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Contents

Foreword

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- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
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The constructions "can" and "cannot" are not substitutes for "may" and "need not".

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

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

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

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

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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 Satellite Access Node (SAN) supporting standalone NB-IoT operation or E-UTRA.

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 36.181: "Evolved Universal Terrestrial Radio Access (E-UTRA); Satellite Access Node conformance testing; 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] ITU-R Recommendation SM.328: "Spectra and bandwidth of emissions".

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

[7] 3GPP TS 38.108: “Satellite Access Node radio transmission and reception”.

[8] void

[9] 3GPP TS 36.211: Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation”

[10] 3GPP TR 38 811: "Study on New Radio (NR) to support non-terrestrial networks".

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].

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.

Channel edge: lowest or highest frequency of the E-UTRA 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.

necessary bandwidth: The width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions.

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 E-UTRA 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 E-UTRA SAN requirement's set as defined for *SAN type 1-H*, *SAN type 1-O*.

SAN channel bandwidth: RF bandwidth supporting a single E-UTRA 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 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*.

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.

SAN transponder bandwidth: Total bandwidth of the carrier(s) in operation by one SAN transponder.

NOTE: When the SAN transponder operates one carrier only, the SAN transponder bandwidth is equal to the SAN channel bandwidth of this carrier.

SAN transponder: part of the SAN permitting to receive, channelize and transmit signals within an allocated bandwidth.

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).

Satellite Access Node: node providing E-UTRA 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.

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.

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.
$BW_{Channel}$	*SAN channel bandwidth.*
BW_{Config}	*Transmission bandwidth configuration*, where BW_{Config} = *E-UTRA*$_B$ x SCS x 12.
BW_{SAN}	The *SAN transponder bandwidth*ΔfSeparation between the *channel edge* frequency and the nominal -3 dB point of the measuring filter closest to the carrier frequency.
Δf_{max}	f_offset$_{max}$ minus half of the bandwidth of the measuring filter.
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.
$EIS_{minSENS}$	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.
$F_{C,low}$	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.
$F_{UL,low}$	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.
n_{PRB}	Physical resource block number.
M_{DL}	Offset of NB-IoT Downlink channel number to Downlink EARFCN
M_{UL}	Offset of NB-IoT Uplink channel number to Uplink EARFCN
N_{DL}	Downlink EARFCN
$N_{Offs-DL}$	Offset used for calculating downlink EARFCN
$N_{Offs-UL}$	Offset used for calculating uplink EARFCN
N_{RB}	*Transmission bandwidth configuration*, expressed in resource blocks.
N_{UL}	Uplink EARFCN
$P_{EIRP,N}$	EIRP level for channel N.
$P_{max,c,TABC}$	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 ($P_{rated,c,TRP}$).
$P_{rated,c,sys}$	$P_{rated,c,sys,GEO}$ for SAN GEO class or $P_{rated,c,sys,LEO}$ for SAN LEO class.
$P_{rated,c,TRP}$	*Rated carrier TRP output power* declared per RIB.
$P_{rated,c,sys,GEO}$	The sum of $P_{rated,c,TABC}$ for all *TAB connectors* for a single carrier of the SAN GEO class.
$P_{rated,c,sys,LEO}$	The sum of $P_{rated,c,TABC}$ for all *TAB connectors* for a single carrier of the SAN LEO class.
$P_{rated,c,TABC}$	$P_{rated,c,TABC,GEO}$ for SAN GEO class or $P_{rated,c,TABC,LEO}$ for SAN LEO class.
$P_{rated,c,TABC,GEO}$	The *rated carrier output power per TAB connector* of the SAN GEO class.
$P_{rated,c,TABC,LEO}$	The *rated carrier output power per TAB connector* of the SAN LEO class.
$P_{rated,t,TABC}$	The *rated total output power* declared at *TAB connector.*
$P_{rated,c,TRP}$	*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.
$P_{rated,t,sys}$	The sum of $P_{rated,t,TABC}$ for all *TAB connectors.*

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
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
EARFCN	E-UTRA Absolute Radio Frequency Channel Number
EIRP	Equivalent Isotropic Radiated Power
EIS	Equivalent Isotropic Sensitivity
EVM	Error Vector Magnitude
E-UTRA	Evolved UTRA
FR	Frequency Range
FRC	Fixed Reference Channel
GEO	Geostationary Earth Orbiting
ICS	In-Channel Selectivity
LEO	Low Earth Orbiting
MCS	Modulation and Coding Scheme
NB-IoT	Narrowband – Internet of Things
NTN	Non-Terrestrial Network
OOB	Out-of-band
OOBE	Out-of-band Emissions
OSDD	OTA Sensitivity Directions Declaration
OTA	Over-The-Air
PRB	Physical Resource Block
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
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 36.181 [3].

The minimum requirements given in this specification make no allowance for measurement uncertainty. The test specifications TS 36.181 [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.

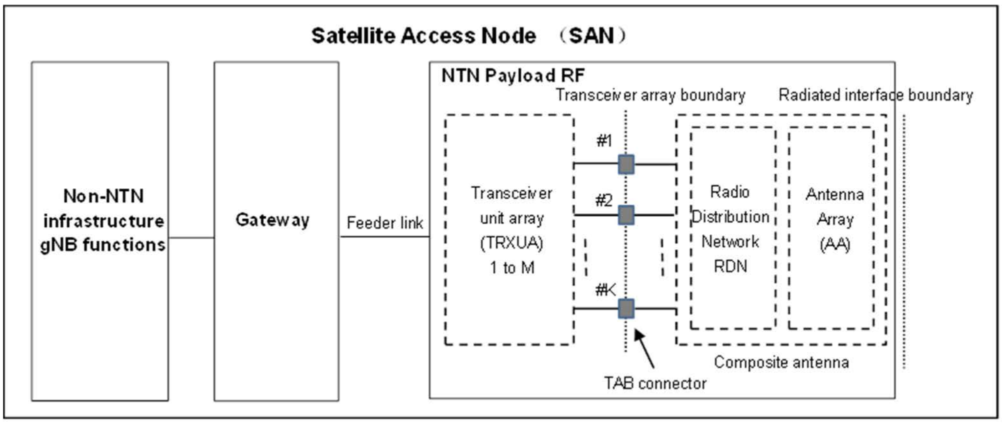

Figure 4.3.1-1: Radiated and conducted reference points for *SAN type 1-H*

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 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.

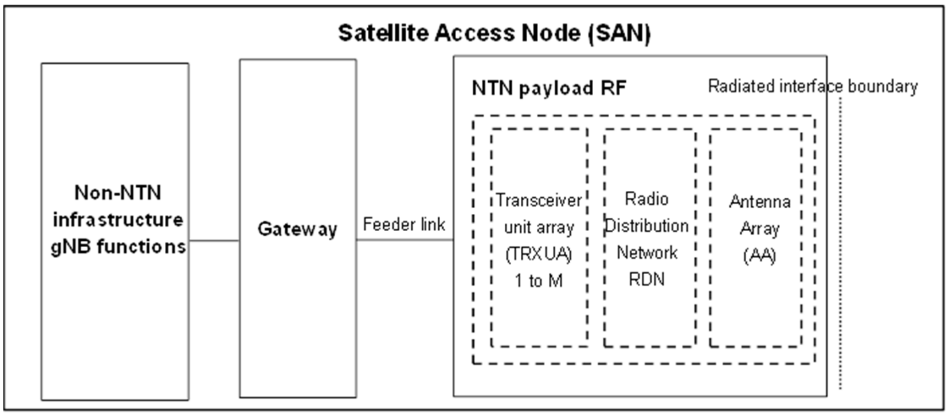

Figure 4.3.2-1: Radiated reference points for *SAN type 1-O*

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 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, 9.7.4	Out-of-band emissions OTA out-of-band emissions	For band 255 operation in US, Limits in FCC Title 47 apply.
6.6.5 9.7.5	Tx spurious emissions, OTA Tx spurious emissions	For band 255 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***
SAN output power	6.2	NA
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	
Out-of-band emissions	6.6.4	
Transmitter spurious emissions	6.6.5	
Transmitter intermodulation	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	NA	
Receiver intermodulation	NA	
In-channel selectivity	7.8	
Performance requirements	8	
Radiated transmit power	9.2	9.2
OTA SAN output power	NA	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		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	NA	10.3
OTA dynamic range		10.4
OTA ACS		10.5.1
OTA in-band blocking		NA
OTA out-of-band blocking		10.6
OTA receiver spurious emission		NA
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 channel bandwidths defined in the present release of specifications.

NOTE: Other operating bands and channel bandwidths may be considered in future releases.

5.2 Operating bands

EUTRA SAN is designed to operate in the operating bands defined in Table 5.2-1.

Table 5.2-1 E-UTRA operating bands for satellite access

E-UTRA Operating Band	Uplink (UL) operating band SAN receive UE transmit			Downlink (DL) operating band SAN transmit UE receive			Duplex Mode
	F_{UL_low}	–	F_{UL_high}	F_{DL_low}	–	F_{DL_high}	
256	1980 MHz	–	2010 MHz	2170 MHz	–	2200 MHz	FDD
255	1626.5 MHz	–	1660.5 MHz	1525 MHz	–	1559 MHz	FDD
254	1610 MHz	-	1626.5 MHz	2483.5 MHz	-	2500 MHz	FDD
253	1668 MHz	-	1675 MHz	1518 MHz	-	1525 MHz	FDD
NOTE: Satellite bands are numbered in descending order from 256.							

5.2A Operating bands for UE category M1

UE category M1 is designed to operate in the E-UTRA satellite access operating bands defined in Table 5.2-1 in both half duplex FDD mode and full-duplex FDD mode.

5.2B Operating bands for category NB1 and NB2

Category NB1 and NB2 UE are designed to operate in the E-UTRA satellite access operating bands defined in Table 5.2-1.

Category NB1 and NB2 UE operate in HD-FDD duplex mode.

5.3 Satellite Access Node channel bandwidth

5.3A Channel bandwidth for category M1

The requirements in present document are specified for the channel bandwidth listed in Table 5.3A-1.

Table 5.3A-1: Transmission bandwidth configuration N_{RB} in E-UTRA channel bandwidths

Channel bandwidth $BW_{Channel}$ (MHz)	1.4
Transmission bandwidth configuration N_{RB}	6

Figure 5.3A-1 shows the relation between the *SAN channel bandwidth* and the transmission bandwidth configuration (N_{RB}). The channel edges are defined as the lowest and highest frequencies of the carrier separated by the channel bandwidth, i.e. at F_C +/- $BW_{Channel}$ /2.

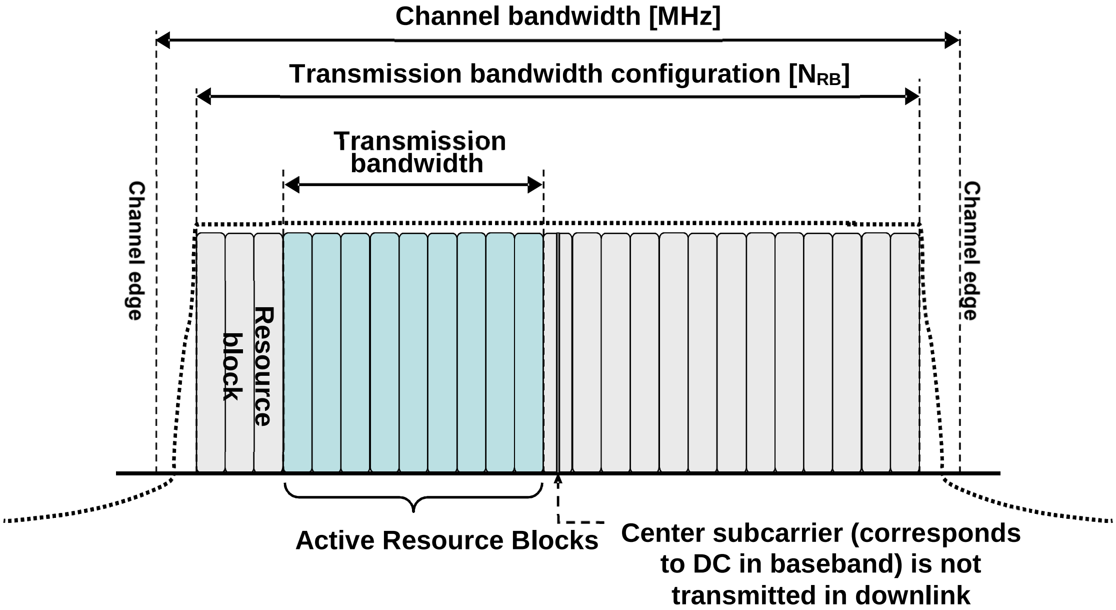

Figure 5.3A-1: Definition of channel bandwidth and transmission bandwidth configuration for one E-UTRA carrier

5.3B Channel bandwidth for category NB1 and NB2

For category NB1 and NB2, requirements in present document are specified for the channel bandwidth listed in Table 5.3B-1.

