s-OFDM NR signal, 30 kHz SCS,10 RBs |
| 10,15,20 | 60 | G-FR1-A1-9 | -98.9  | -80.1  | DFT-s-OFDM NR signal, 60 kHz SCS,5 RBs |
| NOTE: Wanted and interfering signal are placed adjacently around Fc, where the Fc is defined for *SAN channel bandwidth* ofthe wanted signalaccording to the table 5.4.2.2-1. The aggregated wanted and interferer signal shall be centred in the *SAN channel bandwidth* of the wanted signal. |

# 8 Conducted performance requirements

## 8.1 General

<Text will be added.>

## 8.2 Performance requirements for PUSCH

<Text will be added.>

## 8.3 Performance requirements for PUCCH

<Text will be added.>

## 8.4 Performance requirements for PRACH

<Text will be added.>

# 9 Radiated transmitter characteristics

## 9.1 General

Radiated transmitter characteristics requirements apply on the *SAN type 1-H or* *SAN type 1-O* including all its functional components active and for all foreseen modes of operation of the SAN unless otherwise stated.

## 9.2 Radiated transmit power

### 9.2.1 General

*SAN type 1-H and SAN type 1-O* are declared to support one or more beams, as per manufacturer's declarations specified in TS 38.181 [2]. Radiated transmit power is defined as the EIRP level for a declared beam at a specific *beam peak direction*.

For each beam, the requirement is based on declaration of a beam identity, *reference beam direction pair*, beamwidth, *rated beam EIRP*, *OTA peak directions set*, the *beam direction pairs* at the maximum steering directions and their associated *rated beam EIRP* and beamwidth(s).

For a declared beam and *beam direction pair*, the *rated beam EIRP* level is the maximum power that the base station is declared to radiate at the associated *beam peak direction* during the *transmitter ON period*.

For each *beam peak direction* associated with a *beam direction pair* within the *OTA peak directions set*, a specific *rated beam EIRP* level may be claimed. Any claimed value shall be met within the accuracy requirement as described below. *Rated beam EIRP* is only required to be declared for the *beam direction pairs* subject to conformance testing as detailed in TS 38.181 [2].

NOTE 1: *OTA peak directions set* is set of *beam peak directions* for which the EIRP accuracy requirement is intended to be met. 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.

NOTE 2: A *beam direction pair* is data set consisting of the *beam centre direction* and the related *beam peak direction.*

NOTE 3: A declared EIRP value is a value provided by the manufacturer for verification according to the conformance specification declaration requirements, whereas a claimed EIRP value is provided by the manufacturer to the equipment user for normal operation of the equipment and is not subject to formal conformance testing.

 For *operating bands* where the supported *fractional bandwidth* (FBW) is larger than 6%, two rated carrier EIRP may be declared by manufacturer:

- Prated,c,FBWlow for lower supported frequency range, and

- Prated,c,FBWhigh for higher supported frequency range.

For frequencies in between FFBWlow and FFBWhigh the rated carrier EIRP is:

- Prated,c,FBWlow, for the carrier whose carrier frequency is within frequency range FFBWlow ≤ f < (FFBWlow +FFBWhigh) / 2,

- Prated,c,FBWhigh, for the carrier whose carrier frequency is within frequency range (FFBWlow +FFBWhigh) / 2 ≤ f ≤FFBWhigh.

### 9.2.2 Minimum requirement for *SAN type 1-H* and *SAN type 1-O*

For each declared beam, in normal conditions, for any specific *beam peak direction* associated with a *beam direction pair* within the *OTA peak directions set*, a manufacturer claimed EIRP level in the corresponding *beam peak direction* shall be achievable to within ±2.2 dB of the claimed value.

For *SAN type 1-O* only, for each declared beam, in extreme conditions, for any specific *beam peak direction* associated with a *beam direction pair* within the *OTA peak directions set*, a manufacturer claimed EIRP level in the corresponding *beam peak direction* shall be achievable to within ±2.7 dB of the claimed value.

Normal and extreme conditions are defined in TS 38.181, annex B [2].

In certain regions, the minimum requirement for normal conditions may apply also for some conditions outside the range of conditions defined as normal.

## 9.3 OTA Satellite Access Node output power

### 9.3.1 General

OTA SAN output power is declared as the TRP radiated requirement, with the output power accuracy requirement defined at the RIB. TRP does not change with beamforming settings as long as the *beam peak direction* is within the *OTA peak directions set*. Thus the TRP accuracy requirement must be met for any beamforming setting for which the *beam peak direction* is within the *OTA peak directions set*.

The SAN *rated carrier TRP output power* for *SAN type 1-O* shall be based on manufacturer declaration.

Despite the general requirements for the SAN output power described in clause 9.3.2, additional regional requirements might be applicable.

### 9.3.2 Minimum requirement for *SAN type 1-O*

In normal conditions, the *SAN type 1-O* *maximum carrier TRP output power*, Pmax,c,TRP measured at the RIB shall remain within ±2 dB of the *rated carrier TRP output power* Prated,c,TRP, as declared by the manufacturer.

Normal conditions are defined in TS38.181 [2].

## 9.4 OTA output power dynamics

### 9.4.1 General

Transmit signal quality (as specified in clause 9.6) shall be maintained for the output power dynamics requirements.

The OTA output power requirements are *directional requirements* and apply to the *beam peak directions* over the *OTA peak directions set*.

### 9.4.2 OTA RE power control dynamic range

#### 9.4.2.1 General

The OTA RE power control dynamic range is the difference between the power of an RE and the average RE power for a SAN at maximum output power (Pmax,c,EIRP) for a specified reference condition.

This requirement shall apply at each RIB supporting transmission in the *operating band*.

#### 9.4.2.2 Minimum requirement for *SAN type 1-O*

The OTA RE power control dynamic range is specified the same as the conducted RE power control dynamic range requirement for *SAN type 1-H* in table 6.3.2.2-1.

