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

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

Siret N° 348 623 562 00017 - APE 7112B
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In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Contents

Foreword

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

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

shall indicates a mandatory requirement to do something

shall not indicates an interdiction (prohibition) to do something

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

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

should indicates a recommendation to do something

should not indicates a recommendation not to do something

may indicates permission to do something

need not indicates permission not to do something

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

can indicates that something is possible

cannot indicates that something is impossible

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

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

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

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

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

In addition:

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

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

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

1 Scope

The present document establishes the minimum RF and performance requirements for NR User Equipment (UE) supporting satellite access operation.

2 References

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

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

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

[2] 3GPP TS 38.521-5: "NR; User Equipment (UE) conformance specification; Radio transmission and reception; Part 5: Satellite access Radio Frequency (RF) and performance requirements ".

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

[4] 3GPP TS 38.108: "NR; Satellite Node radio transmission and reception"

[5] 3GPP TS 38.101-1: "NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone".

[6] 3GPP TS 38.101-4: "NR; User Equipment (UE) radio transmission and reception; Part 4: Performance requirements".

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

[8] 3GPP TS 38.331: " Radio Resource Control (RRC) protocol specification".

[9] 3GPP TS 38.300: "NR; NR and NG-RAN Overall description; Stage-2".

[10] 3GPP TS 36.101: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception".

[11] 3GPP TS 38.306: "User Equipment (UE) radio access capabilities".

[12] 3GPP TR 38.811: "Study on New Radio (NR) to support non-terrestrial networks".

[13] 3GPP TS 38.508-1: "5GS; User Equipment (UE) conformance specification; Part 1: Common test environment".

3 Definitions of terms, symbols and abbreviations

3.1 Terms

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].

Geostationary satellite: A geosynchronous satellite whose circular and direct orbit lies in the plane of the Earth's equator and which thus remains fixed relative to the Earth; by extension, a geosynchronous satellite which remains approximately fixed relative to the Earth.

Geostationary-Satellite Orbit: The orbit of a geosynchronous satellite whose circular and direct orbit lies in the plane of the Earth's equator.

Geosynchronous Earth Orbit: Earth-centered orbit at approximately 35786 kilometres above Earth's surface and synchronised with Earth's rotation. A geostationary orbit is a non-inclined geosynchronous orbit, i.e. in the Earth's equator plane.

Geosynchronous satellite: An earth satellite whose period of revolution is equal to the period of rotation of the Earth about its axis.

Low Earth Orbit: Orbit around the Earth with an altitude between 300 km, and 1500 km.

Non-terrestrial networks: Networks, or segments of networks, using an airborne or space-borne vehicle to embark a transmission equipment relay node or base station.

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

Satellite Access Node: see definition in TS 38.108[4].

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

3.2 Symbols

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

ΔF_{Global}	Granularity of the global frequency raster
ΔF_{Raster}	Band dependent channel raster granularity
$BW_{Channel}$	Channel bandwidth
$BW_{interferer}$	Bandwidth of the interferer
F_{DL_low}	The lowest frequency of the downlink *operating band*
F_{DL_high}	The highest frequency of the downlink *operating band*
F_{UL_low}	The lowest frequency of the uplink *operating band*
F_{UL_high}	The highest frequency of the uplink *operating band*
$F_{Interferer}$	Frequency of the interferer
$F_{Interferer}$ (offset)	Frequency offset of the interferer (between the center frequency of the interferer and the carrier frequency of the carrier measured)
$F_{Ioffset}$	Frequency offset of the interferer (between the center frequency of the interferer and the closest edge of the carrier measured)
F_{OOB}	The boundary between the NR out of band emission and spurious emission domains
F_{REF}	RF reference frequency
$F_{REF-Offs}$	Offset used for calculating F_{REF}
F_{uw} (offset)	The frequency separation of the center frequency of the carrier closest to the interferer and the center frequency of the interferer
N_{RB}	Transmission bandwidth configuration, expressed in units of resource blocks
N_{REF}	NR Absolute Radio Frequency Channel Number (NR-ARFCN)
$N_{REF-Offs}$	Offset used for calculating N_{REF}
$P_{Interferer}$	Modulated mean power of the interferer
P_{uw}	Power of an unwanted DL signal

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].

ACLR	Adjacent Channel Leakage Ratio

ACS	Adjacent Channel Selectivity
A-MPR	Additional Maximum Power Reduction
BW	Bandwidth
BWP	Bandwidth Part
CP-OFDM	Cyclic Prefix-OFDM
CW	Continuous Wave
DFT-s-OFDM	Discrete Fourier Transform-spread-OFDM
DM-RS	Demodulation Reference Signal
DTX	Discontinuous Transmission
EIRP	Equivalent Isotropically Radiated Power
EVM	Error Vector Magnitude
FR	Frequency Range
FRC	Fixed Reference Channel
GEO	Geosynchronous Earth Orbit
GSCN	Global Synchronization Channel Number
GSO	Geostationary-Satellite Orbit
IBB	In-band Blocking
ITU-R	Radiocommunication Sector of the International Telecommunication Union
LEO	Low Earth Orbiting
MBW	Measurement bandwidth defined for the protected band
MEO	Medium Earth Orbiting
MOP	Maximum Output Power
MPR	Allowed maximum power reduction
MSD	Maximum Sensitivity Degradation
NGEO	Non-Geostationary Earth Orbiting
NGSO	Non-Geostationary-Satellite Orbit
NR	New Radio
NR-ARFCN	NR Absolute Radio Frequency Channel Number
NS	Network Signalling
NTN	Non-Terrestrial Network
OCNG	OFDMA Channel Noise Generator
OOB	Out-of-band
PRB	Physical Resource Block
QAM	Quadrature Amplitude Modulation
RAN	Radio Access Network
RE	Resource Element
REFSENS	REFerence SENSitivity
RF	Radio Frequency
RMS	Root Mean Square (value)
RSRP	Reference Signal Receive Power
RSRQ	Reference Signal Receive Quality
RX	Receiver
SAN	Satellite Access Node
SC	Single Carrier
SCS	Subcarrier spacing
SEM	Spectrum Emission Mask
SNR	Signal-to-Noise Ratio
SRS	Sounding Reference Symbol
SS	Synchronization Symbol
TN	Terrestrial Network
TX	Transmitter
TxD	Tx Diversity
UE	User Equipment

4 General

4.1 Relationship between minimum requirements and test requirements

The present document is a Single-RAT specification for satellite NR UE, covering RF characteristics and minimum performance requirements. Conformance to the present specification is demonstrated by fulfilling the test requirements specified in the conformance specification 3GPP TS 38.521-5 [2].

