ETSI TS 138 108 V17.0.0 (2022-07)

TECHNICAL SPECIFICATION

5G ;
NR;
Satellite Node radio transmission and reception
(3GPP TS 38.108 version 17.0.0 Release 17)

Reference
DTS/TSGR-0438108vH00

Keywords
5G

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - APE 7112B
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Contents

Foreword

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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.

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

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

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

[5] 3GPP TS 38.211: "NR; Physical channels and modulation".

[6] 3GPP TS 38.331: "NR; Radio Resource Control (RRC); Protocol specification".

[7] 3GPP TS 38.213: "NR; Physical layer procedures for control".

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

[9] ITU-R Recommendation SM.1541-6: "Unwanted emissions in the out-of-band domain".

[10] 3GPP TS 38.212: "NR; Multiplexing and channel coding".

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].

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.

Satellite Access Node (SAN): node providing NR user plane and control plane protocol terminations towards NTN Satellite capable UE, and connected via the NG interface to the 5GC. It encompass a transparent NTN payload on board a NTN platform, a gateway and gNB functions.

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.

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.

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 per RIB during the *transmitter ON period* for a specific carrier in a specified reference condition and corresponding to the declared *rated carrier TRP output* power ($P_{rated,c,TRP}$).

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 per RIB during the *transmitter ON period* in a specified reference condition and corresponding to the declared *rated total TRP output* power ($P_{rated,t,TRP}$).

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 can be seen by a UE.

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.

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 performed by *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.

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.

3.2 Symbols

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

β	Percentage of the mean transmitted power emitted outside the occupied bandwidth on the assigned channel.
$BeW_{\theta,REFSENS}$	Beamwidth equivalent to the *OTA REFSENS RoAoA* in the θ-axis in degrees. Applicable for FR1 only.
$BeW_{\varphi,REFSENS}$	Beamwidth equivalent to the *OTA REFSENS RoAoA* in the φ-axis in degrees. Applicable for FR1 only.
$SAN_{Channel}$	*SAN channel bandwidth.*
BW_{Config}	*Transmission bandwidth configuration*, where $BW_{Config} = N_{RB}$ x SCS x 12.
$BW_{Contiguous}$	Contiguous *transmission bandwidth*, i.e. *SAN channel bandwidth* for single carrier.
$BW_{GB,low}$	The minimum guard band defined in clause 5.3.3 for lowest assigned component carrier.
$BW_{GB,high}$	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.
ΔF_{Global}	Global frequency raster granularity.
Δf_{max}	f_offset_{max} minus half of the bandwidth of the measuring filter.

Δf_{OBUE}	Maximum offset of the *operating band* unwanted emissions mask from the downlink *operating band* edge.
Δf_{OOB}	Maximum offset of the out-of-band boundary from the uplink *operating band* edge.
$\Delta_{minSENS}$	Difference between conducted reference sensitivity and minSENS.
$\Delta_{OTAREFSENS}$	Difference between conducted reference sensitivity and OTA REFSENS.
ΔF_{Raster}	Channel raster granularity.
$EIS_{minSENS}$	The EIS declared for the *minSENS RoAoA.*
$EIS_{REFSENS}$	OTA REFSENS EIS value.
F_C	*RF reference frequency* on the channel raster, given in table 5.4.2.2-1.
$F_{C,low}$	The Fc of the *lowest carrier*, expressed in MHz.
$F_{C,high}$	The Fc of the *highest carrier*, expressed in MHz.
$F_{DL,low}$	The lowest frequency of the downlink *operating band.*
$F_{DL,high}$	The highest frequency of the downlink *operating band.*
F_{filter}	Filter centre frequency.
$F_{offset,high}$	Frequency offset from $F_{C,high}$ to the upper *SAN RF Bandwidth edge.*
$F_{offset,low}$	Frequency offset from $F_{C,low}$ to the lower *SAN RF Bandwidth edge.*
f_offset	Separation between the *channel edge* frequency and the centre of the measuring.
f_offset_{max}	The offset to the frequency Δf_{OBUE} outside the downlink *operating band.*
F_{REF}	RF reference frequency.
$F_{REF-Offs}$	Offset used for calculating $F_{REF.}$
$F_{UL,low}$	The lowest frequency of the uplink *operating band.*
$F_{UL,high}$	The highest frequency of the uplink *operating band.*
$GB_{Channel}$	Minimum guard band defined in clause 5.3.3.
n_{PRB}	Physical resource block number.
N_{RB}	*Transmission bandwidth configuration*, expressed in resource blocks.
N_{REF}	NR Absolute Radio Frequency Channel Number (NR-ARFCN).
$N_{REF-Offs}$	Offset used for calculating N_{REF} scaling per cell, as calculated in clause 6.1.
$P_{EIRP,N}$	EIRP level for channel N.
$P_{max,c,AC}$	*Maximum carrier output power* measured per *antenna connector.*
$P_{max,c,TABC}$	The *maximum carrier output power per TAB connector.*
$P_{max,c,TRP}$	*Maximum carrier TRP output power* measured at the RIB(s), and corresponding to the declared *rated carrier TRP output power* ($P_{rated,c,TRP}$).
$P_{max,c,EIRP}$	The maximum carrier EIRP when the SAN is configured at the maximum rated carrier output TRP ($P_{rated,c,TRP}$).
$P_{rated,c,sys,GEO}$	The sum of $P_{rated,c,TABC}$ for all *TAB connectors* for a single carrier of the GEO SAN.
$P_{rated,c,sys,LEO}$	The sum of $P_{rated,c,TABC}$ for all *TAB connectors* for a single carrier of the LEO SAN.
$P_{rated,c,TABC,GEO}$	The *rated carrier output power per TAB connector* of the GEO SAN.
$P_{rated,c,TABC,LEO}$	The *rated carrier output power per TAB connector* of the LEO SAN.
$P_{rated,c,TRP}$	*Rated carrier TRP output power* declared per RIB.
$P_{rated,t,TRP}$	*Rated total TRP output power* declared per RIB.
$P_{REFSENS}$	Conducted Reference Sensitivity power level.
SS_{REF}	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
CP-OFDM	Cyclic Prefix-OFDM
CW	Continuous Wave
DFT-s-OFDM	Discrete Fourier Transform-spread-OFDM

DM-RS	Demodulation Reference Signal
EIRP	Equivalent 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
NTN	Non-Terrestrial Network
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
TRP	Total Radiated Power
TX	Transmitter

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 [3].

The minimum requirements given in this specification make no allowance for measurement uncertainty. The test specifications TS 38.181 [3] 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 [4].

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.