Table 5.3B-1: Transmission bandwidth configuration N_{RB}, $N_{tone\ 15kHz}$ and $N_{tone\ 3.75kHz}$ in NB1 and NB2 channel bandwidth

Channel bandwidth $BW_{Channel}$ (kHz)	200
Transmission bandwidth configuration N_{RB}	1
Transmission bandwidth configuration $N_{tone\ 15kHz}$	12
Transmission bandwidth configuration $N_{tone\ 3.75kHz}$	48

Figure 5.3B-1 shows the relation between the category NB1/NB2 *SAN channel bandwidth* and the Category NB1 /NB2 transmission bandwidth configuration ($N_{tone\ 15kHz}$, or $N_{tone\ 3.75kHz}$). The channel edges are defined as the lowest and highest frequencies of the carrier separated by the channel bandwidth, i.e. at F_C +/- $BW_{Channel}$ /2.

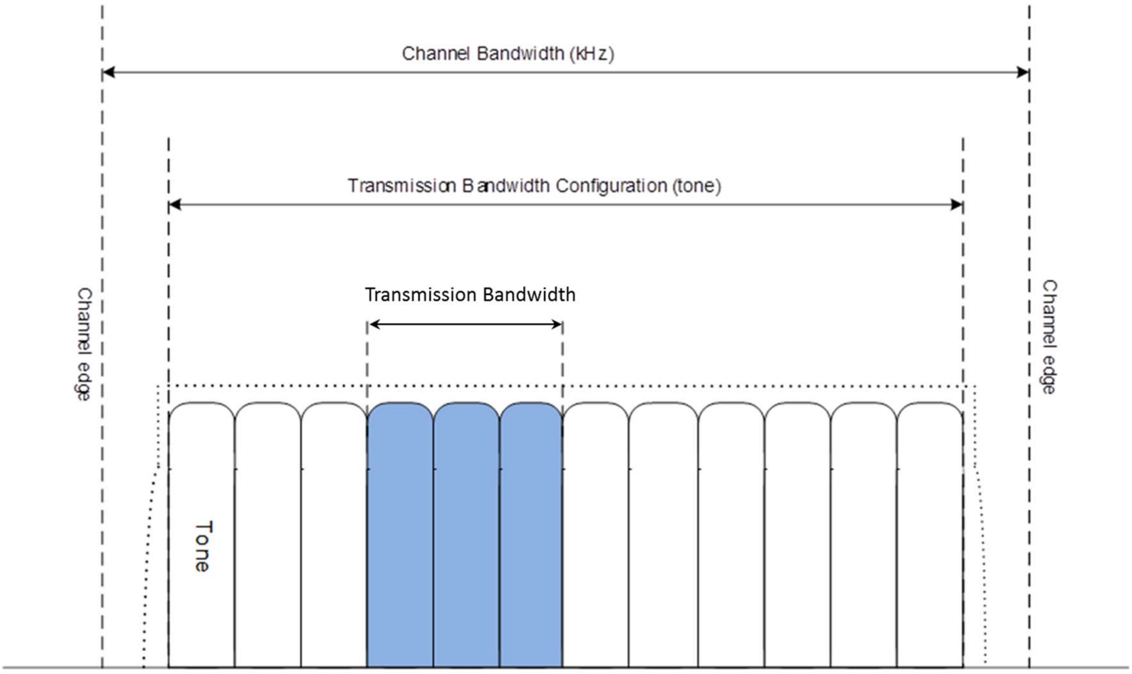

Figure 5.3B-1 Definition of channel bandwidth and transmission bandwidth configuration

For NB-IoT standalone operation, NB-IoT requirements for receiver and transmitter shall apply with a frequency offset F_{offset} as defined in Table 5.3B-1.

Table 5.3B-1: F_{offset} for NB-IoT standalone operation

Lowest or Highest Carrier	F_{offset}
Standalone NB-IoT	[200 kHz]

5.4 Channel arrangement

5.4A Channel arrangement for category M1

5.4A.1 Channel spacing

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

$$\text{Nominal Channel spacing} = (BW_{Channel(1)} + BW_{Channel(2)})/2$$

where $BW_{Channel(1)}$ and $BW_{Channel(2)}$ are the channel bandwidths of the two respective E-UTRA carriers. The channel spacing can be adjusted to optimize performance in a particular deployment scenario.

5.4A.2 Channel raster, carrier frequency and EARFCN

The global frequency raster is defined for all frequencies. The granularity of the global frequency raster is 100 kHz, which means that the carrier centre frequency must be an integer multiple of 100 kHz. For each operating band, a subset of frequencies from the global frequency raster are applicable and forms a channel raster with a granularity ΔF_{Raster}.

The carrier frequency in the uplink and downlink is designated by the E-UTRA Absolute Radio Frequency Channel Number (EARFCN) in the range 0 – 262143. The relation between EARFCN and the carrier frequency in MHz for the downlink is given by the following equation, where F_{DL_low} and $N_{Offs\text{-}DL}$ are given in Table 5.4A.2-1 and N_{DL} is the downlink EARFCN.

$$F_{DL} = F_{DL\_low} + 0.1(N_{DL} – N_{Offs-DL})$$

The relation between EARFCN and the carrier frequency in MHz for the uplink is given by the following equation where F_{UL_low} and $N_{Offs-UL}$ are given in Table 5.4.2-1 and N_{UL} is the uplink EARFCN.

$$F_{UL} = F_{UL\_low} + 0.1(N_{UL} – N_{Offs-UL})$$

The applicable channel raster and EARFCNs for each operating band are specified in Table 5.4A.2-1.

For operating bands with a channel raster of 100 kHz, every EARFCN within the operating band shall be applicable for the channel raster, and the step size for the channel raster in Table 5.4A.2-1 is given as <1>. The broadcast parameter *earfcn-LSB* defined in TS 36.331 [9] may be used to assist the UE in synchronizing to the cell.

Table 5.4A.2-1: E-UTRA channel numbers

E-UTRA Operating Band	ΔF_{Raster} (kHz)	Downlink			Uplink		
		F_{DL_low} (MHz)	$N_{Offs-DL}$	Range of N_{DL} (First – <Step size> – Last)	F_{UL_low} (MHz)	$N_{Offs-UL}$	Range of N_{UL} (First – <Step size> – Last)
256	100	2170	229076	229076 –<1>- 229375	1980	261844	261844 –<1>- 262143
255	100	1525	228736	228736 –<1>- 229075	1626.5	261504	261504 –<1>- 261843
254	100	2483.5	228571	228571 –<1>- 228735	1610	261339	261339 –<1>- 261503
253	100	1518	228501	228501 –<1>- 228570	1668	261269	261269 –<1>- 261338
NOTE: The channel numbers that designate carrier frequencies so close to the operating band edges that the carrier extends beyond the operating band edge shall not be used. This implies that the first 7 channel numbers at the lower operating band edge and the last 6 channel numbers at the upper operating band edge shall not be used for channel bandwidth of 1.4 MHz.							

5.4B Channel arrangement for category NB1 and NB2

5.4B.1 Channel spacing

Nominal channel spacing for UE category NB1 and NB2 in stand-alone mode is 200 kHz.

5.4B.2 Channel raster, carrier frequency and EARFCN

The channel raster of UE category NB1/NB2 shall be as defined in clause 5.4A.2, and the channel raster per-frequency band shall be as defined in table 5.4A.2-1.

The carrier frequency of UE category NB1/NB2 in the downlink is designated by the E-UTRA Absolute Radio Frequency Channel Number (EARFCN) as defined in Table 5.4A.2-1, and the Offset of category NB1/NB2 Channel Number to EARFCN in the range of {-10, -9, -8, -7, -6, -5, -4, -3, -2, -1, -0.5, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9} for FDD. The relation between EARFCN, Offset of category NB1/NB2 Channel Number to EARFCN and the carrier frequency in MHz for the downlink is given by the following equation, where F_{DL} is the downlink carrier frequency of category NB1/NB2, F_{DL_low} and $N_{Offs-DL}$ are given in table 5.4A.2-1, N_{DL} is the downlink EARFCN, M_{DL} is the Offset of category NB1/NB2 Channel Number to downlink EARFCN.

$$F_{DL} = F_{DL\_low} + 0.1(N_{DL} – N_{Offs-DL}) + 0.0025*(2M_{DL})$$

The carrier frequency of UE category NB1/NB2 in the uplink is designated by the E-UTRA Absolute Radio Frequency Channel Number (EARFCN) as defined in Table 5.4A.2-1, and the Offset of category NB1/NB2 Channel Number to EARFCN in the range of {-10, -9, -8, -7, -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9} for FDD. The relation between EARFCN, Offset of category NB1/NB2 Channel Number to EARFCN and the carrier frequency in MHz for the uplink is given by the following equation, where F_{UL} is the uplink carrier frequency of category NB1/NB2, F_{UL_low} and $N_{Offs-UL}$ are given in table 5.4A.2-1, N_{UL} is the uplink EARFCN, M_{UL} is the Offset of category NB1/NB2 Channel Number to uplink EARFCN.

$$F_{UL} = F_{UL\_low} + 0.1(N_{UL} – N_{Offs-UL}) + 0.0025*(2M_{UL})$$

NOTE 1: Guard-band operation and in-band operation for NB-IoT are not supported in this version of the specification.

NOTE 2: For the carrier including NPSS/NSSS for stand-alone operation, $M_{DL} = 0$.

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

The SAN conducted output power requirements in clause 6.2 in TS 38.108 [7] apply.

6.3 Output power dynamics

6.3.1 General

The requirements in clause 6.3 apply during the transmitter ON period. Transmit 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.

The requirements in clause 6.3 does not apply for NB-IoT standalone mode.

6.3.2 RE power control dynamic range

The SAN RE power control dynamic range requirements in clause 6.3.2 in TS 38.108 [7] apply.

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: 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
1.4	7.7

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

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.

6.5.1.1 Minimum requirement

For E-UTRA, the modulated carrier frequency of each E-UTRA carrier configured by the SAN shall be accurate to within the accuracy range given in Table 6.5.1-1 observed over a period of one subframe (1ms).

For NB-IoT, the modulated carrier frequency of each NB-IoT carrier configured by the SAN shall be accurate to within the accuracy range given in Table 6.5.1-1 observed over a period of one subframe (1ms).

Table 6.5.1-1: Frequency error minimum requirement

SAN class	Accuracy
SAN type 1-H	±0.05 ppm

6.5.2 Modulation quality

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. The equaliser parameters are estimated as defined in Annex B. The EVM result is defined as the square root of the ratio of the mean error vector power to the mean reference power expressed in percent.

For E-UTRA, for all bandwidths, the EVM measurement shall be performed for each E-UTRA carrier over all allocated resource blocks and downlink subframes within 10 ms measurement periods for subframe TTI, and over all allocated resource blocks and downlink sTTIs within 10 ms measurement periods for sTTI. The boundaries of the EVM measurement periods need not be aligned with radio frame boundaries. The EVM value is then calculated as the mean square root of the measured values. The EVM of each E-UTRA carrier for different modulation schemes on PDSCH or sPDSCH shall be better than the limits in table 6.5.2-1:

Table 6.5.2-1: EVM requirements for E-UTRA carrier

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

For NB-IoT, for all bandwidths, the EVM measurement shall be performed for each NB-IoT carrier over all allocated resource and downlink subframes within 10 ms measurement periods. The boundaries of the EVM measurement periods need not be aligned with radio frame boundaries. The EVM value is then calculated as the mean square root of the measured values. The EVM of each NB-IoT carrier on NB-PDSCH shall be better than the limits in Table 6.5.2-2:

Table 6.5.2-2: EVM requirements for NB-IoT carrier

Modulation scheme for NB-PDSCH	Required EVM (%)
QPSK	17.5 %
16QAM	12.5%

6.5.3 Time alignment error

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

6.5.4 DL RS power

6.5.4.1 General

For E-UTRA, DL RS power is the resource element power of the Downlink Reference Symbol.