### 9.4.3 OTA total power dynamic range

#### 9.4.3.1 General

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

This requirement shall apply at each RIB supporting transmission in the *operating band*.

NOTE 1: The upper limit of the OTA total power dynamic range is the SAN maximum carrier EIRP (Pmax,c,EIRP) when transmitting on all RBs. The lower limit of the OTA total power dynamic range is the average EIRP for single RB transmission in the same direction using the same beam. The OFDM symbol carries PDSCH and not contain RS or SSB.

#### 9.4.3.2 Minimum requirement for *SAN type 1-O*

OTA total power dynamic range minimum requirement for SAN type 1-O is specified such as for each NR carrier it shall be larger than or equal to the levels specified for the conducted requirement for SAN type 1-H in table 6.3.3.2-1.

## 9.5 OTA transmit ON/OFF power

The requirement is not applicable in this version of the specification.

## 9.6 OTA transmitted signal quality

### 9.6.1 OTA frequency error

#### 9.6.1.1 General

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

OTA frequency error requirement is defined as a *directional requirement* at the RIB and shall be met within the *OTA coverage range*.

#### 9.6.1.2 Minimum requirement for *SAN type 1-O*

The modulated carrier frequency of each carrier configured by the SAN shall be accurate to within 0.05 ppm observed over 1 ms.

### 9.6.2 OTA modulation quality

#### 9.6.2.1 General

Modulation quality is defined by the difference between the measured carrier signal and an ideal signal. Modulation quality can e.g. be expressed as Error Vector Magnitude (EVM). Details about how the EVM is determined are specified in annex B for FR1.

OTA modulation quality requirement is defined as a *directional requirement* at the RIB and shall be met within the *OTA coverage range*.

#### 9.6.2.2 Minimum requirement for *SAN type 1-O*

For *SAN type 1-O*, the EVM levels of each carrier for different modulation schemes on PDSCH outlined in table 6.5.2.2-1 shall be met. Requirements shall be the same as clause 6.5.2.2 and follow EVM frame structure from clause 6.5.2.3.

### 9.6.3 OTA time alignment error

The requirement is not applicable in this version of the specification.

## 9.7 OTA unwanted emissions

### 9.7.1 General

Unwanted emissions consist of so-called out-of-band emissions and spurious emissions according to ITU definitions ITU-R SM.329 [2]. In ITU terminology, out of band emissions are unwanted emissions immediately outside the *SAN channel bandwidth* resulting from the modulation process and non-linearity in the transmitter but excluding spurious emissions. Spurious emissions are emissions which are caused by unwanted transmitter effects such as harmonics emission, parasitic emission, intermodulation products and frequency conversion products, but exclude out of band emissions.

The OTA out-of-band emissions requirement for the *SAN type 1-O* is specified both in terms of Adjacent Channel Leakage power Ratio (ACLR) and operating band unwanted emissions (OBUE). The OTA Operating band unwanted emissions define all unwanted emissions in each supported downlink *operating band* plus the frequency ranges ΔfOBUE above and ΔfOBUE below each band. OTA Unwanted emissions outside of this frequency range are limited by an OTA spurious emissions requirement.

The maximum offset of the operating band unwanted emissions mask from the *operating band* edge is ΔfOBUE. The value of ΔfOBUE is defined in table 9.7.1-1 for *SAN type 1-O* for the SAN *operating bands*.

Table 9.7.1-1: Maximum offset ΔfOBUE outside the downlink *operating band*

|  |  |  |
| --- | --- | --- |
| SAN type | *Operating band* characteristics | ΔfOBUE (MHz) |
| *SAN type 1-O* | FDL,high – FDL,low < 100 MHz | 10 |

The unwanted emission requirements are applied per cell for all the configurations. Requirements for OTA unwanted emissions are captured using TRP, *directional requirements* or co-location requirements as described per requirement.

There is in addition a requirement for occupied bandwidth.

### 9.7.2 OTA occupied bandwidth

#### 9.7.2.1 General

The OTA occupied bandwidth is the width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to a specified percentage /2 of the total mean transmitted power. See also recommendation ITU-R SM.328 [3].

The value of /2 shall be taken as 0.5%.

The minimum requirement below may be applied regionally. There may also be regional requirements to declare the OTA occupied bandwidth according to the definition in the present clause.

The OTA occupied bandwidth is defined as a *directional requirement* and shall be met in the manufacturer's declared *OTA coverage range* at the RIB.

#### 9.7.2.2 Minimum requirement for *SAN type 1-O*

The OTA occupied bandwidth for each carrier shall be less than the *SAN channel bandwidth*.

### 9.7.3 OTA Adjacent Channel Leakage Power Ratio (ACLR)

#### 9.7.3.1 General

OTA Adjacent Channel Leakage power Ratio (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. The measured power is TRP.

The requirement shall be applied per RIB.

#### 9.7.3.2 Minimum requirement for *SAN type 1-O*

The ACLR limit in table 6.6.3.2-1 or the ACLR absolute basic limits in table 6.6.3.2-2, whichever is less stringent, shall apply.

For a RIB operating in multi-carrier, the ACLR requirements in clause 6.6.3.2 shall apply to SAN channel bandwidths of the outermost carrier for the frequency ranges defined in table 6.6.3.2-1.

### 9.7.4 OTA operating band unwanted emissions

#### 9.7.4.1 General

The OTA limits for operating band unwanted emissions are specified as TRP per RIB unless otherwise stated.

#### 9.7.4.2 Minimum requirement for *SAN type 1-O*

Out-of-band emissions in FR1 are limited by OTA operating band unwanted emission limits. Unless otherwise stated, the operating band unwanted emission limits in FR1 are defined from ΔfOBUE below the lowest frequency of each supported downlink operating band up to ΔfOBUE above the highest frequency of each supported downlink operating band. The values of ΔfOBUE are defined in table 9.7.1-1 for the Satellite operating bands.

The requirements shall apply whatever the type of transmitter considered and for all transmission modes foreseen by the manufacturer's specification. For a RIB operating in multi-carrier, the requirements apply to SAN channel bandwidths of the outermost carrier for the frequency ranges defined in clause 6.6.4.1.