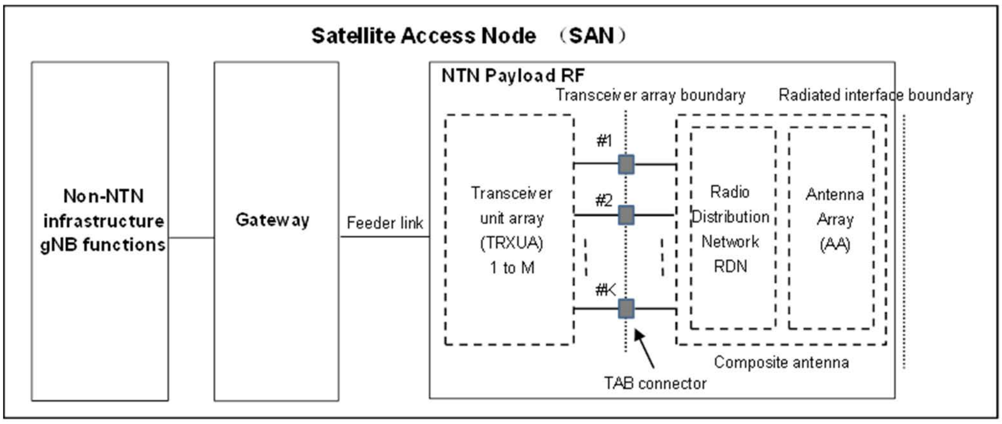


Figure 4.3.1-1: Radiated and conducted reference points for *SAN type 1-H*

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.

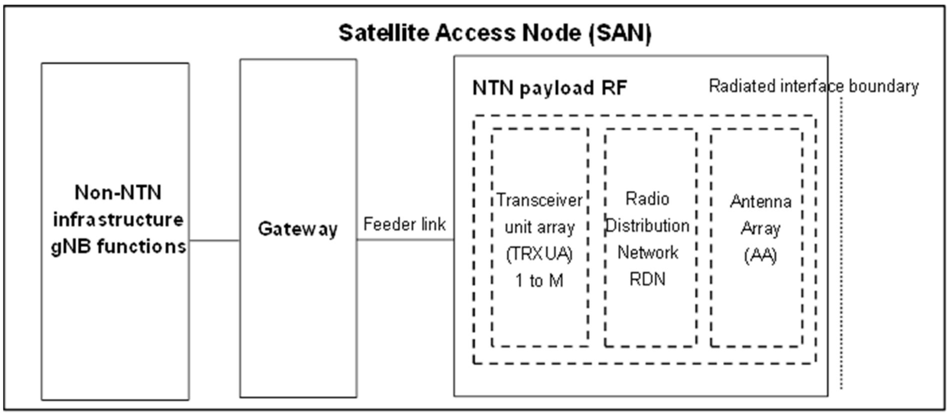


Figure 4.3.2-1: Radiated reference points for *SAN type 1-O*

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 SAN 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. 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 satellite LEO 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*	Satellite *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	NA	
Frequency error	6.5.1	
Modulation quality	6.5.2	
Time alignment error	NA	
Occupied bandwidth	6.6.2	
ACLR	6.6.3	
Operating band unwanted emissions	6.6.4	
Transmitter spurious emissions	6.6.5	
Transmitter intermodulation	NA	NA
Reference sensitivity level	7.2	
Dynamic range	7.3	
ACS	7.4.1	
In-band blocking	NA	
Out-of-band blocking	7.5	
Receiver spurious emissions	7.6	
Receiver intermodulation	NA	
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		NA
OTA frequency error		9.6.1
OTA modulation quality		9.6.2
OTA time alignment error		NA
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		NA
OTA sensitivity	10.2	10.2
OTA reference sensitivity level		10.3
OTA dynamic range		10.4
OTA ACS		10.5.1
OTA in-band blocking		NA
OTA out-of-band blocking	NA	10.6
OTA receiver spurious emission		10.7
OTA receiver intermodulation		NA
OTA in-channel selectivity		10.9
Radiated performance requirements		11

NOTE: Co-location requirements are not applicable to SAN.

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 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

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

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

Satellite *operating band*	Uplink (UL) *operating band* SAN receive / UE transmit $F_{UL,low}$ – $F_{UL,high}$	Downlink (DL) *operating band* SAN transmit / UE receive $F_{DL,low}$ – $F_{DL,high}$	Duplex mode
n256	1980 MHz – 2010 MHz	2170 MHz – 2200 MHz	FDD
n255	1626.5 MHz – 1660.5 MHz	1525 MHz – 1559 MHz	FDD
NOTE: 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.

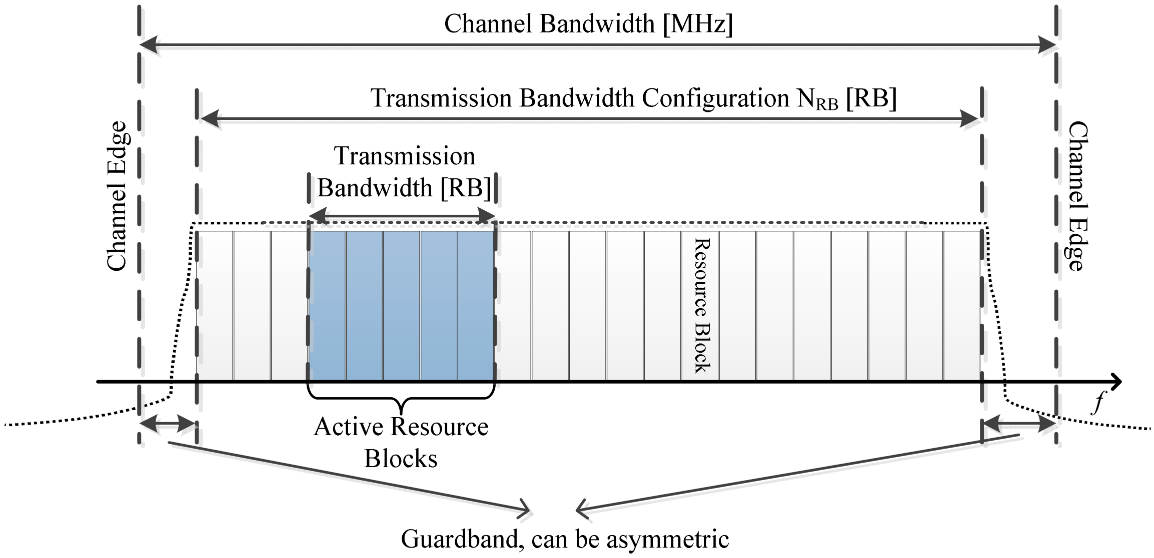


Figure 5.3.1-1: Definition of channel bandwidth and *transmission bandwidth configuration* for one channel

5.3.2 Transmission bandwidth configuration

The *transmission bandwidth configuration* N_{RB} 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 N_{RB} for FR1

SCS (kHz)	5 MHz	10 MHz	15 MHz	20 MHz
	N_{RB}	N_{RB}	N_{RB}	N_{RB}
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.

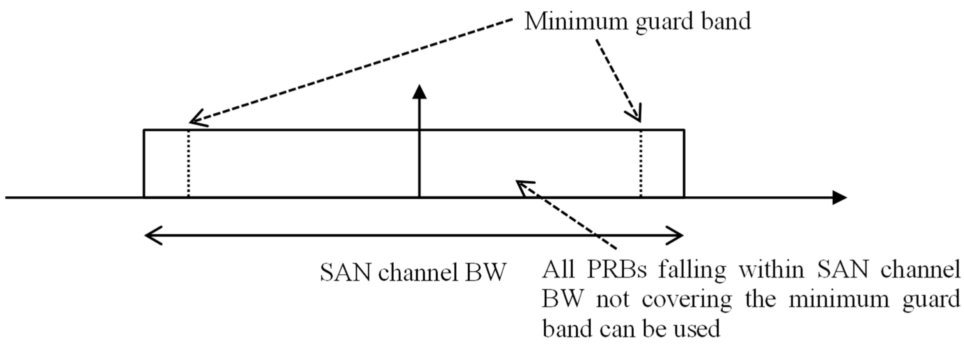


Figure 5.3.3-1: SAN PRB utilization

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.