The absolute DL RS power is indicated on the DL-SCH. The absolute accuracy is defined as the maximum deviation between the DL RS power indicated on the DL-SCH and the DL RS power of each E-UTRA carrier at the SAN *TAB connector* for *SAN type 1-H*.

For NB-IoT, DL NRS power is the resource element power of the Downlink Narrow-band Reference Signal.

The absolute DL NRS power is indicated on the DL-SCH. The absolute accuracy is defined as the maximum deviation between the DL NRS power indicated on the DL-SCH and the DL NRS power of each NB-IoT carrier at the SAN *TAB connector* for *SAN type 1-H*.

6.5.4.2 Minimum requirements

For E-UTRA, DL RS power of each E-UTRA carrier shall be within ± 2.1 dB of the DL RS power indicated on the DL-SCH.

For NB-IoT, DL NRS power of each NB-IoT carrier shall be within ± 2.1 dB of the DL NRS power indicated on the DL-SCH.

6.6 Unwanted emissions

6.6.1 General

General requirements in clause 6.6.1 in TS 38.108 [7] apply.

6.6.2 Occupied bandwidth

6.6.2.1 General

The occupied bandwidth requirements in clause 6.6.2 in TS 38.108 [7] apply.

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 for *SAN type 1-H*

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 and Table 6.6.3.2-2.

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 (dB)
1.4	$BW_{Channel}$	E-UTRA of same BW	Square (BW_{Config}) (NOTE)	14
	2 x $BW_{Channel}$	E-UTRA of same BW	Square (BW_{Config}) (NOTE)	14
NOTE: $BW_{Channel}$ and BW_{Config} are the *SAN channel bandwidth* and *transmission bandwidth configuration* of the *lowest/highest carrier* transmitted on the assigned channel frequency.				

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 (dB)
1.4	$BW_{Channel}$	E-UTRA of same BW	Square (BW_{Config}) (NOTE)	24
	2 x $BW_{Channel}$	E-UTRA of same BW	Square (BW_{Config}) (NOTE)	[24]
NOTE: $BW_{Channel}$ and BW_{Config} are the *SAN channel bandwidth* and *transmission bandwidth configuration* of the *lowest/highest carrier* transmitted on the assigned channel frequency.				

For SAN supporting standalone NB-IoT operation in paired spectrum, the ACLR shall be higher than the value specified in Table 6.6.3.2-3 and Table 6.6.3.2-4.

Table 6.6.3.2-3: ACLR limit of SAN supporting standalone NB-IoT operation for GEO class

Channel bandwidth of NB-IoT lowest/highest carrier transmitted $BW_{Channel}$ (kHz)	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 (dB)
200	[200 kHz]	Standalone NB-IoT	Square (180 kHz)	14
	[400 kHz]	Standalone NB-IoT	Square (180 kHz)	14

Table 6.6.3.2-4: ACLR limit of SAN supporting standalone NB-IoT operation for LEO class

Channel bandwidth of NB-IoT lowest/highest carrier transmitted $BW_{Channel}$ (kHz)	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 (dB)
200	[200 kHz]	Standalone NB-IoT	Square (180 kHz)	24
	[400 kHz]	Standalone NB-IoT	Square (180 kHz)	24

6.6.4 Out-of-band emissions

6.6.4.1 General

Unless otherwise stated, the out-of-band emissions (OOBE) limits for SAN are defined from BW_{SAN} channel edge up to frequencies separated from the BW_{SAN} channel edge by 200% of the *necessary bandwidth*, where the *necessary bandwidth* is BW_{SAN}.

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 BW_{SAN} *channel edge* frequency and the nominal -3 dB 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.
- $\Delta_{Sat\_Class}[dB]$ is the *SAN class parameter* in dB identified to characterize different SAN classes.

6.6.4.2 *Basic limits*

For SAN operating in bands defined in clause 5.2, the out-of-band emissions (OOBE) requirements are specified in table 6.6.4.2-1 for GEO and LEO class, in line with Annex 5 of ITU recommendation SM.1541-6 [6].

Table 6.6.4.2-1: OOBE 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 < $2 \times BW_{SAN}$	0.002 MHz ≤ f_offset < $2 \times BW_{SAN}$ + 0.002 MHz	$max\left(SE\ limit, P_{rated,t,sys} - 10\log10(BW_{SAN}) - 24 - \Delta_{Sat\_Class}[dB] - 40 \times log10\left(\frac{f\_offset - 0.002}{BW_{SAN}} \times 2 + 1\right)\right) dBm$	4 kHz

NOTE 1: BW_{SAN} is in the unit of MHz.
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 [6], 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.

6.6.4.3 Minimum requirements for *SAN type 1-H*

The out-of-band emissions minimum requirements for *SAN type 1-H* are that the power summation emissions at the *TAB connectors* shall not exceed the *basic limit* in clause 6.6.4.2.

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 *SAN transponder bandwidth* BW_{SAN} and the frequency range where the out-of-band emissions apply. 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 to SAN that supports E-UTRA or NB-IoT standalone operation.

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 basic limits

Spurious frequency range	$P_{rated,t,sys}$ (dBm)	Basic limit (dBm)	Measurement bandwidth (kHz)	Notes
30 MHz – 5th harmonic of the upper frequency edge of the DL operating band	≤ 47	-13	4	NOTE 1, NOTE 2, NOTE 3
	> 47	$P_{rated,t,sys}$ – 60		
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 E-UTRA 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.

6.6.5.3 Minimum requirements for *SAN type 1-H*

The transmitter spurious emissions minimum requirements for *SAN type 1-H* are that that the power summation emissions at the *TAB connectors* shall not exceed the *basic limit* in clause 6.6.5.2.

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 and blocking 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 *SAN type 1-H*

For SAN supporting E-UTRA, 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.

Table 7.2.2-1: Reference sensitivity levels of SAN supporting E-UTRA (GEO class payload)

SAN channel bandwidth (MHz)	Sub-carrier spacing (kHz)	Reference measurement channel (NOTE)	Reference sensitivity power level, $P_{REFSENS}$ (dBm)
1.4	15	FRC A1-1 in Annex A.1	-104.4
NOTE: $P_{REFSENS}$ is the power level of a single instance of the reference measurement channel.			

Table 7.2.2-2: Reference sensitivity levels of SAN supporting E-UTRA (LEO class payload)

SAN channel bandwidth (MHz)	Sub-carrier spacing (kHz)	Reference measurement channel (NOTE)	Reference sensitivity power level, $P_{REFSENS}$ (dBm)
1.4	15	FRC A1-1 in Annex A.1	-107.5
NOTE: $P_{REFSENS}$ is the power level of a single instance of the reference measurement channel.			

For SAN supporting standalone NB-IoT operation, 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 7.2.2-3 and 7.2.2-4 for *SAN type 1-H* in all operating band.

Table 7.2.2-3: Reference sensitivity levels of SAN supporting standalone NB-IoT operation (GEO class payload)

SAN channel bandwidth (kHz)	Sub-carrier spacing (kHz)	Reference measurement channel	Reference sensitivity power level, $P_{REFSENS}$ (dBm)
200	15	FRC A14-1 in Annex A.14	-124.9
200	3.75	FRC A14-2 in Annex A.14	-130.9

Table 7.2.2-4: Reference sensitivity levels of SAN supporting standalone NB-IoT operation (LEO class payload)

SAN channel bandwidth (kHz)	Sub-carrier spacing (kHz)	Reference measurement channel	Reference sensitivity power level, $P_{REFSENS}$ (dBm)
200	15	FRC A14-1 in Annex A.14	-128.0
200	3.75	FRC A14-2 in Annex A.14	-134.0

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 *SAN type 1-H*

For SAN supporting E-UTRA, 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: Dynamic range of SAN supporting E-UTRA (LEO class payload)

SAN channel bandwidth (MHz)	Reference measurement channel	Wanted signal mean power (dBm)	Interfering signal mean power (dBm) / BW_{Config}	Type of interfering signal
1.4	FRC A2-1 in Annex A.2	-82.0	-94.4	AWGN
Note*: The wanted signal mean power is the power level of a single instance of the reference measurement channel.				

For SAN supporting standalone NB-IoT operation, 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 7.3.2-2 and 7.3.2-3 .

Table 7.3.2-2: Dynamic range of SAN supporting standalone NB-IoT operation (GEO class payload)

SAN channel bandwidth (kHz)	Reference measurement channel	Wanted signal mean power (dBm)	Interfering signal mean power (dBm) / $BW_{Channel}$	Type of interfering signal
200	FRC A15-1 in Annex A.15	-97.3	-93.6	AWGN
200	FRC A15-2 in Annex A.15	-103.2	-93.6	AWGN

Table 7.3.2-3: Dynamic range of SAN supporting standalone NB-IoT operation (LEO class payload)

SAN channel bandwidth (kHz)	Reference measurement channel	Wanted signal mean power (dBm)	Interfering signal mean power (dBm) / $BW_{Channel}$	Type of interfering signal
200	FRC A15-1 in Annex A.15	-89.4	-85.7	AWGN
200	FRC A15-2 in Annex A.15	-95.3	-85.7	AWGN

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 *SAN type 1-H*

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

For SAN supporting E-UTRA, the wanted and the interfering signal coupled to the *SAN type 1-H TAB connector* are specified in table 7.4.1.2-1. The reference measurement channel for the wanted signal is identified in table 7.2.2-1 for each *SAN channel bandwidth* in any operating band and further specified in annex A.1.

For SAN supporting standalone NB-IoT operation, the wanted and the interfering signal coupled to the *SAN type 1-H TAB connector* are specified in table 7.4.1.2-2. The reference measurement channel for the wanted signal is identified in table 7.2.2-1 for each *SAN channel bandwidth* in any operating band and further specified in annex A.1.

The characteristics of interfering signals are 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: ACS requirement of SAN supporting E-UTRA

SAN channel bandwidth of the lowest/highest carrier received (MHz)	Wanted signal mean power (dBm)	Interfering signal mean power (dBm)	Interfering signal centre frequency offset from the lower/upper SAN RF Bandwidth edge or sub-block edge inside a sub-block gap (MHz)	Type of interfering signal
1.4	$P_{REFSENS}$ + 11 dB (Note)	GEO SAN class: -57.6 LEO SAN class: -60.7	±0.7025	1.4 MHz E-UTRA signal
Note: $P_{REFSENS}$ depends on the channel bandwidth as specified in Table 7.2.2-1 and Table 7.2.2-2.				

Table 7.4.1.2-2: ACS requirement of SAN supporting standalone NB-IoT operation

SAN channel bandwidth of the lowest/highest carrier received (kHz)	Wanted signal mean power (dBm)	Interfering signal mean power (dBm)	Interfering signal centre frequency offset to the lower/upper SAN RF Bandwidth edge or sub-block edge inside a sub-block gap (kHz)	Type of interfering signal
200	$P_{REFSENS}$ + 19.5dB (Note)	GEO SAN class: -56.6 LEO SAN class: -59.7	±100	180 kHz NB-IoT signal
Note: $P_{REFSENS}$ depends on the sub-carrier spacing as specified in Table 7.2.2-3 and Table 7.2.2-4.				

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 *SAN type 1-H*

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 *TAB connector* for *SAN type 1-H.*

Table 7.5.2-1: Out-of-band blocking requirement for SAN supporting E-UTRA or standalone NB-IoT operation

Wanted signal mean power (dBm)	Interfering signal mean power (dBm)	Type of interfering signal
$P_{REFSENS}$ +6 dB (NOTE 1)	-44	CW carrier
NOTE 1: For SAN, $P_{REFSENS}$ depends on the *SAN channel bandwidth*. NOTE 2: [For SAN supporting standalone NB-IoT, up to 24 exceptions are allowed for spurious response frequencies in each wanted signal frequency when measured using a 1 MHz step size. For these exceptions the above throughput requirement shall be met when the blocking signal is set to a level of -46 dBm for 3.75 kHz subcarrier spacing. In addition, each group of exceptions shall not exceed three contiguous measurements using a 1 MHz step size.]		