The Minimum Requirements given in this specification make no allowance for measurement uncertainty. The test specification 3GPP TS 38.521-5 [2] defines test tolerances. These test tolerances are individually calculated for each test. The test tolerances are used to relax the minimum requirements in this specification to create test requirements. For some requirements, including regulatory requirements, the test tolerance is set to zero.

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

The shared risk principle is defined in Recommendation ITU-R M.1545 [3].

4.2 Applicability of minimum requirements

a) In this specification the Minimum Requirements are specified as general requirements and additional requirements. Where the Requirement is specified as a general requirement, the requirement is mandated to be met in all scenarios

b) For specific scenarios for which an additional requirement is specified, in addition to meeting the general requirement, the UE is mandated to meet the additional requirements.

c) The spurious emissions power requirements are for the long-term average of the power. For the purpose of reducing measurement uncertainty, it is acceptable to average the measured power over a period of time sufficient to reduce the uncertainty due to the statistical nature of the signal.

4.3 Specification suffix information

Specification suffix information is not defined for the time being in Release 17.

4.4 Relationship with other core specifications

The present document establishes the minimum RF and performance requirements for NR User Equipment (UE) operating in a Non-Terrestrial Network. The present document for the single-RAT specification of a satellite NR UE side is used together with the technical specification 3GPP TS 38.108 [4] specifying the Satellite Access Node (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.

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

Table 5.1-1: Definition of frequency ranges

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

The present specification covers FR1 operating bands.

5.2 Operating bands

5.2.1 General

NTN satellite covers FR1 operating bands in the present specification.

5.2.2 Operating bands with conducted requirements

NTN satellite is designed to operate in the operating bands defined in Table 5.2.2-1.

Table 5.2.2-1: NTN satellite bands in FR1

NTN satellite operating band	Uplink (UL) operating band Satellite Access Node receive / UE transmit $F_{UL,low}$ – $F_{UL,high}$	Downlink (DL) operating band Satellite Access Node transmit / UE receive $F_{DL,low}$ – $F_{DL,high}$	Duplex mode
n256	1980MHz – 2010 MHz	2170 MHz – 2200 MHz	FDD
n255	1626.5 MHz – 1660.5 MHz	1525 MHz – 1559 MHz	FDD
NOTE: NTN satellite bands are numbered in descending order from n256.			

5.2.3 reserved (for radiated requirements)

[To be updated]

5.3 UE channel bandwidth

5.3.1 General

The UE channel bandwidth supports a single RF carrier in the uplink or downlink at the UE. From a SAN perspective, different UE channel bandwidths may be supported within the same spectrum for transmitting to and receiving from UEs connected to the SAN.

From a UE perspective, the UE is configured with one or more BWP / carriers, each with its own UE channel bandwidth. The UE does not need to be aware of the SAN channel bandwidth or how the SAN allocates bandwidth to different UEs.

The placement of the UE channel bandwidth for each UE carrier is flexible but can only be completely within the SAN channel bandwidth.

The relationship between the channel bandwidth, the guardband and the maximum transmission bandwidth configuration is shown in Figure 5.3.1-1.

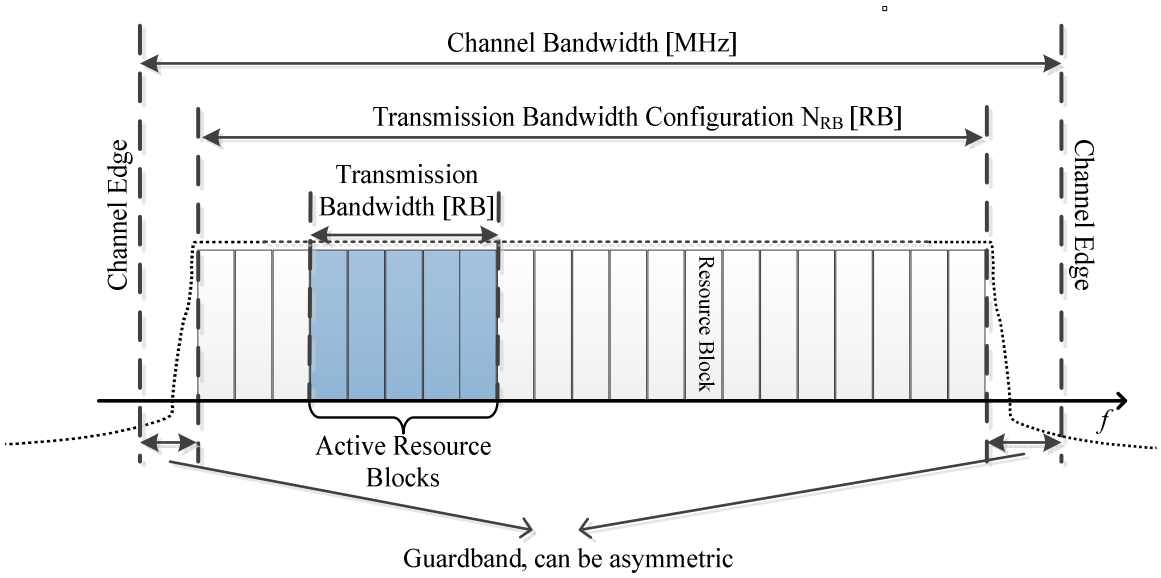

Figure 5.3.1-1: Definition of the channel bandwidth and the maximum transmission bandwidth configuration for one channel

5.3.2 Maximum transmission bandwidth configuration

The maximum transmission bandwidth configuration N_{RB} for each UE channel bandwidth and subcarrier spacing is specified in Table 5.3.2-1.

Table 5.3.2-1: Maximum transmission bandwidth configuration N_{RB}

SCS (kHz)	5 MHz	10 MHz	15 MHz	20 MHz
	N_{RB}	N_{RB}	N_{RB}	N_{RB}
15	25	52	79	106
30	11	24	38	51
60	N/A	11	18	24

5.3.3 Minimum guardband and transmission bandwidth configuration

The minimum guardband for each UE channel bandwidth and SCS is specified in Table 5.3.3-1,

Table 5.3.3-1: Minimum guardband for each UE channel bandwidth and SCS (kHz)

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

NOTE: The minimum guardbands have been calculated using the following equation: ($BW_{Channel}$ x 1000 (kHz) - N_{RB} x SCS x 12) / 2 - SCS/2, where N_{RB} are from Table 5.3.2-1.