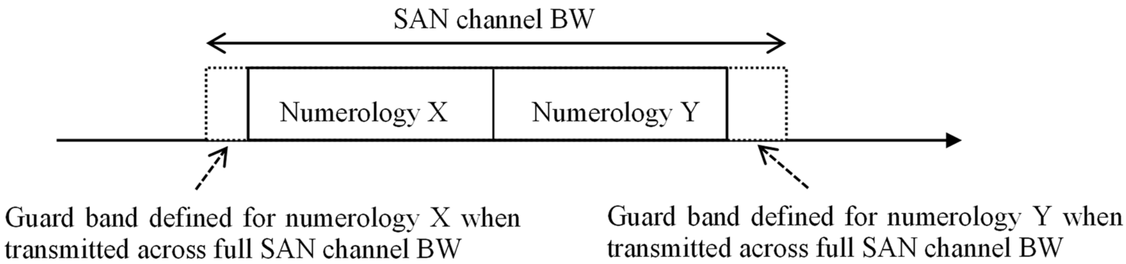


Figure 5.3.3-2: Guard band definition when transmitting multiple numerologies

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 TS 38.211 [5], 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 [6] 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
n256	15	5	10	15	20
	30		10	15	20
	60		10	15	20
n255	15	5	10	15	20
	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 = $(BW_{Channel(1)} + BW_{Channel(2)})/2$

where $BW_{Channel(1)}$ and $BW_{Channel(2)}$ 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* F_{REF}. 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 ΔF_{Global}.

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* F_{REF} in MHz is given by the following equation, where $F_{REF-Offs}$ and $N_{Ref-Offs}$ are given in table 5.4.2.1-1 and N_{REF} is the NR-ARFCN.

$$F_{REF} = F_{REF-Offs} + \Delta F_{Global} (N_{REF} – N_{REF-Offs})$$

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

Range of frequencies (MHz)	ΔF_{Global} (kHz)	$F_{REF-Offs}$ (MHz)	$N_{REF-Offs}$	Range of N_{REF}
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 ΔF_{Raster}, which may be equal to or larger than ΔF_{Global}.

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

	$N_{\mathrm{RB}}\, mod\, 2 = 0$	$N_{\mathrm{RB}}\, mod\, 2 = 1$
Resource element index k	0	6
Physical resource block number n_{PRB}	$n_{\mathrm{PRB}} = \left\lfloor \frac{N_{\mathrm{RB}}}{2} \right\rfloor$	$n_{\mathrm{PRB}} = \left\lfloor \frac{N_{\mathrm{RB}}}{2} \right\rfloor$

k, n_{PRB} and N_{RB} are as defined in TS 38.211 [5].

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, $\Delta F_{Raster} = 20 \times \Delta F_{Global}$. 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	ΔF_{Raster} (kHz)	Uplink range of N_{REF} (First – <Step size> – Last)	Downlink range of N_{REF} (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 SS_{REF} with corresponding number GSCN. The parameters defining the SS_{REF} 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 SS_{REF} 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 SS_{REF}	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 [5].

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)	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: SS Block pattern is defined in clause 4.1 in TS 38.213 [7].			

6 Conducted transmitter characteristics

6.1 General

Unless otherwise stated, the conducted transmitter characteristics are specified at the *TAB connector* for *SAN type 1-H*, with a full complement of transceiver units for the configuration in normal operating conditions.

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	$P_{rated,c,sys}$ (NOTE)	$P_{rated,c,TABC}$ (NOTE)
SAN GEO class	$P_{rated,c,sys,GEO}$	$P_{rated,c,TABC,GEO}$
SAN LEO class	$P_{rated,c,sys,LEO}$	$P_{rated,c,TABC,LEO}$
NOTE: $P_{rated,c,sys}$ or $P_{rated,c,TABC}$ of SAN shall be based on manufacturer declaration and comply with regulation requirement.		

6.2.2 Minimum requirement for *SAN type 1-H*

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

[In extreme conditions, $P_{max,c,TABC}$ shall remain within +2.5 dB and -2.5 dB of the *rated carrier output power* $P_{rated,c,TABC}$ 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 ($P_{max,c,TABC}$) 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 on the RE	RE power control dynamic range (dB)	
	(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 bandwidth (MHz)	Total power dynamic range (dB)		
	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 this version of the specification.

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

Unwanted emissions consist of out-of-band emissions and spurious emissions according to ITU definitions [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 out-of-band emissions requirement for the SAN transmitter is specified both in terms of Adjacent Channel Leakage power Ratio (ACLR) and *operating band* unwanted emissions (OBUE).

The maximum offset of the *operating band* unwanted emissions mask from the *operating band* edge is Δf_{OBUE}. The Operating band unwanted emissions define all unwanted emissions in each supported downlink *operating band* plus the frequency ranges Δf_{OBUE} above and Δf_{OBUE} below each band. Unwanted emissions outside of this frequency range are limited by a spurious emissions requirement.

The values of Δf_{OBUE} are defined in table 6.6.1-1 for the SAN *operating bands*.

Table 6.6.1-1: Maximum offset of OBUE outside the downlink *operating band*

SAN type	*Operating band* characteristics	Δf_{OBUE} (MHz)
SAN type 1-H	$F_{DL,high} – F_{DL,low}$ < 100 MHz	$2*BW_{Channel}$

For *SAN type 1-H* the unwanted emission requirements are applied per the *TAB connector TX min cell groups* for all the configurations supported by the SAN.

There is in addition a requirement for occupied bandwidth.

6.6.2 Occupied bandwidth

6.6.2.1 General

The occupied bandwidth is the width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to a specified percentage $\beta/2$ of the total mean transmitted power. See also Recommendation ITU-R SM.328 [8].

The value of $\beta/2$ shall be taken as 0.5%.

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

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

6.6.2.2 Minimum requirement

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

6.6.3 Adjacent Channel Leakage Power Ratio

6.6.3.1 General

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 requirements shall apply outside the *SAN RF Bandwidth* or *Radio Bandwidth* whatever the type of transmitter considered (single carrier or multi-carrier) and for all transmission modes foreseen by the manufacturer's specification.

6.6.3.2 Minimum requirement

The ACLR is defined with a square filter of bandwidth equal to the transmission bandwidth configuration of the transmitted signal (BW_{Config}) centred on the assigned channel frequency and a filter centred on the adjacent channel frequency according to the tables below.

The ACLR shall be higher than the value specified in Table 6.6.3.2-1/2.

Table 6.6.3.2-1: SAN ACLR limit for GEO class

SAN channel bandwidth of lowest/highest carrier transmitted $BW_{Channel}$ (MHz)	SAN adjacent channel centre frequency offset below the lowest or above the highest carrier centre frequency transmitted	Assumed adjacent channel carrier (informative)	Filter on the adjacent channel frequency and corresponding filter bandwidth	ACLR limit
5, 10, 15, 20	$BW_{Channel}$	NR of same BW (NOTE 2)	Square (BW_{Config}) (NOTE 1)	14
	2 x $BW_{Channel}$	NR of same BW (NOTE 2)	Square (BW_{Config}) (NOTE 1)	14
NOTE 1: $BW_{Channel}$ and BW_{Config} are the *SAN channel bandwidth* and *transmission bandwidth configuration* of the *lowest/highest carrier* transmitted on the assigned channel frequency. NOTE 2: With SCS that provides largest transmission bandwidth configuration (BW_{Config}).				