The OTA operating band unwanted emission requirement for SAN type 1-O shall not exceed each applicable limit in clause 6.6.4.2.

### 9.7.5 OTA transmitter spurious emissions

#### 9.7.5.1 General

Unless otherwise stated, all requirements are measured as mean power.

The OTA spurious emissions limits are specified as TRP per RIB unless otherwise stated.

#### 9.7.5.2 Minimum requirement for *SAN type 1-O*

##### 9.7.5.2.1 General

The OTA transmitter spurious emission limits for FR1 shall apply from 30 MHz to 12.75 GHz, excluding the frequency range from ΔfOBUE below the lowest frequency of each supported downlink *operating band*, up to ΔfOBUE above the highest frequency of each supported downlink *operating band*, where the ΔfOBUE is defined in table 9.7.1-1.

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.

*SAN type 1-O* requirement consists of OTA transmitter spurious emission requirements based on TRP and co-location requirements not based on TRP.

##### 9.7.5.2.2 General OTA transmitter spurious emissions requirements

The Tx spurious emissions requirements for *SAN type 1-O* shall not exceed each applicable limit above 30 MHz in clause 6.6.5.2.1.

##### 9.7.5.2.3 Protection of the SAN receiver of own

This requirement shall be applied for NR FDD operation in order to prevent degradation of own receivers by emissions from a type 1-O SAN.

This requirement is a co-location requirement as defined in clause 4.9, the power levels are specified at the *co-location reference antenna* output.

The total power of any spurious emission from both polarizations of the *co-location reference antenna* connector output shall not exceed the limits in clause 6.6.5.2.2.

## 9.8 OTA transmitter intermodulation

The requirement is not applicable in this version of the specification.

# 10 Radiated receiver characteristics

## 10.1 General

Radiated receiver characteristics are specified at RIB for *SAN type 1-H or* *SAN type 1-O*, with full complement of transceivers for the configuration in normal operating condition.

Unless otherwise stated, the following arrangements apply for the radiated receiver characteristics requirements in clause 10:

- Requirements shall be met for any transmitter setting.

- The requirements shall be met with the transmitter unit(s) ON.

- Throughput requirements defined for the radiated receiver characteristics do not assume HARQ retransmissions.

- When SAN is configured to receive multiple carriers, all the throughput requirements are applicable for each received carrier.

- For ACS, blocking and intermodulation characteristics, the negative offsets of the interfering signal apply relative to the lower *SAN RF Bandwidth* edge, and the positive offsets of the interfering signal apply relative to the upper *SAN RF Bandwidth* edge.

- Each requirement shall be met over the RoAoA specified.

NOTE 1: In normal operating condition the SAN in FDD operation is configured to transmit and receive at the same time.

For FR1 requirements which are to be met over the *OTA REFSENS RoAoA* absolute requirement values are offset by the following term:

 ΔOTAREFSENS = 44.1 - 10\*log10(BeWθ,REFSENS\*BeWφ,REFSENS) dB for the reference direction

and

 ΔOTAREFSENS = 41.1 - 10\*log10(BeWθ,REFSENS\*BeWφ,REFSENS) dB for all other directions

For requirements which are to be met over the *minSENS RoAoA* absolute requirement values are offset by the following term:

 ΔminSENS = PREFSENS – EISminSENS (dB)

## 10.2 OTA sensitivity

#### 10.2.1 General

The OTA sensitivity requirement is a *directional requirement* based upon the declaration of one or more *OTA sensitivity direction declarations* (OSDD), related to a *SAN type 1-H* and *SAN type 1-O* receiver.

The *SAN type 1-H* and *SAN type 1-O* may optionally be capable of redirecting/changing the *receiver target* by means of adjusting SAN settings resulting in multiple *sensitivity RoAoA*. The *sensitivity RoAoA* resulting from the current SAN settings is the active *sensitivity RoAoA*.

If the SAN is capable of redirecting the *receiver target* related to the OSDD then the OSDD shall include:

- *SAN channel bandwidth* and declared minimum EISlevel applicable to any active *sensitivity RoAoA* inside the *receiver target redirection range* in the OSDD.

- A declared *receiver target redirection range*, describing all the angles of arrival that can be addressed for the OSDD through alternative settings in the SAN.

- Five declared *sensitivity RoAoA* comprising the conformance testing directions as detailed in TS 38.141‑2 [6].

- The *receiver target reference direction*.

NOTE 1: Some of the declared *sensitivity RoAoA* may coincide depending on the redirection capability.

NOTE 2: In addition to the declared *sensitivity RoAoA*, several *sensitivity RoAoA* may be implicitly defined by the *receiver target redirection range* without being explicitly declared in the OSDD.

If the SAN is not capable of redirecting the *receiver target* related to the OSDD, then the OSDD includes only:

- The set(s) of RAT, *SAN channel bandwidth* and declared minimum EISlevel applicable to the *sensitivity RoAoA* in the OSDD.

- One declared active *sensitivity RoAoA*.

- The *receiver target reference direction*.

NOTE 4: For SAN without target redirection capability, the declared (fixed) *sensitivity RoAoA* is always the active *sensitivity RoAoA*.

The OTA sensitivity EIS level declaration shall apply to each supported polarization, under the assumption of *polarization match*.

#### 10.2.2 Minimum requirement

For a received signal whose AoA of the incident wave is within the active *sensitivity RoAoA* of an OSDD, the error rate criterion as described in clause 7.2 shall be met when the level of the arriving signal is equal to the minimum EIS level in the respective declared set of EIS level and *SAN channel bandwidth*.

## 10.3 OTA reference sensitivity level

### 10.3.1 General

The OTA REFSENS requirement is a *directional requirement* and is intended to ensure the minimum OTA reference sensitivity level for a declared *OTA REFSENS RoAoA*. The OTA reference sensitivity power level EISREFSENS is the minimum mean power received at the RIB at which a reference performance requirement shall be met for a specified reference measurement channel.