Figure 5.3.3-1: Void

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

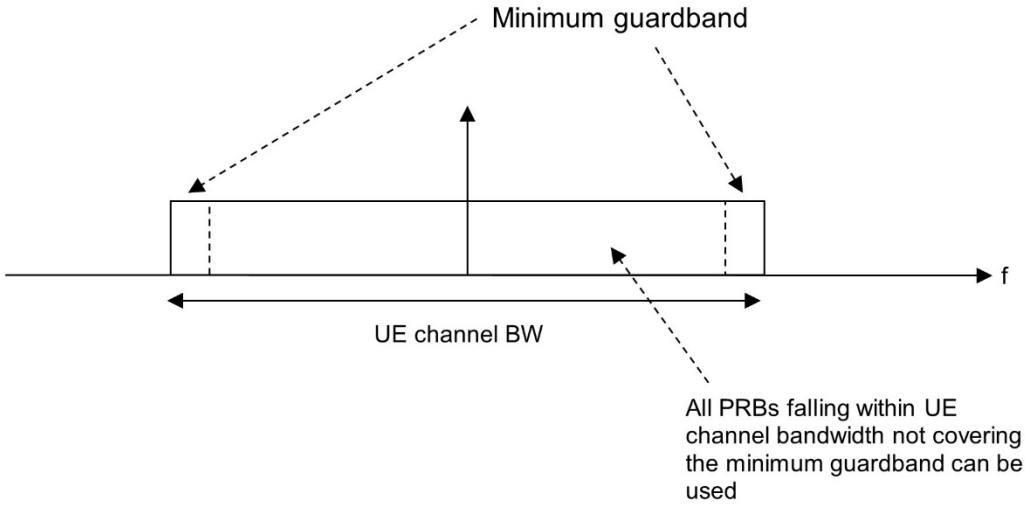

Figure 5.3.3-2: UE PRB utilization

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

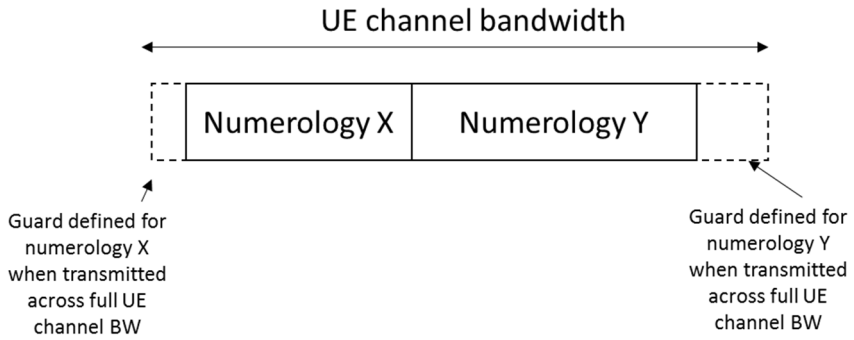

Figure 5.3.3-3: Guard band definition when transmitting multiple numerologies

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

5.3.4 RB alignment

The RB alignment refers to NR RB alignments as specified in 3GPP TS 38.101-1 [5] clause 5.3.4.

5.3.5 UE channel bandwidth per operating band

The requirements in this specification apply to the combination of channel bandwidths, SCS and operating bands shown in Table 5.3.5-1. The transmission bandwidth configuration in Table 5.3.2-1 shall be supported for each of the specified channel bandwidths. The channel bandwidths are specified for both the TX and RX path.

Table 5.3.5-1: Channel bandwidths for each NTN satellite band

NTN satellite band	SCS kHz	UE Channel bandwidth (MHz)			
		5	10	15	20
n256	15	5	10	15	20
	30		10	15	20
	60		10	15	20
n255	15	5	10	15	20
	30		10	15	20
	60		10	15	20

5.4 Channel arrangement

5.4.1 Channel spacing

5.4.1.1 Channel spacing for adjacent NTN satellite carriers

The channel spacing for adjacent NTN satellite carriers refers to the NR channel spacing as specified in 3GPP TS 38.101-1 [5] clause 5.4.1.1.

5.4.2 Channel raster

5.4.2.1 NR-ARFCN and channel raster

The global frequency channel raster defines a set of RF reference frequencies $F_{REF.}$ The RF reference frequency is used in signalling to identify the position of RF channels, SS blocks and other elements.

The global frequency raster is defined for all frequencies from 0 to 100 GHz. The granularity of the global frequency raster is ΔF_{Global}.

RF reference frequencies are designated by an NR Absolute Radio Frequency Channel Number (NR-ARFCN) in the range (0…2016666) on the global frequency raster. The relation between the NR-ARFCN and the RF reference frequency F_{REF} in MHz is given by the following equation, where $F_{REF-Offs}$ and $N_{REF-Offs}$ are given in Table 5.4.2.1-1 and N_{REF} is the NR-ARFCN.

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

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

Frequency range (MHz)	ΔF_{Global} (kHz)	$F_{REF-Offs}$ (MHz)	$N_{REF-Offs}$	Range of N_{REF}
0 – 3000	5	0	0	0 – 599999

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

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

5.4.2.2 Channel raster to resource element mapping

The mapping between the RF reference frequency on the channel raster and the corresponding resource element refers to the NR requirements specified in 3GPP TS 38.101-1 [5] clause 5.4.2.2.

5.4.2.3 Channel raster entries for each operating band

The RF channel positions on the channel raster in each NTN satellite operating band are given through the applicable NR-ARFCN in Table 5.4.2.3-1, using the channel raster to resource element mapping in clause 5.4.2.2.

For NTN satellite operating bands with 100 kHz channel raster, $\Delta F_{Raster} = 20 \times \Delta F_{Global}$. In this case every 20th NR-ARFCN within the operating band are applicable for the channel raster within the operating band and the step size for the channel raster in Table 5.4.2.3-1 is given as <20>.

Table 5.4.2.3-1: Applicable NR-ARFCN per operating band

NTN satellite operating band	ΔF_{Raster} (kHz)	Uplink Range of N_{REF} (First – <Step size> – Last)	Downlink Range of N_{REF} (First – <Step size> – Last)
n256	100	396000 – <20> – 402000	434000 – <20> – 440000
n255	100	325300 – <20> – 332100	305000 – <20> – 311800
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.			