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

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

7.6 Receiver spurious emissions

7.6.1 General

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

NOTE: Receiver spurious emissions requirement is not applicable based on the assumption of *TAB connectors* supporting both TX and RX.

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 E-UTRA signal which is time aligned with the wanted signal.

7.8.2 Minimum requirements for *SAN type 1-H*

For *SAN* supporting E-UTRA, 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 In-channel selectivity of SAN supporting E-UTRA (GEO class payload)

SAN channel bandwidth (MHz)	Reference measurement channel	Wanted signal mean power (dBm)	Interfering signal mean power (dBm)	Type of interfering signal
1.4	A1-4 in Annex A.1	-104.5	-97.6	1.4 MHz E-UTRA signal, 3 RBs

Table 7.8.2-2 In-channel selectivity of SAN supporting E-UTRA (LEO class payload)

SAN channel bandwidth (MHz)	Reference measurement channel	Wanted signal mean power (dBm)	Interfering signal mean power (dBm)	Type of interfering signal
1.4	A1-4 in Annex A.1	-107.6	-88.7	1.4 MHz E-UTRA signal, 3 RBs

8 Conducted performance requirements

8.1 General

Performance requirements for the SAN are specified for the fixed reference channels defined in Annex A and the propagation conditions in Annex E. The requirements only apply to those FRCs that are supported by the base station.

Unless stated otherwise, performance requirements apply for a single carrier only. For FDD operation the requirements in clause 8 shall be met with the transmitter(s) on.

NOTE: In normal operating conditions the SAN in FDD operation is configured to transmit and receive at the same time. The transmitter may be off for some of the tests as specifed in 36.181 [3].

The SNR used in this clause is specified based on a single carrier and defined as:

SNR = S / N

Where:

S is the total signal energy in the subframe on a single antenna port.

N is the noise energy in a bandwidth corresponding to the transmission bandwidth over the duration of a subframe.

8.2 Performance requirements for PUSCH

8.2.1 Requirements for PUSCH supporting coverage enhancement

For the parameters specified in Table 8.2.1-1 the throughput shall be equal to or larger than the fraction of maximum throughput stated in the Tables 8.2.1-2 and 8.2.1-3 at the given SNR.

Table 8.2.1-1 Test Parameters for PUSCH

Parameter	unit	Mode A	Mode B
Maximum number of HARQ transmissions		4	2
RV sequences		0, 2, 3, 1, 0, 2, 3, 1	FDD: 0, 0, 0, 0, 2, 2, 2, 2, 3, 3, 3, 3, 1, 1, 1, 1
Frequency hopping		OFF	OFF
Frequency hopping interval	subframes	N/A	N/A
Duration of PUSCH segment transmission ($N_{segment}^{precompensation}$)	subframes	8	256
Note 1: Guard period shall be created according to TS36.211 [9], 5.2.5			

Table 8.2.1-2 Minimum requirements for PUSCH, 1.4 MHz Channel Bandwidth for Mode A, 1Tx

Number of TX antennas	Number of RX antennas	CE Mode	Number of PUSCH repetitions	Propagation conditions and correlation matrix (Annex C)	FRC (Annex A)	Fraction of maximum throughput	SNR [dB]
1	1	Mode A	8	NTN-TDLA100-5	A5-2	70%	-3.1
1	1	Mode A	8	NTN-TDLC5-5	A5-2	70%	-3.4
1	2	Mode A	8	NTN-TDLA100-5	A5-2	70%	-7.3
1	2	Mode A	8	NTN-TDLC5-5	A5-2	70%	-7.3

Table 8.2.1-3 Minimum requirements for PUSCH, 1.4 MHz Channel Bandwidth for Mode B, 1Tx

Number of TX antennas	Number of RX antennas	CE Mode	Number of PUSCH repetitions	Propagation conditions and correlation matrix (Annex C)	FRC (Annex A)	Fraction of maximum throughput	SNR [dB]
1	1	Mode B	256	NTN-TDLA100-5	A5-1	70%	-11.6
1	1	Mode B	256	NTN-TDLC5-5	A5-1	70%	-13.3
1	2	Mode B	256	NTN-TDLA100-5	A5-1	70%	-14.5
1	2	Mode B	256	NTN-TDLC5-5	A5-1	70%	-15.5

8.3 Performance requirements for PUCCH

8.3.1 PUCCH performance requirements for coverage enhancement

8.3.1.1 DTX to ACK performance

The DTX to ACK requirement is valid for any number of receive antennas, for all frame structures and for any channel bandwidth.

8.3.1.1.1 Minimum requirement

The DTX to ACK probability, i.e. the probability that ACK is detected when nothing is sent per PUCCH transmission, shall not exceed 1% per PUCCH transmission. A PUCCH transmission may take multiple subframes due to PUCCH transmission repetition. The performance measure is defined as follows:

$$\mathrm{Prob(PUCCH\ DTX \rightarrow ACK\ bits)} = \frac{\#(\mathrm{false\ ACK\ bits})}{\#(\mathrm{PUCCH\ DTX}) \times \#(\mathrm{ACK/NAK\ bits})} \leq 10^{-2}$$

where:

- #(false ACK bits) denotes the number of detected ACK bits per PUCCH transmission.
- #(ACK/NACK bits) denotes the number of encoded bits per PUCCH transmission.

- #(PUCCH DTX) denotes the number of DTX occasions per PUCCH transmission.

8.3.1.2 ACK missed detection requirements for single user PUCCH format 1a

The ACK missed detection probability is the probability of not detecting an ACK when an ACK is sent.

8.3.1.2.1 Minimum requirements

The ACK missed detection probability shall not exceed 1% at the SNR given in table 8.3.1.2.1-1 for 1Tx.

Table 8.3.1.2.1-1 Minimum requirements for single user PUCCH format 1a, 1Tx

Number of TX antennas	Number of RX antennas	Channel Bandwidth	Cyclic Prefix	Propagation conditions and correlation matrix (Annex C)	Repetitions	Duration of PUCCH segment transmission (subframes)	SNR (dB)
1	1	1.4MHz	Normal	NTN-TDLA100-5	8	8	-2.6
1	2	1.4MHz	Normal	NTN-TDLA100-5	8	8	-8.2
Note 1 Frequency Hopping: OFF Note 2 Guard period shall be created according to TS36.211 [9], 5.2.5.							

8.4 Performance requirements for PRACH

8.4.1 PRACH False alarm probability

The false alarm requirement is valid for any number of receive antennas, for all frame structures and for any channel bandwidth.

The false alarm probability is the conditional total probability of erroneous detection of the preamble (i.e. erroneous detection from any detector) when input is only noise.

8.4.1.1 Minimum requirement

The false alarm probability shall be less than or equal to 0.1%.

8.4.2 PRACH detection requirements

The probability of detection is the conditional probability of correct detection of the preamble when the signal is present. There are several error cases – detecting different preamble than the one that was sent, not detecting a preamble at all or correct preamble detection but with the wrong timing estimation. For NTN-TDLA100-5, a timing estimation error occurs if the estimation error of the timing of the strongest path is larger than 2.08us. The strongest path for the timing estimation error refers to the strongest path.

The test preambles for coverage enhancement are listed in table A.6-1.

8.4.2.1 Minimum requirements

The probability of detection shall be equal to or exceed 99% for the SNR levels listed in Table 8.4.2.1-1.

The requirements for coverage enhancement (Table 8.4.2.1-1) are only valid for the satellite access node supporting coverage enhancement.

Table 8.4.2.1-1 PRACH missed detection requirements (PRACH frequency hopping OFF)

Number of TX antennas	Number of RX antennas	Propagation conditions and correlation matrix (Annex C)	Frequency offset	Number of Repetitions	SNR [dB]			
					Burst format 0	Burst format 1	Burst format 2	Burst format 3
1	1	NTN-TDLA100-5	270Hz	8	-11.0	-10.6	-	-
1	1	NTN-TDLA100-5	270Hz	16	-	-	-16.1	-16.1
1	2	NTN-TDLA100-5	270Hz	8	-16.3	-16.1	-	-
1	2	NTN-TDLA100-5	270Hz	16	-	-	-20.1	-20.1
Note 1: Under fading channels, the PRACH detection performance may be significantly different with different PRACH Configuration Indexes. The requirements in this table are defined based on the simulation results with PRACH Configuration Indexes (3, 19, 35, 51) for Format 0, Format 1, Format 2, and Format 3 respectively.								

8.5 Performance requirements for Narrowband IoT

8.5.1 Requirements for NPUSCH format 1

8.5.1.1 Requirements

The performance requirement of NPUSCH format 1 is determined by a minimum required throughput for a given SNR. The required throughput is expressed as a fraction of maximum throughput for the FRCs listed in Annex A.7. The performance requirements assume HARQ retransmissions.

An NB-IoT Base Station supports 15 kHz subcarrier spacing requirements, or 3.75 kHz subcarrier spacing requirements, or both.

For 15kHz subcarrier spacing multi-subcarrier, the demodulation requirements apply for the supported number of subcarriers.

Table 8.5.1.1-1: Test parameters

Parameter	Value
Maximum number of HARQ transmissions	4
RV sequence	RV0, RV2

8.5.1.1.1 Minimum requirements

The throughput shall be equal to or larger than the fraction of maximum throughput stated in table 8.5.1.1.1-1 for the single-subcarrier of 3.75KHz subcarrier spacing, and in table 8.5.1.1.1-2 for multi-subcarrier of 15KHz subcarrier spacing at the given SNR for 1Tx.

Table 8.5.1.1.1-1: Minimum requirements for NPUSCH format 1, 200KHz Channel Bandwidth, 3.75KHz subcarrier spacing, 1Tx

Number of TX antennas	Number of RX antennas	Subcarrier spacing	Number of allocated subcarriers	Propagation conditions and correlation matrix (Annex D))	FRC (Annex A)	Frequency offset	TxDuration	Repetition number	Fraction of maximum throughput	SNR [dB]
1	1	3.75KHz	1	NTN TDLA100-1	A7-1	128 Hz	256	4	70%	-2.0
1	1	3.75KHz	1	NTN TDLC5-1	A7-1	128 Hz	256	4	70%	-3.6
1	2	3.75KHz	1	NTN TDLA100-1	A7-1	128 Hz	256	4	70%	-5.4
1	2	3.75KHz	1	NTN TDLC5-1	A7-1	128 Hz	256	4	70%	-6.5

Table 8.5.1.1.1-2: Minimum requirements for NPUSCH format 1, 200KHz Channel Bandwidth, 15KHz subcarrier spacing, multiple subcarriers, 1Tx

Number of TX antennas	Number of RX antennas	Subcarrier spacing	Number of allocated subcarriers	Propagation conditions and correlation matrix (Annex D)	FRC (Annex A)	Frequency offset	Tx-Duration	Repetition number	Fraction of maximum throughput	SNR [dB]
1	1	15KHz	12	NTN TDLA100-1	A7-2	8 Hz	16	16	70%	-3.2
1	1	15KHz	12	NTN TDLC5-1	A7-2	8 Hz	16	16	70%	-4.0
1	2	15KHz	12	NTN TDLA100-1	A7-2	8 Hz	16	16	70%	-7.1
1	2	15KHz	12	NTN TDLC5-1	A7-2	8 Hz	16	16	70%	-7.8

8.5.2 Performance requirements for NPUSCH format 2

8.5.2.1 DTX to ACK performance

The DTX to ACK probability for NPUSCH format 2 case denotes the probability that ACK is detected when nothing is sent on the wanted signal and only the noise is present per NPUSCH format 2 transmission.

An NB-IoT Base Station supports 15 KHz sub-carrier spacing requirements, or 3.75 KHz sub-carrier spacing requirements, or both.