The OTA REFSENS requirement shall apply to each supported polarization, under the assumption of *polarization match*.

### 10.3.2 Minimum requirement for *SAN type 1-O*

The throughput shall be ≥ 95% of the maximum throughput of the reference measurement channel as specified in the corresponding table and annex A.1 when the OTA test signal is at the corresponding EISREFSENS level and arrives from any direction within the *OTA REFSENS RoAoA.*

Table 10.3.2-1: GEO class SAN reference sensitivity levels

|  |  |  |  |
| --- | --- | --- | --- |
| *SAN channel bandwidth* (MHz) | Sub-carrier spacing (kHz) | Reference measurement channel | OTA reference sensitivity level, EISREFSENS(dBm) |
| 5, 10, 15 | 15 | G-FR1-A1-1 | -99.3 - ΔOTAREFSENS |
| 10, 15  | 30 | G-FR1-A1-2 | -99.4 - ΔOTAREFSENS |
| 10, 15 | 60 | G-FR1-A1-3 |  -96.5 - ΔOTAREFSENS |
| 20  | 15 | G-FR1-A1-4 |  -92.9 - ΔOTAREFSENS |
| 20 | 30 | G-FR1-A1-5 | -93.2 - ΔOTAREFSENS |
| 20  | 60 | G-FR1-A1-6 | -93.3 - ΔOTAREFSENS |
| NOTE: EISREFSENS is the power level of a single instance of the reference measurement channel. This requirement shall be met for each consecutive application of a single instance of the reference measurement channel mapped to disjoint frequency ranges with a width corresponding to the number of resource blocks of the reference measurement channel each, except for one instance that might overlap one other instance to cover the full *SAN channel bandwidth*. |

Table 10.3.2-2: LEO class SAN reference sensitivity levels

|  |  |  |  |
| --- | --- | --- | --- |
| *SAN channel bandwidth* (MHz) | Sub-carrier spacing (kHz) | Reference measurement channel | OTA reference sensitivity level, EISREFSENS(dBm) |
| 5, 10, 15 | 15 | G-FR1-A1-1 | -102.4 - ΔOTAREFSENS |
| 10, 15  | 30 | G-FR1-A1-2 | -102.5 - ΔOTAREFSENS |
| 10, 15 | 60 | G-FR1-A1-3 | -99.6 - ΔOTAREFSENS |
| 20  | 15 | G-FR1-A1-4 | -96.0 - ΔOTAREFSENS |
| 20  | 30 | G-FR1-A1-5 | -96.3 - ΔOTAREFSENS |
| 20 | 60 | G-FR1-A1-6 | -96.4 - ΔOTAREFSENS |
| NOTE: EISREFSENS is the power level of a single instance of the reference measurement channel. This requirement shall be met for each consecutive application of a single instance of the reference measurement channel mapped to disjoint frequency ranges with a width corresponding to the number of resource blocks of the reference measurement channel each, except for one instance that might overlap one other instance to cover the full *SAN channel bandwidth*. |

## 10.4 OTA dynamic range

### 10.4.1 General

The OTA dynamic range is a measure of the capability of the receiver unit to receive a wanted signal in the presence of an interfering signal inside the received *SAN channel bandwidth*.

The requirement shall apply at the RIB when the AoA of the incident wave of a received signal and the interfering signal are from the same direction and are within the *OTA REFSENS RoAoA.*

The wanted and interfering signals apply to each supported polarization, under the assumption of *polarization match*.

### 10.4.2 Minimum requirement for *SAN type 1-O*

The throughput shall be ≥ 95% of the maximum throughput of the reference measurement channel as specified in annex A.2 with parameters specified in table 10.4.2-1 for LEO SAN.

Table 10.4.2-1: LEO class SAN dynamic range

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *SAN channel bandwidth* (MHz) | Subcarrier spacing (kHz) | Reference measurement channel | Wanted signal mean power (dBm) | Interfering signal mean power (dBm) / BWConfig | Type of interfering signal |
| 5 | 15 | G-FR1-A2-1 | -76.4 - ΔOTAREFSENS  | -88.2 - ΔOTAREFSENS | AWGN |
|  | 30 | G-FR1-A2-2  | -77.1 - ΔOTAREFSENS |  |  |
| 10 | 15 | G-FR1-A2-1 | -76.4 - ΔOTAREFSENS | -85.0 - ΔOTAREFSENS | AWGN |
|  | 30 | G-FR1-A2-2  | -77.1 - ΔOTAREFSENS |  |  |
|  | 60 | G-FR1-A2-3  | -74.1- ΔOTAREFSENS  |  |  |
| 15 | 15 | G-FR1-A2-1 | -76.4- ΔOTAREFSENS  | -83.2 - ΔOTAREFSENS  | AWGN |
|  | 30 | G-FR1-A2-2  | -77.1 - ΔOTAREFSENS |  |  |
|  | 60 | G-FR1-A2-3 | -74.1 - ΔOTAREFSENS |  |  |
| 20 | 15 | G-FR1-A2-4 | -70.2 - ΔOTAREFSENS | -81.9 - ΔOTAREFSENS | AWGN |
|  | 30 | G-FR1-A2-5 | -70.2 - ΔOTAREFSENS |  |  |
|  | 60 | G-FR1-A2-6 | -70.5 - ΔOTAREFSENS |  |  |
| NOTE: The wanted signal mean power is the power level of a single instance of the corresponding reference measurement channel. This requirement shall be met for each consecutive application of a single instance of the reference measurement channel mapped to disjoint frequency ranges with a width corresponding to the number of resource blocks of the reference measurement channel each, except for one instance that might overlap one other instance to cover the full *SAN channel bandwidth*. |

## 10.5 OTA in-band selectivity and blocking

### 10.5.1 OTA adjacent channel selectivity

#### 10.5.1.1 General

OTA Adjacent channel selectivity (ACS) is a measure of the receiver's ability to receive an OTA wanted signal at its assigned channel frequency in the presence of an OTA adjacent channel signal with a specified centre frequency offset of the interfering signal to the band edge of a victim system.