5.4.3 Synchronization raster

5.4.3.1 Synchronization raster and numbering

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

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

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

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

Frequency range	SS Block frequency position SS_{REF}	GSCN	Range of GSCN
0 – 3000 MHz	N * 1200kHz + M * 50 kHz, N=1:2499, M ϵ {1,3,5}[1]	3N + (M-3)/2	2 – 7498
NOTE: The default value for operating bands with which only support SCS spaced channel raster(s) is M=3.			

5.4.3.2 Synchronization raster to synchronization block resource element mapping

The mapping between the synchronization raster and the corresponding resource element of the SS block refers to 3GPP TS 38.101-1 [5] clause 5.4.3.2.

5.4.3.3 Synchronization raster entries for each operating band

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

Table 5.4.3.3-1: Applicable SS raster entries per operating band

NTN satellite operating band	SS Block SCS	SS Block pattern[1]	Range of GSCN (First – <Step size> – Last)
n256	15 kHz	Case A	5429 – <1> – 5494
n255	15 kHz	Case A	3818 – <1> – 3892
	30 kHz	Case B	3824 – <1> – 3886
NOTE : SS Block pattern is defined in clause 4.1 in 3GPP TS 38.213 [7].			

5.4.4 TX–RX frequency separation

The default TX channel (carrier centre frequency) to RX channel (carrier centre frequency) separation for operating bands is specified in Table 5.4.4-1.

Table 5.4.4-1: UE TX-RX frequency separation

NTN Satellite Operating Band	TX – RX carrier centre frequency separation
n256	190 MHz
n255	-101.5 MHz

6 Conducted transmitter characteristics

6.1 General

Unless otherwise stated, the transmitter characteristics for satellite access UEs are specified at the antenna connector of the UE with a single or multiple transmit antenna(s). For UE with integral antenna only, a reference antenna with a gain of 0 dBi is assumed. Handheld power class 3 UE is assumed in Release 17 for satellite access.

All requirements in this section are applicable to devices supporting GSO and/or NGSO satellites.

6.2 Transmitter power

6.2.1 UE maximum output power

The following UE Power Classes define the maximum output power for any transmission bandwidth within the channel bandwidth of NR carrier unless otherwise stated. The period of measurement shall be at least one sub frame (1ms).

Table 6.2.1-1: UE Power Class

NR satellite band	Class 3 (dBm)	Tolerance (dB)
n256	23	±2
n255	23	±2
NOTE 1: $P_{PowerClass}$ is the maximum UE power specified without taking into account the tolerance NOTE 2: Power class 3 is default power class unless otherwise stated		

6.2.2 UE maximum output power reduction

UE is allowed to reduce the maximum output power due to higher order modulations and transmit bandwidth configurations. For UE power class 3, the allowed maximum power reduction (MPR) is defined as Table 6.2.2-1 in 3GPP TS 38.101-1[5] clause 6.2.2.

6.2.3 UE additional maximum output power reduction

6.2.3.1 General

Additional emission requirements can be signalled by the network. Each additional emission requirement is associated with a unique network signalling (NS) value indicated in RRC signalling by an NR frequency band number of the applicable operating band and an associated value in the field *additionalSpectrumEmission.* Throughout this specification, the notion of indication or signalling of an NS value refers to the corresponding indication of an NR satellite band number of the applicable operating band, the IE field *freqBandIndicatorNR* and an associated value of *additionalSpectrumEmission* in the relevant RRC information elements [6].

To meet the additional requirements, additional maximum power reduction (A-MPR) is allowed for the maximum output power as specified in Table 6.2.1-1. Unless stated otherwise, the total reduction to UE maximum output power is max(MPR, A-MPR) where MPR is defined in clause 6.2.2. Outer and inner allocation notation used in clause 6.2.3 is defined in 3GPP TS 38.101-1 [5] clause 6.2.2. In absence of modulation and waveform types the A-MPR applies to all modulation and waveform types.

Table 6.2.3.1-1 specifies the additional requirements with their associated network signalling values and the allowed A-MPR and applicable operating band(s) for each NS value. The mapping of NR satellite band numbers and values of the *additionalSpectrumEmission* to network signalling labels is specified in Table 6.2.3.1-1A.

Table 6.2.3.1-1: Additional maximum power reduction (A-MPR)

Network signalling label	Requirements (clause)	NR satellite Band	Channel bandwidth (MHz)	Resources blocks (N_{RB})	A-MPR (dB)
NS_01		Table 5.2-1	5, 10, 15, 20	Table 5.3.2-1 in 3GPP TS 38.101-1 [5]	N/A
NS_24	6.5.3.3.13 in 3GPP TS 38.101-1 [5]	n256	5, 10, 15, 20	Table 6.2.3.15-1 in 3GPP TS 38.101-1 [5]	Clause 6.2.315 in 3GPP TS 38.101-1 [5][2]
NS_02N	6.5.3.3.2	n255	5, 10, 15, 20		N/A
NS_100	6.5.2.4.2 in 3GPP TS 38.101-1 [5]	n256[1]			Table 6.2.3.1-2 in 3GPP TS 38.101-1 [5]
NOTE 1: This NS can be signalled for NR bands that have UTRA services deployed. NOTE 2: A-MPR for the upper 5 MHz of the band is not specified, and therefore shall be used as a guard band.					

[The NS_01 label with the field *additionalPmax* [8] absent is default for all NTN satellite bands.]

Table 6.2.3.1-1A: Mapping of network signalling label

NR satellite band	Value of additionalSpectrumEmission							
	0	1	2	3	4	5	6	7
n256	NS_01	NS_24	NS_100					
n255	NS_01	NS_02N						
NOTE: *additionalSpectrumEmission* corresponds to an information element of the same name defined in clause 6.3.2 of 3GPP TS 38.331 [8].								

6.2.4 Configured transmitted power

The requirements for configured transmitted power defined in subclause 6.2.4 of 3GPP TS 38.101-1 [5] clause 6.2.4 shall apply to NTN satellite UE.

6.3 Output power dynamics.

6.3.1 Minimum output power

The minimum controlled output power of the UE is defined as the power in the channel bandwidth for all transmit bandwidth configurations (resource blocks), when the power is set to a minimum value.

The minimum output power is defined as the mean power in at least one sub-frame (1 ms). The minimum output power shall not exceed the values specified in Table 6.3.1-1.

Table 6.3.1-1: Minimum output power

Channel bandwidth (MHz)	Minimum output power (dBm)	Measurement bandwidth (MHz)
5	-40	4.515
10	-40	9.375
15	-40	14.235
20	-40	19.095

6.3.2 Transmit OFF power

Transmit OFF power is defined as the mean power in the channel bandwidth when the transmitter is OFF. The transmitter is considered OFF when the UE is not allowed to transmit on any of its ports.