8.5.2.1.1 Minimum requirement

The DTX to ACK probability, i.e. the probability that ACK is detected when nothing was sent, shall not exceed 1% per NPUSCH format 2 transmission. Where the performance measure definition is as follows:

$$\text{Prob}(\text{NPUSCH format 2 DTX} \rightarrow \text{ACK bits}) = \frac{\#(\text{false ACK bits})}{\#\left(\text{NPUSCH format 2 DTX}\right) \times \#(\text{ACK/NAK bits})} \leq 10^{-2}$$

where:

- #(false ACK bits) denotes the number of detected ACK bits.
- #(ACK/NACK bits) denotes the number of HARQ-ACK information bit per NPUSCH format 2 transmission.
- #(NPUSCH format 2 DTX) denotes the number of DTX occasions.

8.5.2.2 ACK missed detection requirements

The ACK missed detection probability is the probability of not detecting an ACK when an ACK was sent per NPUSCH format 2 transmission.

8.5.2.2.1 Minimum requirements

The ACK missed detection probability shall not exceed 1% at the SNR given in table 8.5.2.2.1-1 and table 8.5.2.2.1-2 for 1Tx case.

Table 8.5.2.2.1-1: Minimum requirements for NPUSCH format 2, 200KHz Channel Bandwidth, 3.75KHz subcarrier spacing, 1Tx

Number of TX antennas	Number of RX antennas	Propagation conditions and correlation matrix (Annex D)	Number of allocated subcarriers	Subcarrier spacing	Frequency offset	TxDuration	Repetition number	SNR [dB]
1	1	NTN TDLA100-1	1	3.75KHz	64 Hz	256	4	1.8
1	2	NTN TDLA100-1	1	3.75KHz	64 Hz	256	4	-3.9

Table 8.5.2.2.1-2: Minimum requirements for NPUSCH format 2, 200KHz Channel Bandwidth, 15KHz subcarrier spacing, 1Tx

Number of TX antennas	Number of RX antennas	Propagation conditions and correlation matrix (Annex D)	Number of allocated subcarriers	Subcarrier spacing	Frequency offset	TxDuration	Repetition number	SNR [dB]
1	1	NTN TDLA100-1	1	15KHz	16 Hz	32	16]	5.1
1	2	NTN TDLA100-1	1	15KHz	16 Hz	32	16	-3.3

8.5.3 Performance requirements for NPRACH

8.5.3.1 NPRACH False alarm probability

The false alarm requirement is valid for any number of receive antennas, for all repetition numbers and for any number of subcarriers.

The false alarm probability is the conditional total probability of erroneous detection of the preamble (i.e. erroneous detection from any detector) when input is only noise.

8.5.3.1.1 Minimum requirement

The false alarm probability shall be less than or equal to 0.1%.

8.5.3.2 NPRACH detection requirements

The probability of detection is the conditional probability of correct detection of the preamble when the signal is present. There are several error cases – detecting different preamble than the one that was sent, not detecting a preamble at all or correct preamble detection but with the wrong timing estimation. For NTN-TDLA100 and NTN-TDLC5, a timing estimation erros occurs if the estimation error of the timing of the largest delay path is larger than the time orror tolerance given in Table 8.5.3.2-2

Table 8.5.3.2-1: Test preambles for NPRACH

Parameter	Value
Narrowband physical layer cell identity	0
Initial subcarrier index	0

Table 8.5.3.2-2: Time error tolerance for AWGN, NTN-TDLA100-1

PRACH preamble	PRACH SCS (kHz)	Time error tolerance NTN-TDLA100-1
0	3.75KHz	3.646us
1	3.75KHz	3.646us

8.5.3.2.1 Minimum requirements

The probability of detection shall be equal to or exceed 99% for the SNR levels listed in table 8.5.3.2.1-1.

Table 8.5.3.2.1-1: NPRACH missed detection requirements for FDD

Number of TX antennas	Number of RX antennas	TxDuration	Repetition number	Propagation conditions and correlation matrix (Annex D)	Frequency offset	SNR [dB]	
						Preamble format 0	Preamble format 1
1	1	8	8	NTN-TDLA100-1	200 Hz	13.3	13.7
1	1	16	16	NTN-TDLA100-1	200 Hz	9.8	9.6
1	2	8	8	NTN-TDLA100-1	200 Hz	6.0	6.1
1	2	16	16	NTN-TDLA100-1	200 Hz	1.6	1.7

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 36.181 [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 SAN 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 36.181 [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.

Normal conditions are defined in TS 36.181, 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 36.181 [3], annex B.

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*.

The requirements in clause 9.4 does not apply for NB-IoT standalone mode.

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 dynamic range is the OFDM symbol power for a SAN at maximum output power. The lower limit of the dynamic range is the OFDM symbol power for a SAN when one resource block is transmitted.

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 E-UTRA 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.

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.

9.6.3 OTA time alignment error

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

9.6.4 OTA DL RS power

For E-UTRA, DL RS power is the resource element power of the Downlink Reference Symbol.

The absolute DL RS power is indicated on the DL-SCH. The OTA absolute accuracy is defined as the maximum deviation between the DL RS power indicated on the DL-SCH and the DL RS power of each E-UTRA carrier within the *OTA coverage range*.

For NB-IoT, DL NRS power is the resource element power of the Downlink Narrow-band Reference Signal.

The absolute DL NRS power is indicated on the DL-SCH. The OTA absolute accuracy is defined as the maximum deviation between the DL NRS power indicated on the DL-SCH and the DL NRS power of each NB-IoT carrier within the *OTA coverage range.*

9.6.4.1 Minimum requirements for *SAN type 1-O*

For *SAN type 1-O*, the OTA absolute accuracy for DL RS power shall be the same as clause 6.5.4.1.

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 out-of-band emissions (OOBE).

Table 9.7.1-1: Void

The unwanted emission requirements are applied per cell for all the configurations. Requirements for OTA unwanted emissions are captured as TRP requirements or *directional 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 [5].

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*

For SAN supporting E-UTRA in paired spectrum, the ACLR limit specified in tables 6.6.3.2-1 for SAN GEO class and 6.6.3.2-2 for SAN LEO class shall apply.

For SAN supporting standalone NB-IoT in paired spectrum, the ACLR limit specified in tables 6.6.3.2-3 for SAN GEO class and 6.6.3.2-4 for SAN LEO class 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 tables 6.6.3.2-1, 6.6.3.2-2,6.6.3.2-3 and 6.6.3.2-4.

9.7.4 OTA out-of-band emissions

9.7.4.1 General

The OTA limits for out-of-band 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 are limited by OTA out-of-band emission limits. Unless otherwise stated, the out-of-band emission limits are defined from channel edge up to frequencies separated from the channel edge by 200% of the *necessary bandwidth*, where the *necessary bandwidth* is BW_{SAN}

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 out-of-band emissions 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 shall apply from 30 MHz to the 5^{th} harmonic of the upper frequency edge of the DL operating band, excluding the *SAN transponder bandwidth* BW_{SAN} and the frequency range where the out-of-band emissions apply.

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.

9.7.5.2.2 General OTA transmitter spurious emissions requirements

The *basic limits* of table 9.7.5.2.2-1 shall apply. The application of those limits shall be the same as for out-of-band emissionsin clause 6.6.4.

Table 9.7.5.2.2-1: General SAN transmitter spurious emission basic limits

Spurious frequency range	$P_{rated,t,TRP}$ (dBm)	Basic limit (dBm)	Measurement bandwidth (kHz)	Notes
30 MHz – 5th harmonic of the upper frequency edge of the DL operating band	≤ 47	-13	4	NOTE 1, NOTE 2, NOTE 3
	> 47	$P_{rated,t,TRP}$ – 60 dB		
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.				

The transmitter spurious emissions minimum requirements for *SAN type 1-O* are that the power summation emissions at the *TAB connectors* shall not exceed the *basic limit* in table 9.7.5.2.2-1.

9.7.5.2.3 Protection of the SAN receiver

The co-location requirement is not applicable for SAN in this version of the specification.

9.7.5.2.4 Additional spurious emissions requirements

The additional spurious emissions requirement is not applicable for SAN.

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 and blocking 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 36.181 [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 3: 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 *SAN type 1-O*

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*

For SAN supporting E-UTRA, the throughput shall be ≥ 95% of the maximum throughput of the reference measurement channel as specified in annex A.1 with parameter specified in table 10.3.2-1 and table 10.3.2-2 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: Reference sensitivity levels of SAN supporting E-UTRA (GEO class payload)

SAN channel bandwidth (MHz)	**Sub-carrier spacing (kHz)**	**Reference measurement channel** (NOTE)	**Reference sensitivity power level, $EIS_{REFSENS}$ (dBm)**
1.4	15	FRC A1-1 in Annex A.1	$-104.4 - \Delta_{OTAREFSENS}$
NOTE: $P_{REFSENS}$ is the power level of a single instance of the reference measurement channel.			

Table 10.3.2-2: Reference sensitivity levels of SAN supporting E-UTRA (LEO class payload)

SAN channel bandwidth (MHz)	**Sub-carrier spacing (kHz)**	**Reference measurement channel** (NOTE)	**Reference sensitivity power level, $EIS_{REFSENS}$ (dBm)**
1.4	15	FRC A1-1 in Annex A.1	$-107.5 - \Delta_{OTAREFSENS}$
NOTE: $P_{REFSENS}$ is the power level of a single instance of the reference measurement channel.			

For SAN supporting standalone NB-IoT operation, the throughput shall be ≥ 95% of the maximum throughput of the reference measurement channel as specified in annex A.1 with parameter specified in table 10.3.2-3 and table 10.3.2-4 when the OTA test signal is at the corresponding $EIS_{REFSENS}$ level and arrives from any direction within the *OTA REFSENS RoAoA*.

Table 10.3.2-3: Reference sensitivity levels of SAN supporting standalone NB-IoT operation (GEO class payload)

SAN channel bandwidth (kHz)	Sub-carrier spacing (kHz)	Reference measurement channel	Reference sensitivity power level, $EIS_{REFSENS}$ (dBm)
200	15	FRC A14-1 in Annex A.14	-124.9 - $\Delta_{OTAREFSENS}$
200	3.75	FRC A14-2 in Annex A.14	-130.9 - $\Delta_{OTAREFSENS}$

Table10.3.2-4: Reference sensitivity levels of SAN supporting standalone NB-IoT operation (LEO class payload)

SAN channel bandwidth (kHz)	Sub-carrier spacing (kHz)	Reference measurement channel	Reference sensitivity power level, $EIS_{REFSENS}$ (dBm)
200	15	FRC A14-1 in Annex A.14	-128.0 - $\Delta_{OTAREFSENS}$
200	3.75	FRC A14-2 in Annex A.14	-134.0 - $\Delta_{OTAREFSENS}$

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*

For SAN supporting E-UTRA, 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: Dynamic range of SAN supporting E-UTRA (LEO class payload)

SAN channel bandwidth (MHz)	Reference measurement channel	Wanted signal mean power (dBm)	Interfering signal mean power (dBm) / BW_{Config}	Type of interfering signal
1.4	FRC A2-1 in Annex A.2	-82.0 - $\Delta_{OTAREFSENS}$	-94.4 - $\Delta_{OTAREFSENS}$	AWGN
Note*: The wanted signal mean power 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 FRC A2-3 mapped to disjoint frequency ranges with a width of 25 resource blocks each.				

For SAN supporting standalone NB-IoT, 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 10.4.2-2 for GEO SAN and table 10.4.2-3 for LEO SAN.

Table 10.4.2-2: Dynamic range of SAN supporting standalone NB-IoT operation (GEO class payload)

SAN channel bandwidth (kHz)	Reference measurement channel	Wanted signal mean power (dBm)	Interfering signal mean power (dBm) / $BW_{Channel}$	Type of interfering signal
200	FRC A15-1 in Annex A.15	-97.3 - $\Delta_{OTAREFSENS}$	-93.6 - $\Delta_{OTAREFSENS}$	AWGN
200	FRC A15-2 in Annex A.15	-103.2 - $\Delta_{OTAREFSENS}$	-93.6 - $\Delta_{OTAREFSENS}$	AWGN

Table 10.4.2-3: Dynamic range of SAN supporting standalone NB-IoT operation (LEO class payload)

SAN channel bandwidth (kHz)	Reference measurement channel	Wanted signal mean power (dBm)	Interfering signal mean power (dBm) / $BW_{Channel}$	Type of interfering signal
200	FRC A15-1 in Annex A.15	-89.4 - $\Delta_{OTAREFSENS}$	-85.7 - $\Delta_{OTAREFSENS}$	AWGN
200	FRC A15-2 in Annex A.15	-95.3 - $\Delta_{OTAREFSENS}$	-85.7 - $\Delta_{OTAREFSENS}$	AWGN

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 SAN supporting E-UTRA, the OTA wanted signal and the interfering signal are specified in table 10.5.1.2-1 for OTA ACS. The reference measurement channel for the OTA wanted signal is further specified in annex A.1.