Table 6.6.3.2-2: SAN ACLR limit for LEO class

SAN channel bandwidth of lowest/highest carrier transmitted $BW_{Channel}$ (MHz)	SAN adjacent channel centre frequency offset below the lowest or above the highest carrier centre frequency transmitted	Assumed adjacent channel carrier (informative)	Filter on the adjacent channel frequency and corresponding filter bandwidth	ACLR limit
5, 10, 15, 20	$BW_{Channel}$	NR of same BW (NOTE 2)	Square (BW_{Config}) (NOTE 1)	24
	2 x $BW_{Channel}$	NR of same BW (NOTE 2)	Square (BW_{Config}) (NOTE 1)	24
NOTE 1: $BW_{Channel}$ and BW_{Config} are the *SAN channel bandwidth* and *transmission bandwidth configuration* of the *lowest/highest carrier* transmitted on the assigned channel frequency. NOTE 2: With SCS that provides largest transmission bandwidth configuration (BW_{Config}).				

6.6.4 Operating band unwanted emissions

6.6.4.1 General

Unless otherwise stated, the operating band unwanted emission (OBUE) limits for SAN in FR1 are defined from channel edge up to frequencies separated from the channel edge by 200% of the necessary bandwidth.

The requirements shall apply whatever the type of transmitter considered and for all transmission modes foreseen by the manufacturer's specification.

Basic limits are specified in the tables below, where:

- Δf is the separation between the *channel edge* frequency and the nominal -3dB point of the measuring filter closest to the carrier frequency.
- f_offset is the separation between the *channel edge* frequency and the centre of the measuring filter.
- $PSD_{channel}$ represents the Power Spectral Density of the channel for a given channel bandwidth
- $BW_{Channel}$ is the considered NR *channel bandwidth* or SAN total *RF bandwidth* for a given *operating band*.
- $\Delta_{Sat\_Class}[dB]$ is the *SAN class parameter* in dB identified to characterize different SAN classes.

For a multi-carrier *single-band connector* the definitions above apply to the lower edge of the carrier transmitted at the *lowest carrier* frequency and the upper edge of the carrier transmitted at the *highest carrier* frequency within a specified frequency band.

- The operating band unwanted emission *basic limits* of the band where there are carriers transmitted, as defined in the tables of the present clause for the largest frequency offset (Δf_{max}), shall apply from channel edge up to frequencies separated from the channel edge by 200% of the necessary bandwidth.

6.6.4.2 Minimum requirements for *SAN type 1-H*

For SAN operating in Bands n256, n255, basic limits are specified in table 6.6.4.2-1 for GEO and LEO class respectively, in line with Annex 5 of ITU recommendation SM.1541-6 [9].

The SAN Operating Band Unwanted Emissions (OBUE) requirements for GEO and LEO classes are therefore defined as described in Table 6.6.4.2-1 below.

Table 6.6.4.2-1: SAN LEO and GEO Classes OBUE basic limits

Frequency offset of measurement filter -3dB point, Δf	**Frequency offset of measurement filter centre frequency, f_offset**	**Basic limits (dBm)**	**Measurement bandwidth**
0 MHz ≤ Δf < 2× $BW_{Channel}$	0.002 MHz ≤ f_offset < 2× $BW_{Channel}$ + 0.002 MHz	$max\left(SE\ limit,\ PSD_{channel} - \Delta_{Sat\_Class}[dB] - 40 \times log10\left(\frac{f_{\_offset} - 0.002}{BW_{Channel}} \times 2 + 1\right)\right) dBm$	4kHz
NOTE 1: $PSD_{channel} = P_{rated,c} - 10log10(BW_{Channel}) - 24$, unit dBm/4kHz. NOTE 2: SE limit is spurious emission limit specified in spurious emission clause 6.6.5. NOTE 3: PSD attenuation as in ITU-R SM.1541-6 [9], Annex 5 OoB domain emission limits for space services. NOTE 4: $\Delta_{Sat\_Class}[dB]$=0 dB for GEO class and $\Delta_{Sat\_Class}[dB]$=3 dB for LEO class.			

6.6.5 Transmitter spurious emissions

6.6.5.1 General

The transmitter spurious emission limits shall apply from 30 MHz to the fifth harmonic of the upper frequency edge of the DL operating band, excluding the frequency range from Δf_{OBUE} below the lowest frequency of each supported downlink *operating band*, up to Δf_{OBUE} above the highest frequency of each supported downlink *operating band*, where the Δf_{OBUE} is defined in table 6.6.1-1. For some *operating bands*, the upper limit is higher than 12.75 GHz in order to comply with the 5th harmonic limit of the downlink *operating band*, as specified in ITU-R recommendation SM.329 [2].

The requirements shall apply whatever the type of transmitter considered (single carrier or multi-carrier). It applies for all transmission modes foreseen by the manufacturer's specification.

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

6.6.5.2 Basic Limits

6.6.5.2.1 General transmitter spurious emissions requirements

The *basic limits* of table 6.6.5.2.1-1 shall apply. The application of those limits shall be the same as for operating band unwanted emissions in clause 6.6.4.

Table 6.6.5.2.1-1: General SAN transmitter spurious emission limits in FR1

Spurious frequency range	$P_{rated,c,sys}$	Basic limit	Measurement bandwidth	Notes
30 MHz – 5th harmonic of the upper frequency edge of the DL operating band	≤ 47 dBm	-13 dBm	4 kHz	NOTE 1, NOTE 2, NOTE 3
	> 47 dBm	$P_{rated,c,sys}$ – 60 dBm		
NOTE 1: *Measurement bandwidth*s as in ITU-R SM.329 [2], s4.1. NOTE 2: Upper frequency as in ITU-R SM.329 [2], s2.5 table 1. NOTE 3: The lower frequency limit is replaced by 0.7 times the waveguide cut-off frequency, according to ITU-R SM.329 [2], for systems having an integral antenna incorporating a waveguide section, or with an antenna connection in such form, and of unperturbed length equal to at least twice the cut-off.				

6.6.5.2.2 Protection of the own Satellite Access Node receiver

This requirement shall be applied for NR FDD operation in order to prevent the receivers of the SAN being de-sensitized by emissions from its own SAN transmitter. It is measured at the *TAB connector* for *SAN type 1-H* for any type of SAN which has common or separate Tx/Rx *TAB connectors*.

The spurious emission *basic limits* are provided in table 6.6.5.2.2-1.

Table 6.6.5.2.2-1: SAN spurious emissions *basic limits* for protection of the SAN receiver

Frequency range	*Basic limits*	*Measurement bandwidth*
$F_{UL,low}$ – $F_{UL,high}$	-96 dBm	100 kHz

6.6.5.2.3 Additional spurious emissions requirements

The additional spurious emissions requirement is not applicable for SAN.