The transmit OFF power is defined as the mean power in a duration of at least one sub-frame (1 ms) excluding any transient periods. The transmit OFF power shall not exceed the values specified in Table 6.3.2-1.

Table 6.3.2-1: Transmit OFF power

Channel bandwidth	(MHz)	5, 10, 15, 20
REF_SCS	(kHz)	15
Transmit OFF power	(dBm)	-50
Measurement bandwidth	(MHz)	MBW=REF_SCS*(12*N_{RB}+1)/1000

6.3.3 Transmit ON/OFF time mask

The requirements for transmit ON/OFF time mask defined in 3GPP TS 38.101-1 [5] clause 6.3.3 shall apply for NTN satellite UE.

6.3.4 Power control

The requirements for Power control defined in 3GPP TS 38.101-1 [5] clause 6.3.4 shall apply for NTN satellite UE.

6.4 Transmit signal quality

6.4.1 Frequency error

The NTN satellite UE basic measurement interval of modulated carrier frequency is 1 UL slot. The NTN satellite UE pre-compensates the uplink modulated carrier frequency by the estimated Doppler shift according to 3GPP TS 38.300 [9] clause 16.14.2. The mean value of basic measurements of NTN UE modulated carrier frequency shall be accurate to within ± 0.1 PPM observed over a period of 1 ms of cumulated measurement intervals compared to ideally pre-compensated reference uplink carrier frequency.

[NOTE: The ideally pre-compensated reference uplink carrier frequency consists of the UL carrier frequency signalled to the UE by SAN and UL pre-compensated Doppler frequency shift.]

6.4.2 Transmit modulation quality

The requirements for transmit modulation quality defined in 3GPP TS 38.101-1 [5] clause 6.4.2 shall apply for NTN satellite UE.

6.5 Output RF spectrum emissions

6.5.1 Occupied bandwidth

Occupied bandwidth is defined as the bandwidth containing 99 % of the total integrated mean power of the transmitted spectrum on the assigned channel. The occupied bandwidth for all transmission bandwidth configurations (Resources Blocks) shall be less than the channel bandwidth specified in Table 6.5.1-1.

Table 6.5.1-1: Occupied channel bandwidth

	NR NTN satellite channel bandwidth (MHz)
	5, 10, 15, 20
Occupied channel bandwidth (MHz)	Same as NR NTN satellite channel bandwidth

6.5.2 Out of band emission

6.5.2.1 General

The Out of band emissions are unwanted emissions immediately outside the assigned channel bandwidth resulting from the modulation process and non-linearity in the transmitter but excluding spurious emissions. This out of band emission limit is specified in terms of a spectrum emission mask and an adjacent channel leakage power ratio.

To improve measurement accuracy, sensitivity and efficiency, the resolution bandwidth may be smaller than the measurement bandwidth. When the resolution bandwidth is smaller than the measurement bandwidth, the result should be integrated over the measurement bandwidth in order to obtain the equivalent noise bandwidth of the measurement bandwidth.

6.5.2.2 Spectrum emission mask

The spectrum emission mask of the UE applies to frequencies (Δf_{OOB}) starting from the ± edge of the assigned NR channel bandwidth. For frequencies offset greater than Δf_{OOB}, the spurious requirements in clause 6.5.3 are applicable.

NOTE: For measurement conditions at the edge of each frequency range, the lowest frequency of the measurement position in each frequency range should be set at the lowest boundary of the frequency range plus MBW/2. The highest frequency of the measurement position in each frequency range should be set at the highest boundary of the frequency range minus MBW/2. MBW denotes the measurement bandwidth defined for the protected band.

The power of any UE emission shall not exceed the levels specified in Table 6.5.2.2-1 for the specified channel bandwidth.

Table 6.5.2.2-1: General NR spectrum emission mask

Δf_{OOB} (MHz)	Channel bandwidth (MHz) / Spectrum emission limit (dBm)		Measurement bandwidth
	5	10, 15, 20	
± 0-1	-13	-13	1 % of channel BW
± 1-5	-10	-10	1 MHz
± 5-6	-13		
± 6-10	-25		
± 5-$BW_{Channel}$		-13	
± $BW_{Channel}$-($BW_{Channel}$+5)		-25	

6.5.2.3 “Reserved”

6.5.2.4 Adjacent channel leakage ratio

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.

To improve measurement accuracy, sensitivity and efficiency, the resolution bandwidth may be smaller than the measurement bandwidth. When the resolution bandwidth is smaller than the measurement bandwidth, the result should be integrated over the measurement bandwidth in order to obtain the equivalent noise bandwidth of the measurement bandwidth.

6.5.2.4.1 NR ACLR

NR Adjacent Channel Leakage power Ratio (NR_{ACLR}) is the ratio of the filtered mean power centred on the assigned NR channel frequency to the filtered mean power centred on an adjacent NR channel frequency at nominal channel spacing.

The assigned NR channel power and adjacent NR channel power are measured with rectangular filters with measurement bandwidths specified in Table 6.5.2.4.1-1.

If the measured adjacent channel power is greater than –50 dBm then the NR_{ACLR} shall be higher than the value specified in Table 6.5.2.4.1-2.

Table 6.5.2.4.1-1: NR ACLR measurement bandwidth

Channel bandwidth	(MHz)	5,10,15,20
REF_SCS	(kHz)	15
NR ACLR measurement bandwidth	(MHz)	MBW=REF_SCS*(12*N_{RB}+1)/1000

Table 6.5.2.4.1-2: NR ACLR requirement

	Power class 3
NR ACLR	30 dB

6.5.2.4.2 UTRA ACLR

UTRA adjacent channel leakage power ratio ($UTRA_{ACLR}$) is the ratio of the filtered mean power centred on the assigned NR channel frequency to the filtered mean power centred on an adjacent(s) UTRA channel frequency.

$UTRA_{ACLR}$ is specified for the first adjacent UTRA channel ($UTRA_{ACLR1}$) which center frequency is ± 2.5 MHz from NR channel edge and for the 2nd adjacent UTRA channel ($UTRA_{ACLR2}$) which center frequency is ± 7.5 MHz from NR channel edge.

The UTRA channel power is measured with a RRC filter with roll-off factor α = 0.22 and bandwidth of 3.84 MHz. The assigned NR channel power is measured with a rectangular filter with measurement bandwidth specified in Table 6.5.2.4.1-1.