#### 10.5.1.2 Minimum requirement for *SAN type 1-O*

The requirement shall apply at the RIB when the AoA of the incident wave of a received signal and the interfering signal are from the same direction and are within the *minSENS RoAoA*.

The wanted and interfering signals apply to each supported polarization, under the assumption o*f polarization match*.

The throughput shall be ≥ 95% of the maximum throughput of the reference measurement channel.

For FR1, the OTA wanted signal and the interfering signal are specified in table 10.5.1.2-1 and table 10.5.1.2-2 for OTA ACS. The reference measurement channel for the OTA wanted signal is further specified in annex A.1. The characteristic of the interfering signal is further specified in annex D.

The OTA ACS requirement is applicable outside the *SAN RF Bandwidth* or *Radio Bandwidth*. The OTA interfering signal offset is defined relative to the *SAN RF Bandwidth edges* or *Radio Bandwidth edges*.

Table 10.5.1.2-1: OTA ACS requirement for *SAN type 1-O*

|  |  |  |
| --- | --- | --- |
| *SAN channel bandwidth* of the *lowest/highest carrier* received (MHz) | Wanted signal mean power (dBm)(Note 2) | Interfering signal mean power (dBm) |
| 5, 10, 15, 20 (Note 1) | EISminSENS + 6 dB | LEO: -60 – ΔminSENSGEO: -57 – ΔminSENS |
| NOTE 1: The SCS for the *lowest/highest carrier* received is the lowest SCS supported by the SAN for that bandwidthNOTE 2: EISminSENS depends on the *SAN channel bandwidth* |

Table 10.5.1.2-2: OTA ACS interferer frequency offset for *SAN type 1-O*

|  |  |  |
| --- | --- | --- |
| *SAN channel bandwidth* of the *lowest/highest carrier* received (MHz) | Interfering signal centre frequency offset from the lower/upper *Base Station RF Bandwidth* edge or *sub-block* edge inside a *sub-block gap* (MHz) | Type of interfering signal |
| 5 | ±2.5025 | 5 MHz [DFT-s-OFDM] NR signal,15 kHz SCS, 25 RBs |
| 10 | ±2.5075 |
| 15 | ±2.5125 |
| 20 | ±2.5025 |

## 10.6 OTA out-of-band blocking

### 10.6.1 General

The OTA out-of-band blocking characteristics are a measure of the receiver unit ability to receive a wanted signal at the *RIB* at its assigned channel in the presence of an unwanted interferer.

### 10.6.2 Minimum requirement for *SAN type 1-O*

#### 10.6.2.1 General minimum requirement

The requirement shall apply at the RIBwhen the AoA of the incident wave of the received signal and the interfering signal are from the same direction and are within the *minSENS RoAoA*.

The wanted signal applies to each supported polarization, under the assumption of *polarization match.* The interferer shall be *polarization matched* in-band and the polarization maintained for out-of-band frequencies.

For OTA wanted and OTA interfering signals provided at the RIB using the parameters in table 10.6.2.1-1, the following requirements shall be met:

- The throughput shall be ≥ 95% of the maximum throughput of the reference measurement channel. The reference measurement channel for the OTA wanted signal is identified in clause 10.3.2 for each *SAN channel bandwidth* and further specified in annex A.1.

For *SAN type 1-O* the OTA out-of-band blocking requirement apply from 30 MHz to FUL,low - ΔfOOB and from FUL,high + ΔfOOB up to 12750 MHz, including the downlink frequency range of the FDD *operating band* for SAN supporting FDD. The ΔfOOB for *SAN type 1-O* is defined in table 10.5.2.2-0.

Table 10.6.2.1-1: OTA out-of-band blocking performance requirement

|  |  |  |
| --- | --- | --- |
| Wanted signal mean power (dBm) | Interfering signal RMS field-strength (V/m) | Type of interfering Signal |
| EISminSENS + 6 dB (Note 1) | 0.36 | CW carrier |
| NOTE 1: EISminSENS depends on the *channel bandwidth* as specified in clause 10.2.NOTE 2: The RMS field-strength level in V/m is related to the interferer EIRP level at a distance described as , where EIRP is in W and r is in m; for example, 0.36 V/m is equivalent to 36 dBm at fixed distance of 30 m. |

## 10.7 OTA receiver spurious emissions

### 10.7.1 General

The OTA RX spurious emission is the power of the emissions radiated from the antenna array from a receiver unit.

The metric used to capture OTA receiver spurious emissions for *SAN type 1-O* is *total radiated power* (TRP), with the requirement defined at the RIB.

### 10.7.2 Minimum requirement for *SAN type 1-O*

For a SAN operating in FDD, OTA RX spurious emissions requirement do not apply as they are 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.

Table 10.7.2-1: General SAN receiver spurious emission basic limits for *SAN type 1-O*

|  |  |  |  |
| --- | --- | --- | --- |
| Spurious frequency range | *Basic limit* | Measurement bandwidth | Notes |
| 30 MHz – 1 GHz | -36 dBm | 100 kHz | Note 1 |
| 1 GHz – 12.75 GHz | -30 dBm | 1 MHz | Note 1, Note 2 |
| NOTE 1: Measurement bandwidths as in ITU-R SM.329 [x], s4.1.NOTE 2: Upper frequency as in ITU-R SM.329 [x], s2.5 table 1.NOTE 3: The frequency range from ΔfOBUE below the lowest frequency of the SAN transmitter *operating band* to ΔfOBUE above the highest frequency of the SAN transmitter *operating band* may be excluded from the requirement. ΔfOBUE is defined in clause 9.7.1.  |

## 10.8 OTA receiver intermodulation

The requirement is not applicable in this version of the specification.

## 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 an interfering signal received at a larger power spectral density. In this condition a throughput requirement shall be met for a specified reference measurement channel. The interfering signal shall be an NR signal as specified in annex A.1 and shall be time aligned with the wanted signal.