6.6.5.2.4 Co-location with other Satellite Access Nodes

The co-location requirement is not applicable for SAN.

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: 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 $P_{REFSENS}$ 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 (NOTE)	Reference sensitivity power level, $P_{REFSENS}$ (dBm)
5, 10, 15	15	G-FR1-A1-1	-99.3
10, 15	30	G-FR1-A1-2	-99.4
10, 15	60	G-FR1-A1-3	-96.5
20	15	G-FR1-A1-4	-92.9
20	30	G-FR1-A1-5	-93.2
20	60	G-FR1-A1-6	-93.3
NOTE: $P_{REFSENS}$ 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 (NOTE)	Reference sensitivity power level, $P_{REFSENS}$ (dBm)
5, 10, 15	15	G-FR1-A1-1	-102.4
10, 15	30	G-FR1-A1-2	-102.5
10, 15	60	G-FR1-A1-3	-99.6
20	15	G-FR1-A1-4	-96.0
20	30	G-FR1-A1-5	-96.3
20	60	G-FR1-A1-6	-96.4
NOTE: $P_{REFSENS}$ 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) / BW_{Config}	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 and 7.2.2-2 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 C.

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)	$P_{REFSENS}$ + 6 dB (NOTE 2)	GEO SAN class: -57 LEO 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: $P_{REFSENS}$ depends on the *SAN channel bandwidth* as specified in table 7.2.2-1 and 7.2.2-2.		

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	5 MHz CP-OFDM NR signal 15 kHz SCS, 25 RBs
10	±2.5075	
15	±2.5125	
20	±2.5025	

7.4.2 In-band blocking

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

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 $F_{UL,low}$ - Δf_{OOB} and from $F_{UL,high}$ + Δf_{OOB} up to 12750 MHz, including the downlink frequency range of the FDD *operating band* for SAN. The Δf_{OOB} for *SAN type 1-H* is defined in table 7.5.2-2.

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
$P_{REFSENS}$ +6 dB (NOTE)	-44	CW carrier
NOTE: For SAN, $P_{REFSENS}$ depends on the *SAN channel bandwidth*.		

Table 7.5.2-2: Δf_{OOB} offset for NR *operating bands*

SAN type	*Operating band* characteristics	Δf_{OOB} (MHz)
SAN type 1-H	$F_{UL,high} – F_{UL,low}$ < 100 MHz	20

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 SAN receiver 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 [2], s4.1. NOTE 2: Upper frequency as in ITU-R SM.329 [2], s2.5 table 1. NOTE 3: The frequency range from Δf_{OBUE} below the lowest frequency of the SAN transmitter *operating band* to Δf_{OBUE} above the highest frequency of the SAN transmitter *operating band* may be excluded from the requirement. Δf_{OBUE} 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 C.

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 F_c, where the F_c is defined for *SAN channel bandwidth* of the wanted signal according 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 F_c, where the F_c is defined for *SAN channel bandwidth* of the wanted signal according 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 [3]. 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 [3].

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.

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 [3].

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*, $P_{max,c,TRP}$ measured at the RIB shall remain within ±2 dB of the *rated carrier TRP output power* $P_{rated,c,TRP}$, as declared by the manufacturer.

Normal conditions are defined in TS 38.181 [3].

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 ($P_{max,c,EIRP}$) 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 ($P_{max,c,EIRP}$) 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 Δf_{OBUE} above and Δf_{OBUE} below each band. OTA Unwanted emissions outside of this frequency range are limited by an OTA spurious emissions requirement.

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

Table 9.7.1-1: Maximum offset Δf_{OBUE} outside the downlink *operating band*

SAN type	*Operating band* characteristics	Δf_{OBUE} (MHz)
SAN type 1-O	$F_{DL,high} – F_{DL,low} < 100$ 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 $\beta/2$ of the total mean transmitted power. See also recommendation ITU-R SM.328 [8].

The value of $\beta/2$ 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 Δf_{OBUE} below the lowest frequency of each supported downlink operating band up to Δf_{OBUE} above the highest frequency of each supported downlink operating band. The values of Δf_{OBUE} 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 Δf_{OBUE} below the lowest frequency of each supported downlink *operating band*, up to Δf_{OBUE} above the highest frequency of each supported downlink *operating band*, where the Δf_{OBUE} is defined in table 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:

$$\Delta_{OTAREFSENS} = 44.1 - 10*\log_{10}(BeW_{\theta,REFSENS}*BeW_{\varphi,REFSENS}) \text{ dB for the reference direction}$$

and

$$\Delta_{OTAREFSENS} = 41.1 - 10*\log_{10}(BeW_{\theta,REFSENS}*BeW_{\varphi,REFSENS}) \text{ dB for all other directions}$$

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

$$\Delta_{minSENS} = P_{REFSENS} – EIS_{minSENS} \text{ (dB)}$$

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 EIS level 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 38.181 [3].
- 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 EIS level 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 $EIS_{REFSENS}$ 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 $EIS_{REFSENS}$ 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, $EIS_{REFSENS}$ (dBm)
5, 10, 15	15	G-FR1-A1-1	$-99.3 - \Delta_{OTAREFSENS}$
10, 15	30	G-FR1-A1-2	$-99.4 - \Delta_{OTAREFSENS}$
10, 15	60	G-FR1-A1-3	$-96.5 - \Delta_{OTAREFSENS}$
20	15	G-FR1-A1-4	$-92.9 - \Delta_{OTAREFSENS}$
20	30	G-FR1-A1-5	$-93.2 - \Delta_{OTAREFSENS}$
20	60	G-FR1-A1-6	$-93.3 - \Delta_{OTAREFSENS}$
NOTE: $EIS_{REFSENS}$ 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, $EIS_{REFSENS}$ (dBm)
5, 10, 15	15	G-FR1-A1-1	$-102.4 - \Delta_{OTAREFSENS}$
10, 15	30	G-FR1-A1-2	$-102.5 - \Delta_{OTAREFSENS}$
10, 15	60	G-FR1-A1-3	$-99.6 - \Delta_{OTAREFSENS}$
20	15	G-FR1-A1-4	$-96.0 - \Delta_{OTAREFSENS}$
20	30	G-FR1-A1-5	$-96.3 - \Delta_{OTAREFSENS}$
20	60	G-FR1-A1-6	$-96.4 - \Delta_{OTAREFSENS}$
NOTE: $EIS_{REFSENS}$ 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) / BW_{Config}	Type of interfering signal
5	15	G-FR1-A2-1	-76.4 - $\Delta_{OTAREFSENS}$	-88.2 - $\Delta_{OTAREFSENS}$	AWGN
	30	G-FR1-A2-2	-77.1 - $\Delta_{OTAREFSENS}$		
10	15	G-FR1-A2-1	-76.4 - $\Delta_{OTAREFSENS}$	-85.0 - $\Delta_{OTAREFSENS}$	AWGN
	30	G-FR1-A2-2	-77.1 - $\Delta_{OTAREFSENS}$		
	60	G-FR1-A2-3	-74.1- $\Delta_{OTAREFSENS}$		
15	15	G-FR1-A2-1	-76.4- $\Delta_{OTAREFSENS}$	-83.2 - $\Delta_{OTAREFSENS}$	AWGN
	30	G-FR1-A2-2	-77.1 - $\Delta_{OTAREFSENS}$		
	60	G-FR1-A2-3	-74.1 - $\Delta_{OTAREFSENS}$		
20	15	G-FR1-A2-4	-70.2 - $\Delta_{OTAREFSENS}$	-81.9 - $\Delta_{OTAREFSENS}$	AWGN
	30	G-FR1-A2-5	-70.2 - $\Delta_{OTAREFSENS}$		
	60	G-FR1-A2-6	-70.5 - $\Delta_{OTAREFSENS}$		
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 C.