If the measured adjacent channel power is greater than – 50 dBm then the $UTRA_{ACLR1}$ and $UTRA_{ACLR2}$ shall be higher than the value specified in Table 6.5.2.4.2-1.

Table 6.5.2.4.2-1: UTRA ACLR requirement

	Power class 3
$UTRA_{ACLR1}$	33 dB
$UTRA_{ACLR2}$	36 dB

UTRA ACLR requirement is applicable when signalled by the network with network signalling value indicated by the field *additionalSpectrumEmission*.

6.5.3 Spurious emission

6.5.3.1 General spurious emissions

Unless otherwise stated, the spurious emission limits apply for the frequency ranges that are more than F_{OOB} (MHz) in Table 6.5.3.1-1 from the edge of the channel bandwidth. The spurious emission limits in Table 6.5.3.1-2 apply for all transmitter band configurations (N_{RB}) and channel bandwidths.

Table 6.5.3.1-1: Boundary between NR out of band and general spurious emission domain

Channel bandwidth	OOB boundary F_{OOB} (MHz)
$BW_{Channel}$	$BW_{Channel}$ + 5

Table 6.5.3.1-2: Requirement for general spurious emissions limits

Frequency Range	Maximum Level	Measurement bandwidth	NOTE
9 kHz ≤ f < 150 kHz	-36 dBm	1 kHz	
150 kHz ≤ f < 30 MHz	-36 dBm	10 kHz	
30 MHz ≤ f < 1000 MHz	-36 dBm	100 kHz	
1 GHz ≤ f < 5th harmonic of the upper frequency edge of the UL operating band in GHz	-30 dBm	1 MHz	

6.5.3.2 Spurious emissions for UE co-existence

This clause specifies the requirements for NR NTN satellite bands for UE coexistence with protected bands.

Table 6.5.3.2-1: Requirements for spurious emissions for UE co-existence

NR NTN satellite Band	Spurious emission for UE co-existence						
	Protected band	Frequency range (MHz)			Maximum Level (dBm)	MBW (MHz)	NOTE
n255	NR Band n1, n2, n3, n5, n7, n8, n12, n13, n14, n18, n20, n24, n25, n26, n28, n29, n30, n34, n38, n39, n40, n41, n48, n50, n51, n53, n65, n66, n67, n70, n71, n74, n75, n76, n85, n90, n91, n92, n93, n94, n100, n101	F_{DL_low}	-	F_{DL_high}	-50	1	
	NR Band n77, n78, n79	F_{DL_low}	-	F_{DL_high}	-50	1	2
n256	NR Band n1, n3, n5, n7, n8, n12, n13, n14, n18, n20, n24, n26, n28, n29, n30, n38, n39, n40, n41, n48, n50, n51, n53, n65, n66, n67, n71, n74, n75, n76, n78, n79, n85, n90, n91, n92, n93, n94, n101, n100, n101	F_{DL_low}	-	F_{DL_high}	-50	1	
	E-UTRA Band 33, 35	F_{DL_low}	-	F_{DL_high}	-50	1	
	NR Band n77	F_{DL_low}	-	F_{DL_high}	-50	1	2
	NR Band n2, n25, n70	F_{DL_low}	-	F_{DL_high}	NA	NA	3
NOTE 1: The protected NR or E-UTRA bands are specified in clause 5.2 from 3GPP TS 38.101-1 [5] or 3GPP TS 36.101 [10]. F_{DL_low} and F_{DL_high} refer to each frequency band specified in Table 5.2-1 in 3GPP TS 38.101-1 [5] or 3GPP TS 36.101 [10].							

NR NTN satellite Band	Spurious emission for UE co-existence				
	Protected band	Frequency range (MHz)	Maximum Level (dBm)	MBW (MHz)	NOTE
NOTE 2: As exceptions, measurements with a level up to the applicable requirements defined in Table 6.5.3.1-2 are permitted for each assigned NR carrier used in the measurement due to 2nd, 3rd, 4th or 5th harmonic spurious emissions. Due to spreading of the harmonic emission the exception is also allowed for the first 1 MHz frequency range immediately outside the harmonic emission on both sides of the harmonic emission. This results in an overall exception interval centred at the harmonic emission of (2 MHz + N x L_{CRB} x RB_{size} kHz), where N is 2, 3, 4, 5 for the 2nd, 3rd, 4th or 5th harmonic respectively. The exception is allowed if the measurement bandwidth (MBW) totally or partially overlaps the overall exception interval. NOTE 3: The co-existence between n256 and band n2, n25 and n70 is subject to regional/national regulation.					

6.5.3.3 Additional spurious emissions

6.5.3.3.1 General

These requirements are specified in terms of an additional spectrum emission requirement. Additional spurious emission requirements are signalled by the network to indicate that the UE shall meet an additional requirement for a specific deployment scenario as part of the cell handover/broadcast message.

6.5.3.3.2 Requirement for network signalling value "NS_02N"

When "NS_02N" is indicated in the cell, the power of any UE emission shall not exceed the levels specified in Table 6.5.3.3.2-1. This requirement also applies for the frequency ranges that are less than F_{OOB} (MHz) in Table 6.5.3.1-1 from the edge of the channel bandwidth.

Table 6.5.3.3.2-1: Additional requirements for "NS_02N"

Frequency band (MHz)	Channel bandwidth / Spectrum emission limit[1] (dBm)	Measurement bandwidth	NOTE
	5 MHz, 10 MHz, 15 MHz, 20 MHz		
1559≤ f ≤ 1605	-50	700 Hz	Averaged over any 2 millisecond active transmission interval
1605≤ f ≤ 1610	-50 + 24/5 (f-1605)	700Hz	
1559 ≤ f ≤ 1605	-40	1MHz	Averaged over any 2 millisecond active transmission interval
1605≤ f ≤ 1610	-40 + 24/5 (f-1605)	1MHz	
NOTE: The EIRP requirement in regulation is converted to conducted requirement using a 0 dBi antenna.			

6.5.4 Transmit intermodulation

The transmit intermodulation performance is a measure of the capability of the transmitter to inhibit the generation of signals in its non-linear elements caused by presence of the wanted signal and an interfering signal reaching the transmitter via the antenna.

UE transmit intermodulation is defined by the ratio of the mean power of the wanted signal to the mean power of the intermodulation product when an interfering CW signal is added at a level below the wanted signal at each transmitter antenna port with the other antenna port(s) if any terminated. Both the wanted signal power and the intermodulation product power are measured through NR rectangular filter with measurement bandwidth shown in Table 6.5.4-1.