### 10.9.2 Minimum requirement for *SAN type 1-O*

The requirement shall apply at the RIBwhen the AoA of the incident wave of the received signal and the interfering signal are the same direction and are within the *minSENS RoAoA*

The wanted and interfering signals applies to each supported polarization, under the assumption of *polarization match.*

For a wanted and an interfering signal coupled to the RIB, the following requirements shall be met:

- For *SAN type 1-O*, the throughput shall be ≥ 95% of the maximum throughput of the reference measurement channel as specified in annex A.1 with parameters specified in table 10.9.2-1 for GEO SAN, in table 10.9.2-2 for LEO SAN. The characteristics of the interfering signal is further specified in annex D.

Table 10.9.2-1: GEO class SAN ICS requirement

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *SAN channel bandwidth* (MHz) | Subcarrier spacing (kHz) | Reference measurement channel | Wanted signal mean power (dBm) | Interfering signal mean power (dBm) | Type of interfering signal |
| 5 | 15 | G-FR1-A1-7 | -98.2 - ΔminSENS  | -92.0 - ΔminSENS  | DFT-s-OFDM NR signal, 15 kHz SCS,10 RBs |
| 10,15,20 | 15 | G-FR1-A1-1 | -96.3 - ΔminSENS  | -88.1 - ΔminSENS  | DFT-s-OFDM NR signal, 15 kHz SCS,25 RBs |
| 5 | 30 | G-FR1-A1-8 | -98.9 - ΔminSENS  | -92.0 - ΔminSENS  | DFT-s-OFDM NR signal, 30 kHz SCS,5 RBs |
| 10,15,20 | 30 | G-FR1-A1-2 | -96.4 - ΔminSENS  | -89.0 - ΔminSENS  | DFT-s-OFDM NR signal, 30 kHz SCS,10 RBs |
| 10,15,20 | 60 | G-FR1-A1-9 | -95.8 - ΔminSENS  | -89.0 - ΔminSENS  | DFT-s-OFDM NR signal, 60 kHz SCS,5 RBs |
| NOTE: Wanted and interfering signal are placed adjacently around Fc, where the Fc is defined for *SAN channel bandwidth* ofthe wanted signalaccording to the table 5.4.2.2-1. The aggregated wanted and interferer signal shall be centred in the *SAN channel bandwidth* of the wanted signal. |

Table 10.9.2-2: LEO class SAN ICS requirement

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *SAN channel bandwidth* (MHz) | Subcarrier spacing (kHz) | Reference measurement channel | Wanted signal mean power (dBm) | Interfering signal mean power (dBm) | Type of interfering signal |
| 5 | 15 | G-FR1-A1-7 | -101.3 - ΔminSENS  | -83.1 - ΔminSENS  | DFT-s-OFDM NR signal, 15 kHz SCS,10 RBs |
| 10,15,20 | 15 | G-FR1-A1-1 | -99.4 - ΔminSENS  | -79.2 - ΔminSENS  | DFT-s-OFDM NR signal, 15 kHz SCS,25 RBs |
| 5 | 30 | G-FR1-A1-8 | -102.0 - ΔminSENS  | -83.1 - ΔminSENS  | DFT-s-OFDM NR signal, 30 kHz SCS,5 RBs |
| 10,15,20 | 30 | G-FR1-A1-2 | -99.5 - ΔminSENS  | -80.1 - ΔminSENS | DFT-s-OFDM NR signal, 30 kHz SCS,10 RBs |
| 10,15,20 | 60 | G-FR1-A1-9 | -98.9 - ΔminSENS  | -80.1 - ΔminSENS  | DFT-s-OFDM NR signal, 60 kHz SCS,5 RBs |
| NOTE: Wanted and interfering signal are placed adjacently around Fc, where the Fc is defined for *SAN channel bandwidth* ofthe wanted signalaccording to the table 5.4.2.2-1. The aggregated wanted and interferer signal shall be centred in the *SAN channel bandwidth* of the wanted signal. |

# 11 Radiated performance requirements

## 11.1 General

<Text will be added.>

## 11.2 Performance requirements for PUSCH

<Text will be added.>

## 11.3 Performance requirements for PUCCH

<Text will be added.>

## 11.4 Performance requirements for PRACH

<Text will be added.>

Annex A (normative):
Reference measurement channels

# A.1 Fixed Reference Channels for RF Rx requirements in FR1 (QPSK, R=1/3)

The parameters for the reference measurement channels are specified in table A.1-1 for FR1 reference sensitivity level, ACS, in-band blocking, out-of-band blocking, in-channel selectivity, OTA sensitivity, OTA reference sensitivity level, OTA ACS, OTA out-of-band blocking and OTA in-channel selectivity.

The reference measurement channels for the dynamic range requirement are captured in annex A.2.