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)	$EIS_{minSENS}$ + 6 dB	LEO SAN class: -60 – $\Delta_{minSENS}$ GEO SAN class: -57 – $\Delta_{minSENS}$
NOTE 1: The SCS for the *lowest/highest carrier* received is the lowest SCS supported by the SAN for that bandwidth NOTE 2: $EIS_{minSENS}$ 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 CP-OFDM NR signal, 15 kHz SCS, 25 RBs
10	±2.5075	
15	±2.5125	
20	±2.5025	

10.5.2 OTA in-band blocking

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

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 RIB when 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 $F_{UL,low}$ - Δf_{OOB} and from $F_{UL,high}$ + Δf_{OOB} up to 12750 MHz, including the downlink frequency range of the SAN *operating band*. The Δf_{OOB} for *SAN type 1-O* is defined in table 10.6.2.1-2.

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
$EIS_{minSENS}$ + 6 dB (NOTE 1)	0.0029 (NOTE 2)	CW carrier
NOTE 1: $EIS_{minSENS}$ 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 $E=\frac{\sqrt{30EIRP}}{r}$, where EIRP is in W and r is in m.		

Table 10.6.2.1-2: Δf_{OOB} offset for satellite *operating bands*

SAN type	*Operating band* characteristics	Δf_{OOB} (MHz)
SAN type 1-O	$F_{UL,high}$ – $F_{UL,low}$ < 100 MHz	20

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 [2], s4.1. NOTE 2: Upper frequency as in ITU-R SM.329 [2], s2.5 table 1. NOTE 3: The frequency range from Δf_{OBUE} below the lowest frequency of the SAN transmitter *operating band* to Δf_{OBUE} above the highest frequency of the SAN transmitter *operating band* may be excluded from the requirement. Δf_{OBUE} 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 RIB when 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 C.

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 - $\Delta_{minSENS}$	-92.0 - $\Delta_{minSENS}$	DFT-s-OFDM NR signal, 15 kHz SCS, 10 RBs
10,15,20	15	G-FR1-A1-1	-96.3 - $\Delta_{minSENS}$	-88.1 - $\Delta_{minSENS}$	DFT-s-OFDM NR signal, 15 kHz SCS, 25 RBs
5	30	G-FR1-A1-8	-98.9 - $\Delta_{minSENS}$	-92.0 - $\Delta_{minSENS}$	DFT-s-OFDM NR signal, 30 kHz SCS, 5 RBs
10,15,20	30	G-FR1-A1-2	-96.4 - $\Delta_{minSENS}$	-89.0 - $\Delta_{minSENS}$	DFT-s-OFDM NR signal, 30 kHz SCS, 10 RBs
10,15,20	60	G-FR1-A1-9	-95.8 - $\Delta_{minSENS}$	-89.0 - $\Delta_{minSENS}$	DFT-s-OFDM NR signal, 60 kHz SCS, 5 RBs
NOTE: Wanted and interfering signal are placed adjacently around F_c, where the F_c is defined for *SAN channel bandwidth* of the wanted signal according 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 - $\Delta_{minSENS}$	-83.1 - $\Delta_{minSENS}$	DFT-s-OFDM NR signal, 15 kHz SCS, 10 RBs
10,15,20	15	G-FR1-A1-1	-99.4 - $\Delta_{minSENS}$	-79.2 - $\Delta_{minSENS}$	DFT-s-OFDM NR signal, 15 kHz SCS, 25 RBs
5	30	G-FR1-A1-8	-102.0 - $\Delta_{minSENS}$	-83.1 - $\Delta_{minSENS}$	DFT-s-OFDM NR signal, 30 kHz SCS, 5 RBs
10,15,20	30	G-FR1-A1-2	-99.5 - $\Delta_{minSENS}$	-80.1 - $\Delta_{minSENS}$	DFT-s-OFDM NR signal, 30 kHz SCS, 10 RBs
10,15,20	60	G-FR1-A1-9	-98.9 - $\Delta_{minSENS}$	-80.1 - $\Delta_{minSENS}$	DFT-s-OFDM NR signal, 60 kHz SCS, 5 RBs
NOTE: Wanted and interfering signal are placed adjacently around F_c, where the F_c is defined for *SAN channel bandwidth* of the wanted signal according 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, 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 l_0= 2, l = 11 as per table 6.4.1.1.3-3 of TS 38.211 [5]. 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 [10].									

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 l_0= 2, l = 11 as per table 6.4.1.1.3-3 of TS 38.211 [5]. 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 [10].						

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.

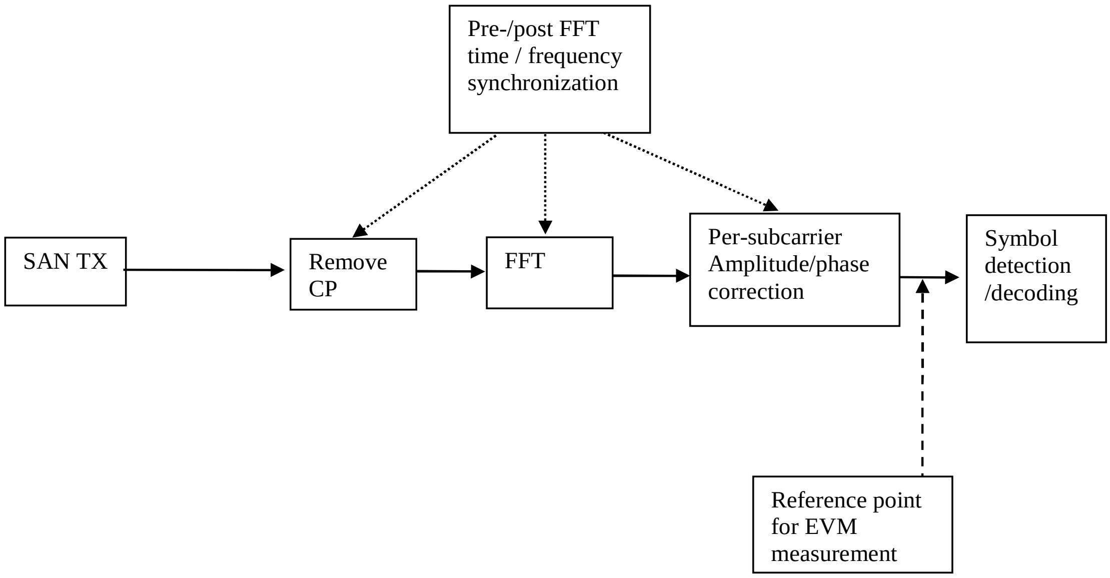


Figure B.1-1: Reference point for EVM measurement

B.2 Basic unit of measurement

The basic unit of EVM measurement is defined over one slot in the time domain and N_{BW}^{RB} subcarriers in the frequency domain:

$$EVM = \sqrt{\frac{\sum_{t \in T} \sum_{f \in F(t)} \left| Z'(t,f) - I(t,f) \right|^2}{\sum_{t \in T} \sum_{f \in F(t)} \left| I(t,f) \right|^2}}$$

where

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

$F(t)$ is the set of subcarriers within the $N_{\mathrm{BW}}^{\mathrm{RB}}$ subcarriers with the considered modulation scheme being active in symbol t,

$I(t,f)$ is the ideal signal reconstructed by the measurement equipment in accordance with relevant Tx models,

$Z'(t,f)$ 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:

$$Z'(t,f) = \frac{FFT\left\{z(v-\Delta\tilde{t}) \cdot e^{-j2\pi\Delta\tilde{f}v}\right\} e^{j2\pi f\Delta\tilde{t}}}{\tilde{a}(f) \cdot e^{j\tilde{\varphi}(f)}}$$

where

$z(v)$ is the time domain samples of the signal under test.