For SAN supporting standalone NB-IoT operation, the OTA wanted signal and the interfering signal are specified in 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 interfering signals are 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: ACS requirement of SAN supporting E-UTRA

SAN channel bandwidth of the lowest/highest carrier received (MHz)	Wanted signal mean power (dBm)	Interfering signal mean power (dBm)	Interfering signal centre frequency offset from the lower/upper SAN RF Bandwidth edge or sub-block edge inside a sub-block gap (MHz)	Type of interfering signal
1.4	$P_{REFSENS}$ + 11dB- $\Delta_{OTAREFSENS}$ (Note)	GEO SAN class: -57.6- $\Delta_{OTAREFSENS}$ LEO SAN class: -60.7- $\Delta_{OTAREFSENS}$	±0.7025	1.4MHz E-UTRA signal
Note: $P_{REFSENS}$ depends on the channel bandwidth as specified in Table 7.2.2-1 and Table 7.2.2-2.				

Table 10.5.1.2-2: ACS requirement of SAN supporting standalone NB-IoT operation

SAN channel bandwidth of the lowest/highest carrier received (kHz)	Wanted signal mean power (dBm)	Interfering signal mean power (dBm)	Interfering signal centre frequency offset to the lower/upper SAN RF Bandwidth edge or sub-block edge inside a sub-block gap (kHz)	Type of interfering signal
200	$P_{REFSENS}$ + 19.5dB - $\Delta_{OTAREFSENS}$(Note)	GEO SAN class: -56.6- $\Delta_{OTAREFSENS}$ LEO SAN class: -59.7- $\Delta_{OTAREFSENS}$	±100	180 kHz NB-IoT signal
Note: $P_{REFSENS}$ depends on the sub-carrier spacing as specified in Table 7.2.2-3 and Table 7.2.2-4.				

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 for SAN supporting E-UTRA or standalone NB-IoT operation

Wanted signal mean power (dBm)	Interfering signal RMS field-strength (V/m)	Type of interfering Signal
$EIS_{minSENS}$ + 6 dB (NOTE 1)	0.0129 (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 $E = \frac{\sqrt{30 EIRP}}{r}$, where EIRP is in W and r is in m. NOTE 3: [For SAN supporting standalone NB-IoT operation, up to 24 exceptions are allowed for spurious response frequencies in each wanted signal frequency when measured using a 1MHz step size. For these exceptions the above throughput requirement shall be met when the blocking signal is set to a level of 0.0103 V/m for 3.75 kHz subcarrier spacing. In addition, each group of exceptions shall not exceed three contiguous measurements using a 1 MHz step size.]		

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

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

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 E-UTRA 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* supporting E-UTRA, 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: In-channel selectivity of SAN supporting E-UTRA (GEO class payload)

SAN channel bandwidth (MHz)	Reference measurement channel	Wanted signal mean power (dBm)	Interfering signal mean power (dBm)	Type of interfering signal
1.4	A1-4 in Annex A.1	$-104.5 - \Delta_{minSENS}$	$-97.6 - \Delta_{minSENS}$	1.4 MHz E-UTRA signal, 3 RBs

Table 10.9.2-2: In-channel selectivity of SAN supporting E-UTRA (LEO class payload)

SAN channel bandwidth (MHz)	Reference measurement channel	Wanted signal mean power (dBm)	Interfering signal mean power (dBm)	Type of interfering signal
1.4	A1-4 in Annex A.1	$-107.6 - \Delta_{minSENS}$	$-88.7 - \Delta_{minSENS}$	1.4 MHz E-UTRA signal, 3 RBs

11 Radiated performance requirements

11.1 General

11.1.1 Scope and definitions

Radiated performance requirements specify the ability of the *SAN type 1-O* to correctly transmit and receive radiated signals in various conditions and configurations. Radiated performance requirements are specified at the RIB.

Radiated performance requirements for the SAN are specified for the fixed reference channels defined in TS 38.108 [7] annex A and for the propagation conditions defined in Recommendation ITU-R P.618 (*Propagation data and prediction methods required for the design of Earth-space telecommunication systems*). The requirements only apply to those FRCs that are supported by the SAN.

The radiated performance requirements for *SAN type 1-O* are limited to two OTA *demodulation branches* as described in clause 11.1.2. Conformance requirements can only be tested for 1 or 2 *demodulation branches* depending on the number of polarizations supported by the SAN, with the required SNR applied separately per polarization.

Unless stated otherwise, radiated performance requirements apply for a single carrier only. Radiated performance requirements for a SAN supporting carrier aggregation are defined in terms of single carrier requirements.

For *SAN type 1-O* in FDD operation the requirements in clause 8 shall be met with the transmitter units associated with the RIB in the *operating band* turned ON.

NOTE 1: *SAN type 1-O* in normal operating conditions in FDD operation is configured to transmit and receive at the same time. The transmitter unit(s) associated with the RIB may be OFF for some of the tests.

In tests performed with signal generators a synchronization signal may be provided from the SAN to the signal generator, to enable correct timing of the wanted signal.

Whenever the "RX antennas" term is used for the radiated performance requirements description, it shall refer to the *demodulation branches* (i.e. not physical antennas of the antenna array).

The SNR used in this clause is specified based on a single carrier and defined as:

SNR = S / N

Where:

S is the total signal power in a slot on a RIB.

N is the noise density integrated in a bandwidth corresponding to the *transmission bandwidth* over the duration where signal energy exists on a RIB.

11.1.2 OTA demodulation branches

Radiated performance requirements are only specified for up to 2 *demodulation branches*.

If the *SAN type 1-O* uses polarization diversity and has the ability to maintain isolation between the signals for each of the *demodulation branches*, then radiated performance requirements can be tested for up to two *demodulation branches* (i.e. 1RX or 2RX test setups). When tested for two *demodulation branches*, each demodulation branch maps to one polarization.

If the *SAN type 1-O* does not use polarization diversity then radiated performance requirements can only be tested for a single *demodulation branch* (i.e. 1RX test setup).

11.2 Performance requirements for PUSCH

Apply the requirements defined in clause 8.2.1.

11.3 Performance requirements for PUCCH

11.3.1 DTX to ACK probability

Apply the requirements defined in clause 8.3.1.1.

11.3.2 Performance requirements for PUCCH format 1a

Apply the requirements defined in sub-clause 8.3.1.2.

11.4 Performance requirements for PRACH

11.4.1 PRACH False alarm probability

Apply the requirements defined in clause 8.4.1.

11.4.2 PRACH detection requirements

Apply the requirements defined in clause 8.4.2.

11.5 Performance requirements for Narrrowband IoT

11.5.1 Requirements for SAN type 1-O

11.5.1.1 Requirements for NPUSCH format1

Apply the requirements defined in clause 8.5.1 for 1Rx.

Apply the requirements defined in clause 8.5.1 for 2Rx.

11.5.1.2 Requirements for NPUSCH format2

Apply the requirements defined in clause 8.5.2 for 1Rx.

Apply the requirements defined in clause 8.5.2 for 2Rx.

11.5.1.3 Requirements for NPRACH

Apply the requirements defined in clause 8.5.3 for 1Rx.

Apply the requirements defined in clause 8.5.3 for 2Rx.

Annex A (normative): Reference measurement channels

The parameters for the reference measurement channels are specified in clause A.1 for E-UTRA reference sensitivity and in-channel selectivity and in clause A.2 for dynamic range.

A schematic overview of the encoding process for the E-UTRA reference measurement channels is provided in Figure A-1.

E-UTRA receiver requirements in the present document are defined with a throughput stated relative to the Maximum throughput of the FRC. The Maximum throughput for an FRC equals the Payload size * the Number of uplink subframes per second. For FDD, 1000 uplink sub-frames per second are used.

The parameters for the reference measurement channels are specified in clause A.14 for NB-IoT reference sensitivity and in clause A.15 for dynamic range.

A schematic overview of the encoding process for the NB-IoT reference measurement channels is provided in Figure A-2.

NB-IoT receiver requirements in the present document are defined with a throughput stated relative to the Maximum throughput of the FRC. The Maximum throughput for an FRC equals the Payload size / (Number of Resource Unit * time to send one Resource Unit).

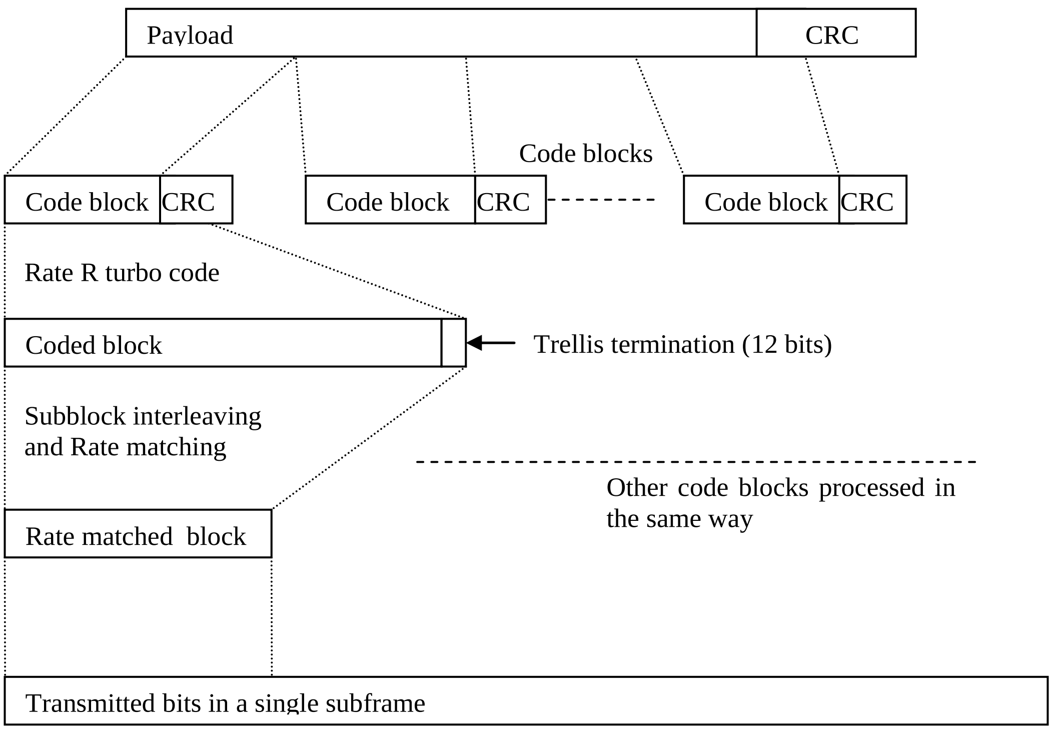

Figure A-1. Schematic overview of the encoding process

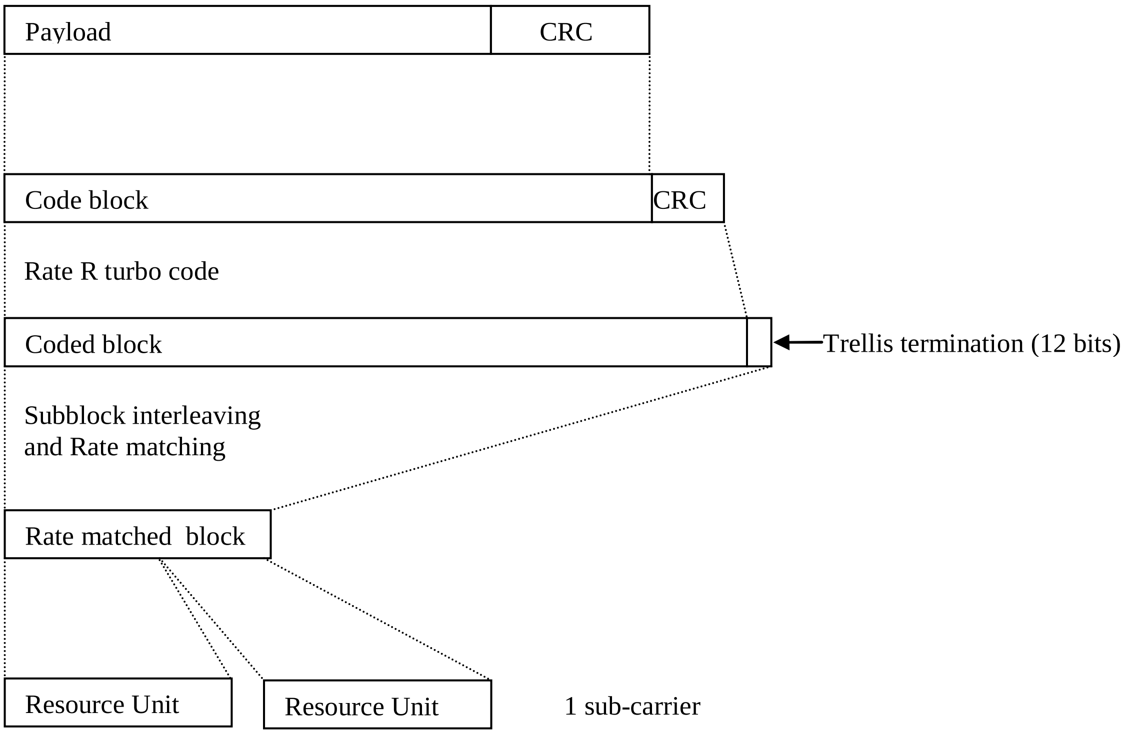

Figure A-2. Schematic overview of the encoding process for NB-IoT

A.1 Fixed Reference Channels for reference sensitivity and in-channel selectivity (QPSK, R=1/3)

The parameters for the reference measurement channels are specified in Table A.1-1 for reference sensitivity and in-channel selectivity.