Table A.1-1: Fixed Reference Channels for SAN Rx requirements, FR1

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Reference channel | G-FR1-A1-1 | G-FR1-A1-2 | G-FR1-A1-3 | G-FR1-A1-4 | G-FR1-A1-5 | G-FR1-A1-6 | G-FR1-A1-7 | G-FR1-A1-8 | G-FR1-A1-9 |
| Subcarrier spacing (kHz) | 15 | 30 | 60 | 15 | 30 | 60 | 15 | 30 | 60 |
| Allocated resource blocks | 25 | 11 | 11 | 106 | 51 | 24 | 15 | 6 | 6 |
| CP-OFDM Symbols per slot (Note 1) | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| Modulation | QPSK | QPSK | QPSK | QPSK | QPSK | QPSK | QPSK | QPSK | QPSK |
| Code rate (Note 2) | 1/3 | 1/3 | 1/3 | 1/3 | 1/3 | 1/3 | 1/3 | 1/3 | 1/3 |
| Payload size (bits) | 2152 | 984 | 984 | 9224 | 4352 | 2088 | 1320 | 528 | 528 |
| Transport block CRC (bits) | 16 | 16 | 16 | 24 | 24 | 16 | 16 | 16 | 16 |
| Code block CRC size (bits) | - | - | - | 24 | - | - | - | - | - |
| Number of code blocks - C | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 |
| Code block size including CRC (bits) (Note 3) | 2168 | 1000 | 1000 | 4648 | 4376 | 2104 | 1336 | 544 | 544 |
| Total number of bits per slot | 7200 | 3168 | 3168 | 30528 | 14688 | 6912 | 4320 | 1728 | 1728 |
| Total symbols per slot | 3600 | 1584 | 1584 | 15264 | 7344 | 3456 | 2160 | 864 | 864 |
| NOTE 1: *UL-DMRS-config-type* = 1 with *UL-DMRS-max-len* = 1, *UL-DMRS-add-pos* = 1 with *l0*= 2, *l* = 11 as per table 6.4.1.1.3-3 of TS 38.211 [x].NOTE 2: MCS index 4 and target coding rate = 308/1024 are adopted to calculate payload size for receiver sensitivity and in-channel selectivity.NOTE 3: Code block size including CRC (bits) equals to *K'* in clause 5.2.2 of TS 38.212 [x]. |

# A.2 Fixed Reference Channels for dynamic range (16QAM, R=2/3)

The parameters for the reference measurement channels are specified in table A.2-1 for FR1 dynamic range and OTA dynamic range.

Table A.2-1: Fixed Reference Channels for dynamic range and OTA dynamic range, FR1

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Reference channel | G-FR1-A2-1 | G-FR1-A2-2 | G-FR1-A2-3 | G-FR1-A2-4 | G-FR1-A2-5 | G-FR1-A2-6 |
| Subcarrier spacing (kHz) | 15 | 30 | 60 | 15 | 30 | 60 |
| Allocated resource blocks | 25 | 11 | 11 | 106 | 51 | 24 |
| CP-OFDM Symbols per slot (Note 1) | 12 | 12 | 12 | 12 | 12 | 12 |
| Modulation | 16QAM | 16QAM | 16QAM | 16QAM | 16QAM | 16QAM |
| Code rate (Note 2) | 2/3 | 2/3 | 2/3 | 2/3 | 2/3 | 2/3 |
| Payload size (bits) | 9224 | 4032 | 4032 | 38936 | 18960 | 8968 |
| Transport block CRC (bits) | 24 | 24 | 24 | 24 | 24 | 24 |
| Code block CRC size (bits) | 24 | - | - | 24 | 24 | 24 |
| Number of code blocks - C | 2 | 1 | 1 | 5 | 3 | 2 |
| Code block size including CRC (bits) (Note 3) | 4648 | 4056 | 4056 | 7816 | 6352 | 4520 |
| Total number of bits per slot | 14400 | 6336 | 6336 | 61056 | 29376 | 13824 |
| Total symbols per slot | 3600 | 1584 | 1584 | 15264 | 7344 | 3456 |
| NOTE 1: DM-RS configuration type = 1 with DM-RS duration = single-symbol DM-RS, additional DM-RS position = pos1 with *l0*= 2, *l* = 11 as per table 6.4.1.1.3-3 of TS 38.211 [x].NOTE 2: MCS index 16 and target coding rate = 658/1024 are adopted to calculate payload size.NOTE 3: Code block size including CRC (bits) equals to *K'* in clause 5.2.2 of TS 38.212 [x]. |

A.3 [Fixed Reference Channels for performance requirements]

Annex B (normative):
Error Vector Magnitude (FR1)

# B.1 Reference point for measurement

The EVM shall be measured at the point after the FFT and a zero-forcing (ZF) equalizer in the receiver, as depicted in figure B.1-1 below.



Figure B.1-1: Reference point for EVM measurement

# B.2 Basic unit of measurement

The basic unit of EVM measurement is defined over one slot in the time domain and  subcarriers in the frequency domain:

 

where

*T* is the set of symbols with the considered modulation scheme being active within the slot,

is the set of subcarriers within the  subcarriers with the considered modulation scheme being active in symbol *t*,

 is the ideal signal reconstructed by the measurement equipment in accordance with relevant Tx models,

 is the modified signal under test defined in annex B.3.

NOTE: Although the basic unit of measurement is one slot, the equalizer is calculated over 10 ms measurement interval to reduce the impact of noise in the reference signals. The boundaries of the 10 ms measurement intervals need not be aligned with radio frame boundaries.

# B.3 Modified signal under test

Implicit in the definition of EVM is an assumption that the receiver is able to compensate a number of transmitter impairments. The signal under test is equalized and decoded according to:

 

where

 is the time domain samples of the signal under test.

 is the sample timing difference between the FFT processing window in relation to nominal timing of the ideal signal. Note that two timing offsets are determined, the corresponding EVM is measured and the maximum used as described in annex B.7.

 is the RF frequency offset.

 is the phase response of the TX chain.

 is the amplitude response of the TX chain.

# B.4 Estimation of frequency offset

The observation period for determining the frequency offset  shall be 1 slot.

# B.5 Estimation of time offset

## B.5.1 General

The observation period for determining the sample timing difference shall be 1 slot.

In the following  represents the middle sample of the EVM window of length *W* (defined in annex B.5.2) or the last sample of the first window half if *W* is even.

is estimated so that the EVM window of length *W* is centred on the measured cyclic prefix of the considered OFDM symbol. To minimize the estimation error the timing shall be based on demodulation reference signals. To limit time distortion of any transmit filter the reference signals in the 1 outer RBs are not taken into account in the timing estimation

Two values for  are determined:

 and

 where  if *W* is odd and  if *W* is even.

When the cyclic prefix length varies from symbol to symbol then *T* shall be further restricted to the subset of symbols with the considered modulation scheme being active and with the considered cyclic prefix length type.

## B.5.2 Window length

Table B.5.2-1, B.5.2-2, B.5.2-3 specify the EVM window length (*W*) for normal CP.