$\Delta\tilde{t}$ 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.

$\Delta\tilde{f}$ is the RF frequency offset.

$\tilde{\varphi}(f)$ is the phase response of the TX chain.

$\tilde{a}(f)$ is the amplitude response of the TX chain.

B.4 Estimation of frequency offset

The observation period for determining the frequency offset $\Delta\tilde{f}$ shall be 1 slot.

B.5 Estimation of time offset

B.5.1 General

The observation period for determining the sample timing difference $\Delta\tilde{t}$ shall be 1 slot.

In the following $\Delta\tilde{c}$ 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.

$\Delta\tilde{c}$ 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 $\Delta\tilde{t}$ are determined:

$$\Delta\tilde{t}_l = \Delta\tilde{c} + \alpha - \left\lfloor \frac{W}{2} \right\rfloor$$ and

$$\Delta\tilde{t}_h = \Delta\tilde{c} + \left\lfloor \frac{W}{2} \right\rfloor$$ where $\alpha = 0$ if *W* is odd and $\alpha = 1$ 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

Channel bandwidth (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

Channel bandwidth (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

Channel bandwidth (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

Channel bandwidth (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 $\tilde{a}(f)$ and $\tilde{\varphi}(f)$ are determined as follows:

1. Calculate the complex ratios (amplitude and phase) of the post-FFT acquired signal $Z'(t,f)$ and the post-FFT ideal signal $I_2(t,f)$, for each reference signal, over 10ms measurement interval. This process creates a set of complex ratios:

   $$a(t,f).e^{j\varphi(t,f)} = \frac{Z'(t,f)}{I_2(t,f)}$$

   Where the post-FFT ideal signal $I_2(t,f)$ 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 $\varphi(t_i,f)$ an unwrap operation must be performed according to the following definition: The unwrap operation corrects the radian phase angles of $\varphi(t_i,f)$ by adding multiples of 2*PI when absolute phase jumps between consecutive time instances t_i 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).

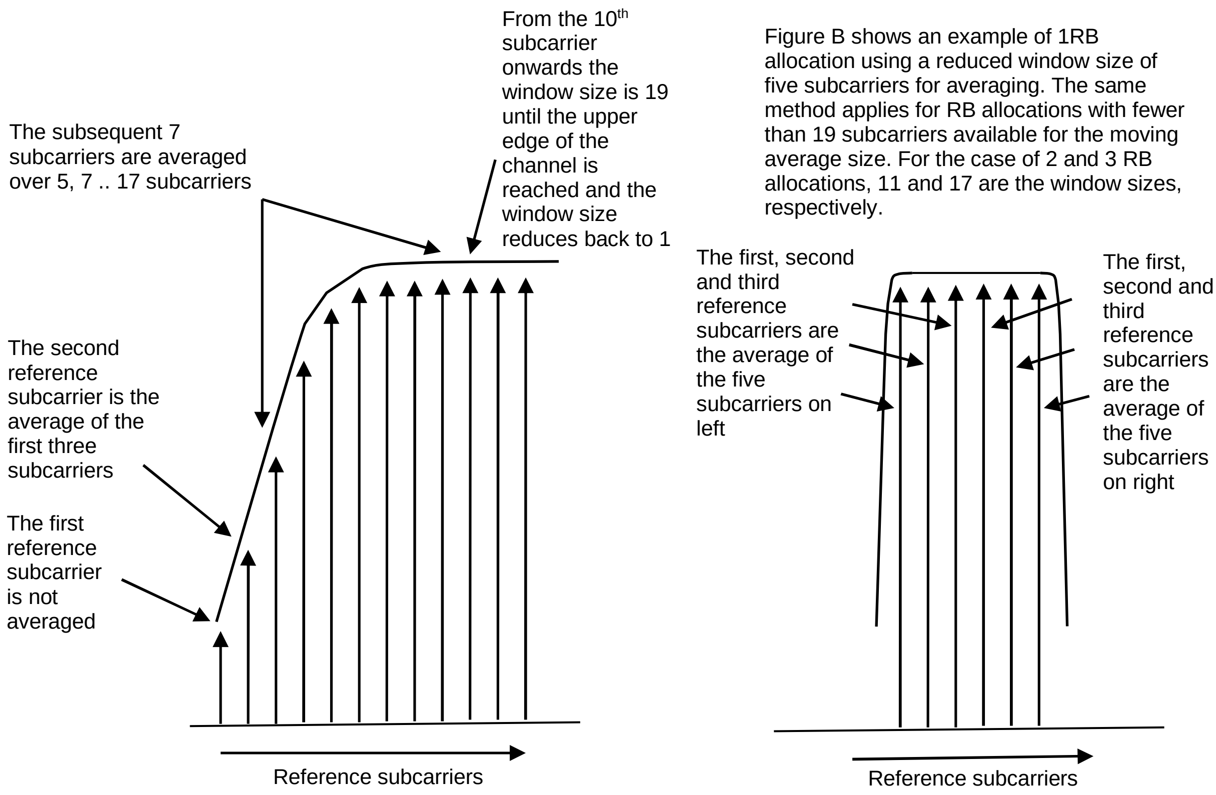
   $$a(f) = \frac{\sum_{i=1}^{N} a(t_i,f)}{N}$$

   $$\varphi(f) = \frac{\sum_{i=1}^{N} \varphi(t_i,f)}{N}$$

   Where *N* is the number of reference signal; time-domain locations t_i from $Z'(t,f)$ for each reference signal subcarrier f.

3. The equalizer coefficients for amplitude and phase $\hat{a}(f)$ and $\hat{\varphi}(f)$ 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 $\hat{a}(f)$ and $\hat{\varphi}(f)$ to compute coefficients $\tilde{a}(f)$, $\tilde{\varphi}(f)$ for each subcarrier.



A. Moving averaging at channel edge

B. Moving averaging for the case when the number of available reference subcarriers within a set of contiguously allocated RBs is smaller than the moving average window size

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 N_{dl} slots where N_{dl} is the number of slots in a 10 ms measurement interval.