Table A.1-1 FRC parameters for reference sensitivity and in-channel selectivity

Reference channel	A1-1	A1-4
Allocated resource blocks	6	3
DFT-OFDM Symbols per subframe	12	12
Modulation	QPSK	QPSK
Code rate	1/3	1/3
Payload size (bits)	600	256
Transport block CRC (bits)	24	24
Code block CRC size (bits)	0	0
Number of code blocks - C	1	1
Coded block size including 12bits trellis termination (bits)	1884	852
Total number of bits per sub-frame	1728	864
Total symbols per sub-frame	864	432

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 dynamic range.

Table A.2-1 FRC parameters for dynamic range

Reference channel	A2-1
Allocated resource blocks	6
DFT-OFDM Symbols per subframe	12
Modulation	16QAM
Code rate	2/3
Payload size (bits)	2344
Transport block CRC (bits)	24
Code block CRC size (bits)	0
Number of code blocks - C	1
Coded block size including 12bits trellis termination (bits)	7116
Total number of bits per sub-frame	3456
Total symbols per sub-frame	864

A.3 Fixed Reference Channels for NB-IOT reference sensitivity (π/2 BPSK, R=1/3)

The parameters for the reference measurement channels are specified in Table A.3-1 for reference sensitivity.

Table A.3-1 FRC parameters for reference sensitivity and in-channel selectivity

Reference channel	A14-1	A14-2
Sub-carrier spacing (kHz)	15	3.75
Number of tone	1	1
Diversity	No	No
Modulation	π/2 BPSK	π/2 BPSK
Frequency offset	0	0
Channel estimation length (ms) Note 1	4	16
Number of NPUSCH repetition	1	1
IMCS / TBS	0 / 0	0 / 0
Payload size (bits)	32	32
Allocated resource unit	2	2
Code rate (target)	1/3	1/3
Code rate (effective)	0.29	0.29
Transport block CRC (bits)	24	24
Code block CRC size (bits)	0	0
Number of code blocks - C	1	1
Total number of bits per resource unit	96	96
Total symbols per resource unit	96	96
Tx time (ms)	16	64
Note: Channel estimation lengths are included in the table for information only.		

A.4 Fixed Reference Channels for NB-IoT dynamic range (π/4 QPSK, R=2/3)

The parameters for the reference measurement channels are specified in Table A.4-1 for NB-IoT dynamic range.

Table A.4-1 FRC parameters for NB-IoT dynamic range

Reference channel	A15-1	A15-2
Sub carrier spacing (kHz)	15	3.75
Number of tone	1	1
Modulation	π/4 QPSK	π/4 QPSK
Diversity	No	No
Frequency offset	0	0
IMCS / ITBS	7 / 7	7 / 7
Payload size (bits)	104	104
Allocated resource units	1	1
Transport block CRC (bits)	24	24
Coding rate (target)	2/3	2/3
Coding Rate	0.67	0.67
Code block CRC size (bits)	0	0
Number of code blocks – C	1	1
Total symbols per resource unit	96	96
Total number of bits per resource unit	192	192
Tx time (ms)	8	32
Frequency offset	0	0
Channel estimation length (ms) (NOTE)	4	16
Note: Channel estimation lengths are included in the table for information only.		

A.5 Fixed Reference Channels for performance requirements (QPSK 1/3)

Table A.5-1 FRC parameters for performance requirements (QPSK 1/3)

Reference channel	A5-1	A5-2
Allocated resource blocks	1	6
DFT-OFDM Symbols per subframe	12	12
Modulation	QPSK	QPSK
Code rate	1/3	1/3
Payload size (bits)	104	600
Transport block CRC (bits)	24	24
Code block CRC size (bits)	0	0
Number of code blocks - C	1	1
Coded block size including 12bits trellis termination (bits)	396	1884
Total number of bits per sub-frame	288	1728
Total symbols per sub-frame	144	864

A.6 PRACH Test preambles

Table A.6-1 Test preambles for coverage enhancement

Burst format	Ncs	Logical sequence index	v
0	13	22	32
1	167	22	2
2	167	22	0
3	0	22	0

A.7 Fixed Reference Channels for NB-IoT NPUSCH format 1

A.7.1 One PRB

Table A.7.1-1: FRC parameters for NB-IoT NPUSCH format 1

Reference channel	A7-1	A7-2
Subcarrier spacing (kHz)	3.75	15
Number of allocated subcarriers	1	12
Diversity	No	No
Modulation	BPSK	QPSK
I_{TBS} / I_{RU}	0 / 1	9 / 0
Payload size (bits)	32	136
Allocated resource unit	2	1
Code rate (target)	1/3	2/3
Code rate (effective)	0.29	0.56
Transport block CRC (bits)	24	24
Code block CRC size (bits)	0	0
Number of code blocks - C	1	1
Total number of bits per resource unit	96	288
Total symbols per resource unit	96	144
Channel estimation length (ms) Note 1	16	2 (when repetition = 2) 4 (when repetition > 2)

A.14 Fixed Reference Channels for NB-IOT reference sensitivity (π/2 BPSK, R=1/3)

The parameters for the reference measurement channels are specified in Table A.14-1 for reference sensitivity.

Table A.14-1 FRC parameters for reference sensitivity and in-channel selectivity

Reference channel	A14-1	A14-2
Sub-carrier spacing (kHz)	15	3.75
Number of tone	1	1
Diversity	No	No
Modulation	π/2 BPSK	π/2 BPSK
Frequency offset	0	0
Channel estimation length (ms) (NOTE)	4	16
Number of NPUSCH repetition	1	1
IMCS / TBS	0 / 0	0 / 0
Payload size (bits)	32	32
Allocated resource unit	2	2
Code rate (target)	1/3	1/3
Code rate (effective)	0.29	0.29
Transport block CRC (bits)	24	24
Code block CRC size (bits)	0	0
Number of code blocks - C	1	1
Total number of bits per resource unit	96	96
Total symbols per resource unit	96	96
Tx time (ms)	16	64
NOTE: Channel estimation lengths are included in the table for information only.		

A.15 Fixed Reference Channels for NB-IoT dynamic range (π/4 QPSK, R=2/3)

The parameters for the reference measurement channels are specified in Table A.15-1 for NB-IoT dynamic range.

Table A.15-1 FRC parameters for NB-IoT dynamic range

Reference channel	A15-1	A15-2
Subcarrier spacing (kHz)	15	3.75
Number of tone	1	1
Modulation	π/4 QPSK	π/4 QPSK
Diversity	No	No
Frequency offset	0	0
IMCS / ITBS	7 / 7	7 / 7
Payload size (bits)	104	104
Allocated resource units	1	1
Transport block CRC (bits)	24	24
Coding rate (target)	2/3	2/3
Coding Rate	0.67	0.67
Code block CRC size (bits)	0	0
Number of code blocks – C	1	1
Total symbols per resource unit	96	96
Total number of bits per resource unit	192	192
Tx time (ms)	8	32
Frequency offset	0	0
Channel estimation length (ms) (NOTE)	4	16
NOTE: Channel estimation lengths are included in the table for information only.		

Annex B (normative): Error Vector Magnitude

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.

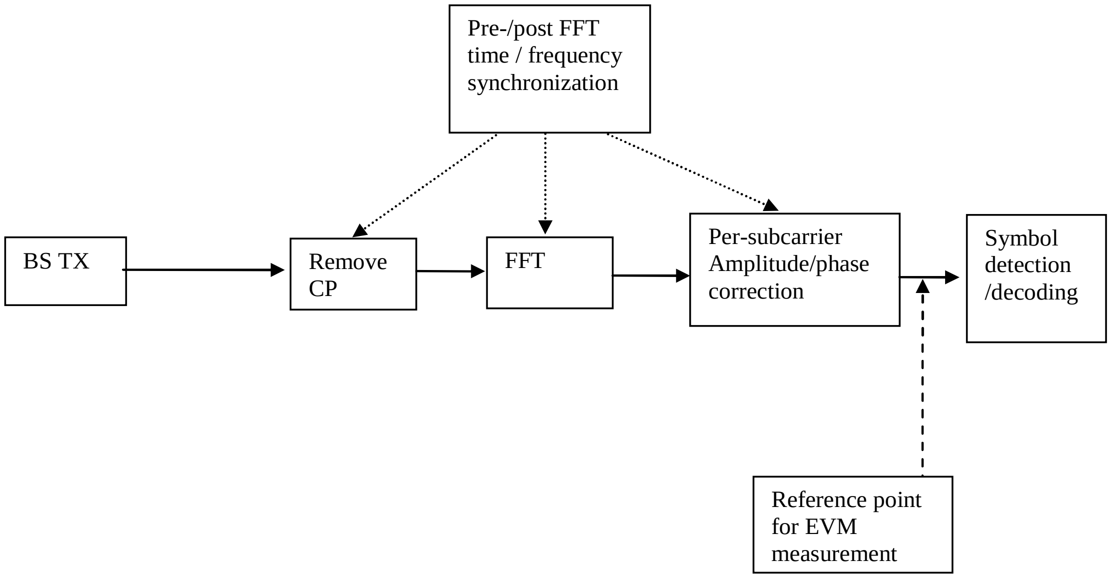

Figure B.1-1: Reference point for EVM measurement

B.2 Basic unit of measurement

For 15 kHz, 7.5 kHz, 1.25 kHz, 2.5 kHz subcarrier spacing, the basic unit of EVM measurement is defined over one subframe (1 ms) for subframe TTI and over one sTTI when supporting sTTI feature in the time domain and N_{BW}^{RB} subcarriers (180 kHz) in the frequency domain:

For 0.37 kHz subcarrier spacing, the basic unit of EVM measurement is defined over one slot (3 ms) in the time domain and N_{BW}^{RB} subcarriers (180 kHz) 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 subframe or within the sTTI,

$F(t)$ 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 B.3.

Note: Although the basic unit of measurement is one subframe or one sTTI, the equalizer is calculated over 10 subframe measurement periods to reduce the impact of noise in the reference symbols. The boundaries of the 10 subframe measurement periods 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 equalised 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 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 ms.

For 0.37 kHz, the observation period for determining the frequency offset $\Delta\tilde{f}$ shall be 6 ms. For 2.5 kHz, the observation period for determining the frequency offset $\Delta\tilde{f}$ shall be 1 ms.

B.5 Estimation of time offset

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

For 0.37 kHz, the observation period for determining the sample timing difference $\Delta\tilde{t}$ shall be 6 ms.