Table B.5.2-1: EVM window length for normal CP, FR1, 15 kHz SCS

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Channelbandwidth (MHz) | FFT size | CP length for symbols 1‑6 and 8-13 in FFT samples | EVM window length *W* | Ratio of *W* to total CP length for symbols 1‑6 and 8-13 (Note) (%) |
| 5 | 512 | 36 | 14 | 40 |
| 10 | 1024 | 72 | 28 | 40 |
| 15 | 1536 | 108 | 44 | 40 |
| 20 | 2048 | 144 | 58 | 40 |
| NOTE: These percentages are informative and apply to a slot's symbols 1 to 6 and 8 to 13. Symbols 0 and 7 have a longer CP and therefore a lower percentage. |

Table B.5.2-2: EVM window length for normal CP, FR1, 30 kHz SCS

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Channelbandwidth (MHz) | FFT size | CP length for symbols 1‑13 in FFT samples | EVM window length *W* | Ratio of *W* to total CP length for symbols 1‑13 (Note) (%) |
| 5 | 256 | 18 | 8 | 40 |
| 10 | 512 | 36 | 14 | 40 |
| 15 | 768 | 54 | 22 | 40 |
| 20 | 1024 | 72 | 28 | 40 |
| NOTE: These percentages are informative and apply to a slot's symbols 1 through 13. Symbol 0 has a longer CP and therefore a lower percentage. |

Table B.5.2-3: EVM window length for normal CP, FR1, 60 kHz SCS

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Channelbandwidth (MHz) | FFT size | CP length in FFT samples | EVM window length *W* | Ratio of *W* to total CP length (Note) (%) |
| 10 | 256 | 18 | 8 | 40 |
| 15 | 384 | 27 | 11 | 40 |
| 20 | 512 | 36 | 14 | 40 |
| NOTE: These percentages are informative and apply to all OFDM symbols within subframe except for symbol 0 of slot 0 and slot 2. Symbol 0 of slot 0 and slot 2 may have a longer CP and therefore a lower percentage. |

Table B.5.2-4 below specifies the EVM window length (*W*) for extended CP. The number of CP samples excluded from the EVM window is the same as for normal CP length.

Table B.5.2-4: EVM window length for extended CP, FR1, 60 kHz SCS

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Channelbandwidth (MHz) | FFT size | CP length in FFT samples | EVM window length *W* | Ratio of *W* to total CP length (Note) (%) |
| 10 | 256 | 64 | 54 | 84 |
| 15 | 384 | 96 | 80 | 83 |
| 20 | 512 | 128 | 106 | 83 |
| NOTE: These percentages are informative. |

# B.6 Estimation of TX chain amplitude and frequency response parameters

The equalizer coefficients and  are determined as follows:

1. Calculate the complex ratios (amplitude and phase) of the post-FFT acquired signal  and the post-FFT ideal signal , for each reference signal, over 10ms measurement interval. This process creates a set of complex ratios:

 

 Where the post-FFT ideal signal  is constructed by the measuring equipment according to the relevant TX specifications, using the following parameters: i.e. nominal demodulation reference signals, (all other modulation symbols are set to 0 V), nominal carrier frequency, nominal amplitude and phase for each applicable subcarrier, nominal timing.

2. Perform time averaging at each reference signal subcarrier of the complex ratios, the time-averaging length is 10ms measurement interval. Prior to the averaging of the phases  an unwrap operation must be performed according to the following definition: The unwrap operation corrects the radian phase angles of  by adding multiples of 2\*PI when absolute phase jumps between consecutive time instances ti are greater than or equal to the jump tolerance of PI radians. This process creates an average amplitude and phase for each reference signal subcarrier (i.e. every second subcarrier).

 

 

 Where *N* is the number of reference signal; time-domain locations *ti* from for each reference signal subcarrier .

3. The equalizer coefficients for amplitude and phase  and  at the reference signal subcarriers are obtained by computing the moving average in the frequency domain of the time-averaged reference signal subcarriers, i.e. every second subcarrier. The moving average window size is 19 and averaging is over the DM-RS subcarriers in the allocated RBs. For DM-RS subcarriers at or near the edge of the channel , or when the number of available DM-RS subcarriers within a set of contiguously allocated RBs is smaller than the moving average window size, the window size is reduced accordingly as per figure B.6-1.

4. Perform linear interpolation from the equalizer coefficients  and  to compute coefficients ,  for each subcarrier.



Figure B.6-1: Reference subcarrier smoothing in the frequency domain

# B.7 Averaged EVM

EVM is averaged over all allocated downlink resource blocks with the considered modulation scheme in the frequency domain, and a minimum of slots where is the number of slots in a 10 ms measurement interval.

For FDD the averaging in the time domain equals the slot duration of the 10 ms measurement interval from the equalizer estimation step.



- Where *Ni* is the number of resource blocks with the considered modulation scheme in slot *i*.

- The EVM requirements shall be tested against the maximum of the RMS average at the window *W* extremities of the EVM measurements:

- Thus  is calculated using in the expressions above and  is calculated using  in the  calculation.

- Thus we get:

Annex C (normative):
Error Vector Magnitude (FR2)

The Annex C is not applicable in Release-17.

Annex D (informative):
Change history

|  |
| --- |
| **Change history** |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2022-01 | RAN4#101-bis-e | R4-2201830 |  |  |  | Initial Skeleton Revised in R4-2203087 | 0.0.1 |
| 2022-01 | RAN4#101-bis-e | R4-2203087 |  |  |  | Initial Skeleton | 0.0.1 |
| 2022-03 | RAN4#102-e | R4-2203955 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2205057 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207331 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207335 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207336 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207337 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207340 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207354 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207355 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207356 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207357 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207359 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207361 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207362 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207363 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207364 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207365 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207366 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207368 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207371 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207372 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207373 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207374 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207377 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207378 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207380 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207382 |  |  |  |  | 0.1.0 |
| 2022-03 | RAN4#102-e | R4-2207383 |  |  |  |  | 0.1.0 |
|  |  |  |  |  |  |  |  |