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

$$\overline{EVM}_{frame} = \sqrt{\frac{1}{\sum_{i=1}^{N_{dl}} Ni} \sum_{i=1}^{N_{dl}} \sum_{j=1}^{Ni} EVM_{i,j}^2}$$

- 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 $\overline{\mathrm{EVM}}_{\mathrm{frame},l}$ is calculated using $\Delta\tilde{t} = \Delta\tilde{t}_l$ in the expressions above and $\overline{\mathrm{EVM}}_{frame,h}$ is calculated using $\Delta\tilde{t} = \Delta\tilde{t}_h$ in the $\overline{EVM}_{frame}$ calculation.
- Thus we get:

$$\overline{EVM} = \max\left(\overline{EVM}_{\mathrm{frame,l}}, \overline{EVM}_{\mathrm{frame,h}}\right)$$

Annex C (normative): Characteristics of the interfering signals

The interfering signal shall be a PUSCH or PDSCH containing data and DM-RS symbols. Normal cyclic prefix is used. The data content shall be uncorrelated to the wanted signal and modulated according to clause 6 of TS 38.211 [9]. Mapping of PUSCH or PDSCH modulation to receiver requirement are specified in table C-1.

Table C-1: Modulation of the interfering signal

Receiver requirement	Modulation	Interfering signal	Clauses
In-channel selectivity	16QAM	PUSCH	7.8 10.9
Adjacent channel selectivity	QPSK	PDSCH	7.4.1 10.5.1
General blocking	N/A	N/A	N/A
Receiver intermodulation	N/A	N/A	N/A

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				TP for 38.108: clause 7.1&7.2 on Rx refsens sensitivity	0.1.0
2022-03	RAN4#102-e	R4-2205057				pCR to TS 38.108 -Radiated Tx general and transmit power	0.1.0
2022-03	RAN4#102-e	R4-2207331				TP for 38.108: clause 5.3&5.4 on system parameters	0.1.0
2022-03	RAN4#102-e	R4-2207335				TP for TS 38.108: General (5.1) and Operating Band (5.2)	0.1.0
2022-03	RAN4#102-e	R4-2207336				Draft text proposal for Clause 4.4 Satellite Access Node classes - TS 38.108	0.1.0
2022-03	RAN4#102-e	R4-2207337				TP for 38.108: clause 4.3 requirement reference point	0.1.0
2022-03	RAN4#102-e	R4-2207340				TP to TR 38.108 on 4.5 Regional Requirement	0.1.0
2022-03	RAN4#102-e	R4-2207354				pCR to TS 38.108 - Scope and general	0.1.0
2022-03	RAN4#102-e	R4-2207355				TP to TS 38.108: section 4	0.1.0
2022-03	RAN4#102-e	R4-2207356				TP to TS 38.108: section 3	0.1.0
2022-03	RAN4#102-e	R4-2207357				TP for 38.108: clause 9.7 OTA unwanted emissions	0.1.0
2022-03	RAN4#102-e	R4-2207359				TP for TS 38.108 OTA output power dynamics(9.4)	0.1.0
2022-03	RAN4#102-e	R4-2207361				TP to TS 38.108: 9.5 (OTA Tx ON/OFF), 9.6 (OTA TX signal quality) and 9.8 (OTA Tx IMD)	0.1.0
2022-03	RAN4#102-e	R4-2207362				TP for 38.108: clause 9.3 OTA Satellite Access Node output power	0.1.0
2022-03	RAN4#102-e	R4-2207363				TP for TS 38.108 Annex B	0.1.0
2022-03	RAN4#102-e	R4-2207364				TP for 38.108: clause 10.5 OTA in-band selectivity and blocking	0.1.0
2022-03	RAN4#102-e	R4-2207365				pCR to TS 38.108 - Radiated Rx general and sensitivity	0.1.0
2022-03	RAN4#102-e	R4-2207366				TP for TS 38.108 OTA Rx requirements(10.3, 10.4,10.6 and 10.9)	0.1.0
2022-03	RAN4#102-e	R4-2207368				TP to TS 38.108: section 10.7 (OTA Rx spur) and 10.8 (OTA Rx IMD)	0.1.0
2022-03	RAN4#102-e	R4-2207371				TP to TS 38.108: section 10.7 (OTA Rx spur) and 10.8 (OTA Rx IMD)	0.1.0
2022-03	RAN4#102-e	R4-2207372				Draft text proposal for Clause 6.1 and 6.2 Satellite Access Node output power - TS 38.108	0.1.0
2022-03	RAN4#102-e	R4-2207373				TP to TS 38.108: section 6.4 (Tx ON/OFF) and 6.5 (TX signal quality)	0.1.0
2022-03	RAN4#102-e	R4-2207374				TP to TS 38.108: section 6.7 (Tx IMD)	0.1.0
2022-03	RAN4#102-e	R4-2207377				pCR to TS 38.108 - In-band selectivity and blocking	0.1.0
2022-03	RAN4#102-e	R4-2207378				TP for TS 38.108 Dynamic range(7.3) and In channel selectivity(7.8)	0.1.0
2022-03	RAN4#102-e	R4-2207380				Draft text proposal for Clause 7.5 Out-of-band blocking - TS 38.108	0.1.0
2022-03	RAN4#102-e	R4-2207382				TP to TS 38.108: section 7.6 (Rx spur) and section 7.7 (Rx IMD)	0.1.0
2022-03	RAN4#102-e	R4-2207383				TP to TS 38.108: annex A (FRC)	0.1.0
2022-05	RAN4#103-e	R4-2208663				TP to TS 38.108 on Conducted receiver characteristics	0.2.0
2022-05	RAN4#103-e	R4-2210849				pCR for Clause 4.3 Requirement reference points - TS 38.108	0.2.0
2022-05	RAN4#103-e	R4-2210850				pCR for Annex D - TS 38.108	0.2.0
2022-05	RAN4#103-e	R4-2210854				TP for 38.108: clause 7.3.2 Conducted transmission characteristics	0.2.0
2022-05	RAN4#103-e	R4-2210855				pCR to TS 38.108 – Transmitter spurious	0.2.0
2022-05	RAN4#103-e	R4-2210856				pCR to TS 38.108 – cleanup - alignment	0.2.0
2022-05	RAN4#103-e	R4-2210857				TP to TS 38.108 on 6.0 Conducted transmitter characteristics	0.2.0
2022-05	RAN4#103-e	R4-2210861				pCR for Clause 7.4 In-band selectivity and blocking - TS 38.108	0.2.0
2022-05	RAN4#103-e	R4-2210862				pCR for Clause 7.5 Out-of-band blocking - TS 38.108	0.2.0
2022-05	RAN4#103-e	R4-2210863				pCR for Clause 7.6 Receiver spurious emissions - TS 38.108	0.2.0
2022-05	RAN4#103-e	R4-2210864				pCR for Clause 10.6.2 Minimum requirement for SAN type 1-O - TS 38.108	0.2.0
2022-05	RAN4#103-e	R4-2210873				TP for TS 38.108, 6.6.4 Operating band unwanted emissions	0.2.0
2022-05	RAN4#103-e	R4-2211135				TP to TS 38.108: TS corrections; RF requirements	0.2.0
2022-05	RAN4#103-e	R4-2211202				TP to TS 38.108: removal of extreme conditions requirements	0.2.0
2022-06	RAN#96	RP-221342				For RAN 1-step approval	1.0.0

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2022-06	RAN#96					Approved by plenary – Rel-17 spec under change control	17.0.0

History

Document history		
V17.0.0	July 2022	Publication