For 2.5 kHz, the observation period for determining the sample timing difference $\Delta \tilde{t}$ shall be 1 ms.

In the following $\Delta \tilde{c}$ represents the middle sample of the EVM window of length W (defined in E.5.1) 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 the primary synchronization signal and 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 (e.g. time multiplexed MBMS and unicast) 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.5.1 Window length

Table B.5.1-1 and Table B.5.1-1a below specify EVM window length (W) for normal CP, the cyclic prefix length N_{cp} is 10 for symbols 0 and 9 for symbols 1-6.

Table B.5.1-2 specify the EVM window length (W) for extended CP for 15 kHz, subcarrier spacing.

Table B5.1-1: EVM window length for normal CP for E-UTRA

Channel Bandwidth (MHz)	FFT size		Cyclic prefix length for symbols 0 in FFT samples	Cyclic prefix length for symbols 1-6 in FFT samples	EVM window length *W*	Ratio of *W* to total CP for symbols 1-6 (NOTE) (%)
1.4	128		10	9	5	55.6
Note: These percentages are informative and apply to symbols 1 through 6. Symbol 0 has a longer CP and therefore a lower percentage.						

Table B.5.1-2: EVM window length for normal CP for NB-IoT

FFT size	Cyclic prefix length for symbols 0 in FFT samples	Cyclic prefix length for symbols 1-6 in FFT samples	EVM window length *W*	Ratio of *W* to total CP for symbols 1-6 (NOTE) (%)
128	10	9	3	33.3
Note: These percentages are informative and apply to symbols 1 through 6. Symbol 0 has a longer CP and therefore a lower percentage.				

Table B.5.1-3: EVM window length for extended CP for 15 kHz subcarrier spacing

Channel Bandwidth (MHz)	FFT size	Cyclic prefix in FFT samples	EVM window length *W*	Ratio of *W* to total CP (NOTE) (%)
1.4	128	32	28	87.5
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 symbol, over 10 subframes. 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: restricted content: i.e. nominal Reference Symbols and the Primary Synchronisation Channel, (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 10 subframes. 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 then 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 third subcarrier with the exception of the reference subcarrier spacing across the DC 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 symbol time-domain locations t_i from Z'(f,t) 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 third subcarrier. The moving average window size is 19. For reference subcarriers at or near the edge of the channel 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.

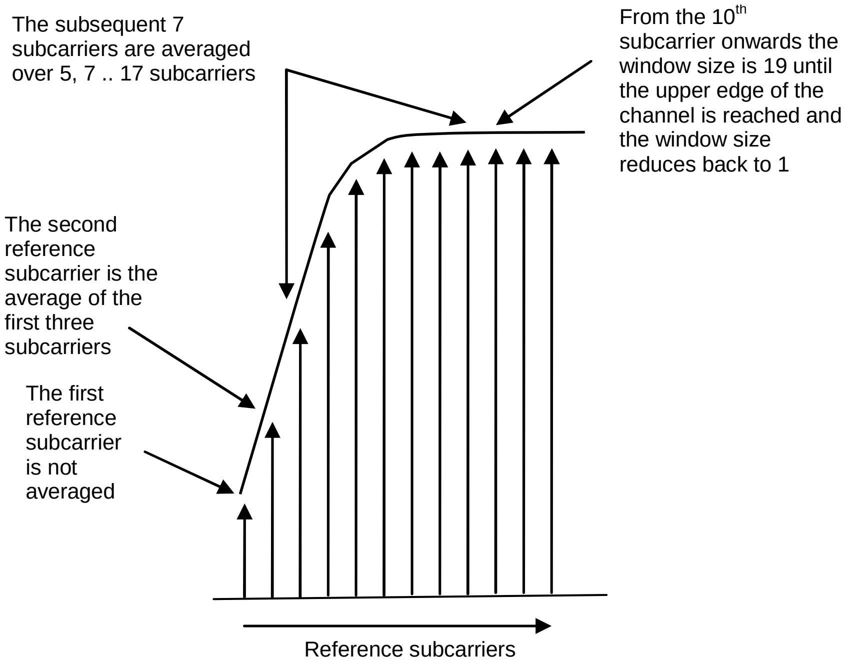

Figure B.6-1: Reference subcarrier smoothing in the frequency domain

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 10 downlink subframes:

For FDD the averaging in the time domain equals the 10 subframe duration of the 10 subframes measurement period 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 subframe or sTTI i and N_{dl} is the number of allocated downlink subframes or sTTI in one frame.

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:

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

The averaged EVM with the minimum averaging length of at least 10 subframes is then achieved by further averaging of the EVM_{frame} results

$$\overline{EVM} = \sqrt{\frac{1}{N_{frame}} \sum_{k=1}^{N_{frame}} EVM_{frame,k}^{2}}\ ,\ N_{frame} = \left\lceil \frac{10}{N_{dl}} \right\rceil$$

Annex C (normative): Characteristics of the interfering signals

For E-UTRA SAN, the interfering signal shall be a PUSCH containing data and reference symbols. Normal cyclic prefix is used. The data content shall be uncorrelated to the wanted signal and modulated according to clause 5 of TS36.211[9]. Mapping of PUSCH modulation to receiver requirement are specified in table C-1.

Table C-1: Modulation of the interfering signal for E-UTRA

Receiver requirement	Modulation
In-channel selectivity	16QAM
Adjacent channel selectivity	QPSK

For NB-IoT standalone SAN, the interfering signal shall be a NPUSCH containing data and reference symbols. Normal cyclic prefix is used. The data content shall be uncorrelated to the wanted signal and modulated according to clause 10.1 of TS36.211[9]. Mapping of NPUSCH modulation to receiver requirement are specified in table C-2.

Table C-2: Modulation of the interfering signal for standalone NB-IoT

Receiver requirement	Modulation
Adjacent channel selectivity	π/4 QPSK

Annex D (Normative): Propagation condition

D.1 Static propagation condition

The propagation for the static performance measurement is an Additive White Gaussian Noise (AWGN) environment. No fading or multi-paths exist for this propagation model.

D.2 Multi-path fading propagation conditions

The multipath propagation conditions consist of several parts:

- A delay profile in the form of a "tapped delay-line", characterized by a number of taps at fixed positions on a sampling grid. The profile can be further characterized by the r.m.s. delay spread and the maximum delay spanned by the taps.
- A combination of channel model parameters that include the Delay profile and the Doppler spectrum that is characterized by a classical spectrum shape and a maximum Doppler frequency.

D.2.1 Delay profiles

The delay profiles are simplified from the TR 38.811 [10] TDL models. The simplification steps are described in TS 38.108 D.2 [7].

D.2.1.1 Delay profiles

The delay profiles are selected to be representative of low and medium delay spread environment. The resulting model parameters are specified in table D.2.1.1-1 and the tapped delay line models are specified in tables D.2.1.1-2 and D.2.1.1-3.

Table D.2.1.1-1: Delay profiles for NR channel models

Model	Number of channel taps	Delay spread (r.m.s.)	Maximum excess tap delay (span)	Delay resolution
NTN-TDLA100	3	100 ns	285	5ns
NTN-TDLC5	2	5 ns	60	5ns

Table D.2.1.1-2: NTN-TDLA100 (DS = 100 ns)

Tap #	Delay (ns)	Power (dB)	Fading distribution
1	0	0	Rayleigh
2	110	-4.7	Rayleigh
3	285	-6.5	Rayleigh

Table D.2.1.1-3: NTN-TDLC5 (DS = 5 ns)

Tap #	Delay (ns)	Power (dB)	Fading distribution
1	0	-0.6	LOS path
	0	-8.9	Rayleigh
2	60	-21.5	Rayleigh

D.2.2 Combinations of channel model parameters

The propagation conditions used for the performance measurements in multi-path fading environment are indicated as a combination of a channel model name and a maximum Doppler frequency, i.e., NTN-TDLA<DS>-<Doppler> or NTN-TDLC<DS>-<Doppler> where '<DS>' indicates the desired delay spread and '<Doppler>' indicates the maximum Doppler frequency (Hz).

Table D.2.2-1 show the propagation conditions that are used for the performance measurements in multi-path fading environment.

Table D.2.2-1: Channel model parameters

Combination name	Tapped delay line model	Maximum Doppler frequency
NTN-TDLA100-5	NTN-TDLA100	5 Hz
NTN-TDLC5-5	NTN-TDLC5	5 Hz

Annex E (informative): Change history

Change history							
Date	Meeting	TDoc	CR	Rev	Cat	Subject/Comment	New version
2022-08	RAN4#104-e	R4-2215119				Draft spec for TS 36.108	0.0.1
2022-11	RAN4#105	R4-2219362				R4-2220296 TP for TS 36.108: Section 1,2,3 R4-2220297 TP for TS 36.108: Clause 7 R4-2220298 TP for TS 36.108: Clause 10 R4-2219369 TP for TS 36.108: Annex R4-2220300 TP for SAN RF requirement clause 9 R4-2220301 TP for SAN RF requirement clause 6 R4-2220302 TP to TS 36.108 (section 4) R4-2220614 TP to TS 36.108 (section 5)	0.1.0
2022-12	RAN#98e	RP-223092				Draft version for approval to RAN Plenary meeting: RP-223092 TS 36.108 v1.0.0 Evolved Universal Terrestrial Radio Access (E-UTRA);Satellite Access Node radio transmission and reception	1.0.0

Change history							
Date	Meeting	TDoc	CR	Rev	Cat	Subject/Comment	New version
2022-12	RAN#98-e					Approved by plenary – Rel-18 spec under change control	18.0.0
2023-03	RAN#99	RP-230526	0001	1	F	Maintenance CR to TS36.108 : dynamic range requirement and others	18.1.0
2023-03	RAN#99	RP-230526	0002		F	CR to TS 36.108: corrections NOTE: CR was not implemented as the formal CR document with coversheet did not include any content.	18.1.0
2023-06	RAN#100	RP-231364	0003	1	F	CR to 36.108: Annex for characteristics of the interfering signals	18.2.0
2023-06	RAN#100	RP-231364	0005		F	Re-submission of the CR to TS 36.108: corrections	18.2.0
2023-06	RAN#100	RP-231361	0006		B	Big CR to TS 36.108 for IoT over NTN SAN demodulation requirements introduction	18.2.0
2023-09	RAN#101	RP-232510	0010	1	F	CR on output power dynamic range for IoT NTN	18.3.0
2023-09	RAN#101	RP-232510	0011		F	CR on SAN demodulation requirements for NB-IoT over NTN	18.3.0
2023-09	RAN#101	RP-232510	0012		F	draft CR: Introduction of SAN demodulation requirements for IoT-NTN	18.3.0
2023-12	RAN#102	RP-233355	0013		B	CR to TS36.108 Introduction of a new FDD band (L+S band) for IoT NTN operation	18.4.0
2023-12	RAN#102	RP-233354	0014		B	CR to TS36.108 Introduction of the Extended L-band	18.4.0
2023-12	RAN#102	RP-233357	0017	1	F	CR to 36.108: Out-of-band emissions requirements	18.4.0
2024-03	RAN#103	RP-240582	0019		F	(LTE_NBIOT_eMTC_NTN_req-Perf) CR on SAN demodulation requirements for NB-IoT over NTN	18.5.0
2024-03	RAN#103	RP-240582	0020		F	(LTE_NBIOT_eMTC_NTN_req-Perf) CR: Completion of eMTC SAN demodulation requirements	18.5.0
2024-06	RAN#104	RP-241411	0022		F	(LTE_NBIOT_eMTC_NTN_req-Core)CR for TS 36.108, Correction on antenna connector for RF requirements	18.6.0
2024-06	RAN#104	RP-241411	0023		F	(LTE_NBIOT_eMTC_NTN_req-Core)CR for TS 36.108, Correction on general SAN transmitter spurious emission limits	18.6.0
2024-06	RAN#104	RP-241411	0024	1	F	CR to 36.108: Minimum requirements for unwanted emissions for SAN	18.6.0
2024-06	RAN#104	RP-241411	0026	2	F	CR to TS 36.108: Band-agnostic OBUE requirement	18.6.0
2024-09	RAN#105	RP-242151	0028		F	(LTE_NBIoT_eMTC_NTN_req) Collection of IoT-NTN SAN demodulation performance requirements	18.7.0

History

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