The requirement of transmit intermodulation is specified in Table 6.5.4-1.

Table 6.5.4-1: Transmit Intermodulation

Wanted signal channel bandwidth	$BW_{Channel}$	
Interference signal frequency offset from channel center	$BW_{Channel}$	$2*BW_{Channel}$
Interference CW signal level	-40 dBc	
Intermodulation product	< -29 dBc	< -35 dBc
Measurement bandwidth	The maximum transmission bandwidth configuration among the different SCS's for the channel BW as defined in Table 6.5.2.4.1-1	
Measurement offset from channel center	$BW_{Channel}$ and $2*BW_{Channel}$	$2*BW_{Channel}$ and $4*BW_{Channel}$

7 Conducted receiver characteristics

7.1 General

Unless otherwise stated the receiver characteristics are specified at the antenna connector(s) of the UE. For UE(s) with an integral antenna only, a reference antenna(s) with a gain of 0 dBi is assumed for each antenna port(s). UE with an integral antenna(s) may be taken into account by converting these power levels into field strength requirements, assuming a 0 dBi gain antenna. For UEs with more than one receiver antenna connector, identical interfering signals shall be applied to each receiver antenna port if more than one of these is used (diversity).

The levels of the test signal applied to each of the antenna connectors shall be as defined in the respective clauses below.

With the exception of clause 7.3, the requirements shall be verified with the network signalling value NS_01 configured in Table 6.2.3.1-1.

All requirements in this section are applicable to devices supporting GSO and/or NGSO satellites.

All the parameters in clause 7 are defined using the UL reference measurement channels specified in 3GPP TS 38.101-1 [5] Annex A.2.2, the DL reference measurement channels specified in 3GPP TS 38.101-1 [5] Annex A.3.2 and using the set-up specified in 3GPP TS 38.101-1 [5] Annex C.3.1.

7.2 Diversity characteristics

The UE is required to be equipped with a minimum of two RX antenna ports in all operating bands.

The UE shall be verified with two RX antenna ports in all supported frequency bands.

The above rules apply for all clauses with the exception of clause 7.9.

7.3 Reference sensitivity

7.3.1 General

The reference sensitivity power level REFSENS is the minimum mean power applied to each one of the UE antenna ports for all UE categories, at which the throughput shall meet or exceed the requirements for the specified reference measurement channel.

In later clauses of Clause 7 where the value of REFSENS is used as a reference to set the corresponding requirement:

in all bands, the UE shall be verified against those requirements by applying the REFSENS value in Table 7.3.2-1.

7.3.2 Reference sensitivity power level

The throughput shall be ≥ 95 % of the maximum throughput of the reference measurement channels as specified in Annex A3.2.2 of 3GPP TS 38.101-1 [5], with parameters specified in Table 7.3.2-1.

Table 7.3.2-1: Two antenna port reference sensitivity QPSK PREFSENS for FDD bands

Operating band / SCS / Channel bandwidth											
Operating Band	SCS kHz	5 MHz (dBm)	10 MHz (dBm)	15 MHz (dBm)	20 MHz (dBm)	25 MHz (dBm)	30 MHz (dBm)	35 MHz (dBm)	40 MHz (dBm)	45 MHz (dBm)	50 MHz (dBm)
n256	15	-99.5	-96.3	-94.5	-93.8						
	30		-96.6	-94.6	-94.0						
	60		-97.0	-94.9	-94.2						
n255	15	-100.0	-96.8	-95.0	-93.8						
	30		-97.1	-95.1	-94.0						
	60		-97.5	-95.4	-94.2						
NOTE: The transmitter shall be set to P_{UMAX} as defined in clause 6.2.4 of 3GPP TS 38.101-1 [5].											

The reference receiver sensitivity (REFSENS) requirement specified in Table 7.3.2-1 shall be met with uplink transmission bandwidth less than or equal to that specified in Table 7.3.2-2.

less than or equal to that specified in Table 7.3.2-2.

Table 7.3.2-2: Uplink configuration for reference sensitivity

Operating band / SCS (kHz) / Channel bandwidth (MHz) / Duplex mode						
Operating Band	SCS	5	10	15	20	Duplex Mode
n256	15	25	50	75	100	FDD
	30		24	36	50	
	60		10	18	24	
n255	15	25	50	75	[75]	FDD
	30		24	36	[36]	
	60		10	18	[18]	
NOTE: UL resource blocks shall be located as close as possible to the downlink operating band but confined within the transmission bandwidth configuration for the channel bandwidth (Table 5.3.2-1 of 3GPP TS 38.101-1 [5]).						

The minimum requirements specified in Table 7.3.2-1 shall be verified with the network signalling value NS_01 (Table 6.2.3.1-1 of 3GPP TS 38.101-1 [5]) configured.

7.4 Maximum input level

Maximum input level is defined as the maximum mean power received at the UE antenna port, at which the specified relative throughput shall meet or exceed the minimum requirements for the specified reference measurement channel. The throughput shall be ≥ 95 % of the maximum throughput of the reference measurement channels as specified in 3GPP TS 38.101-1 [5] Annex A.3.2 (with one sided dynamic OCNG Pattern OP.1 FDD as described in 3GPP TS 38.101-1 [5] Annex A.5.1.1) with parameters specified in Table 7.4-1.

Table 7.4-1: Maximum input level

Rx Parameter	Units	Channel bandwidth (MHz)
		5, 10, 15, 20

Power in Transmission Bandwidth Configuration[3]	dBm	-40[2]
NOTE 1: The transmitter shall be set to 4 dB below $P_{CMAX\_L,f,c}$ at the minimum uplink configuration specified in Table 7.3.2-2 with $P_{CMAX\_L,f,c}$ as defined in clause 6.2.4. NOTE 2: Reference measurement channel is specified in 3GPP TS 38.101-1 [5] Annex A.3.2.3 for 64 QAM. NOTE 3: Power in transmission bandwidth configuration value is rounded to the nearest 0.5dB value.		

7.5 Adjacent channel selectivity

Adjacent channel selectivity (ACS) is a measure of a receiver's ability to receive an NR signal at its assigned channel frequency in the presence of an adjacent channel signal at a given frequency offset from the centre frequency of the assigned channel. ACS is the ratio of the receive filter attenuation on the assigned channel frequency to the receive filter attenuation on the adjacent channel(s).

In Release 17, only frequency bands below 2.7GHz are considered. The NR satellite UE shall fulfil the minimum requirements specified in Table 7.5-1 for NR satellite bands with FDL_high < 2700 MHz and FUL_high < 2700 MHz. These requirements apply for all values of an adjacent channel interferer in case 1 and for any SCS specified for the channel bandwidth of the wanted signal. The lower and upper range of test parameters are chosen as in Table 7.5-2 and Table 7.5-3 for verification of the requirements specified in Table 7.5-1. For these test parameters, the throughput shall be ≥ 95 % of the maximum throughput of the reference measurement channels as specified in 3GPP TS 38.101-1 [5] Annexes A.2.2 and A.3.2 (with one sided dynamic OCNG Pattern OP.1 FDD for the DL-signal as described in 3GPP TS 38.101-1 [5] Annex A.5.1.1).

Table 7.5-1: ACS for NR satellite bands with F_{DL_high} < 2700 MHz and F_{UL_high} < 2700 MHz

RX parameter	Units	Channel bandwidth (MHz)		
		5, 10	15	20
ACS	dB	33	30	27

Table 7.5-2: Test parameters for NR bands with F_{DL_high} < 2700 MHz and F_{UL_high} < 2700 MHz, case 1

RX parameter	Units	Channel bandwidth (MHz)		
		5, 10	15	20
Power in transmission bandwidth configuration	dBm	REFSENS + 14 dB		
$P_{interferer}$[4]	dBm	REFSENS + 45.5 dB	REFSENS + 42.5 dB	REFSENS + 39.5
$BW_{interferer}$	MHz	5		
$F_{interferer}$ (offset)[2]	MHz	$BW_{Channel}$/2 + 2.5 / -($BW_{Channel}$/2 + 2.5)		
NOTE 1: The transmitter shall be set to 4 dB below $P_{CMAX\_L,f,c}$ at the minimum UL configuration specified in clause 7.3.2 with $P_{CMAX\_L,f,c}$ defined in clause 6.2.4. NOTE 2: The absolute value of the interferer offset $F_{interferer}$ (offset) shall be further adjusted to $(\lceil \lvert F_{interferer} \rvert / SCS \rceil + 0.5)SCS$ MHz with SCS the sub-carrier spacing of the wanted signal in MHz. The interferer is an NR signal with 15 kHz SCS. NOTE 3: The interferer consists of the NR interferer RMC specified in 3GPP TS 38.101-1 [5] Annex A.3.2.2 with one sided dynamic OCNG Pattern OP.1 FDD for the DL-signal as described in 3GPP TS 38.101-1 [5] Annex A.5.1.1. NOTE 4: $P_{interferer}$ shall be rounded to the next higher 0.5dB value.				

Table 7.5-3: Test parameters for NR bands with F_{DL_high} < 2700 MHz and F_{UL_high} < 2700 MHz, case 2

RX parameter	Units	Channel bandwidth (MHz)		
		5, 10	15	20
Power in transmission bandwidth configuration	dBm	-71.5	-68.5	-65.5
$P_{interferer}$	dBm	-40		
$BW_{interferer}$	MHz	5		
$F_{interferer}$ (offset)	MHz	$BW_{Channel}$ /2 + 2.5 / -($BW_{Channel}$ /2 + 2.5)		
NOTE 1: The transmitter shall be set to 24 dB below $P_{CMAX\_L,f,c}$ at the minimum UL configuration specified in clause 7.3.2 with $P_{CMAX\_L,f,c}$ defined in clause 6.2.4.				
NOTE 2: The absolute value of the interferer offset $F_{interferer}$ (offset) shall be further adjusted to $(\lceil \lvert F_{interferer} \rvert / SCS \rceil + 0.5)SCS$ MHz with SCS the sub-carrier spacing of the wanted signal in MHz. The interferer is an NR signal with 15 kHz SCS.				
NOTE 3: The interferer consists of the NR interferer RMC specified in 3GPP TS 38.101-1 [5] Annex A.3.2.2 with one sided dynamic OCNG Pattern OP.1 FDD for the DL-signal as described in 3GPP TS 38.101-1 [5] Annex A.5.1.1.				
NOTE 4: $P_{interferer}$ shall be rounded to the next higher 0.5dB value.				

7.6 Blocking characteristics

7.6.1 General

The blocking characteristic is a measure of the receiver's ability to receive a wanted signal at its assigned channel frequency in the presence of an unwanted interferer on frequencies other than those of the spurious response or the adjacent channels, without this unwanted input signal causing a degradation of the performance of the receiver beyond a specified limit. The blocking performance shall apply at all frequencies except those at which a spurious response occurs.

7.6.2 In-band blocking

For NR satellite bands with F_{DL_high} < 2700 MHz and F_{UL_high} < 2700 MHz in-band blocking (IBB) is defined for an unwanted interfering signal falling into the UE receive band or into the first 15 MHz below or above the UE receive band.

The throughput of the wanted signal shall be ≥ 95 % of the maximum throughput of the reference measurement channels as specified in 3GPP TS 38.101-1 [5] Annexes A.2.2 and A.3.2 (with one sided dynamic OCNG Pattern OP.1 FDD for the DL-signal as described in Annex A.5.1.1) with parameters specified in Table 7.6.2-1 and Table 7.6.2-2. The relative throughput requirement shall be met for any SCS specified for the channel bandwidth of the wanted signal.

Table 7.6.2-1: In-band blocking parameters for NR satellite bands with F_{DL_high} < 2700 MHz and F_{UL_high} < 2700 MHz

RX parameter	Units	Channel bandwidth (MHz)		
		5, 10	15	20
Power in transmission bandwidth configuration[3]	dBm	REFSENS + 6 dB	REFSENS + 7 dB	REFSENS + 9 dB
$BW_{interferer}$	MHz	5		
$F_{Ioffset,\ case\ 1}$	MHz	7.5		
$F_{Ioffset,\ case\ 2}$	MHz	12.5		
NOTE 1: The transmitter shall be set to 4 dB below $P_{CMAX\_L,f,c}$ at the minimum UL configuration specified in clause 7.3.2 with $P_{CMAX\_L,f,c}$ defined in clause 6.2.4.				
NOTE 2: The interferer consists of the RMC specified in 3GPP TS 38.101-1 [5] Annex A.3.2.2 with one sided dynamic OCNG Pattern OP.1 FDD for the DL-signal as described in Annex A.5.1.1 and 15 kHz SCS.				
NOTE 3: Power in transmission bandwidth configuration shall be rounded to the next higher 0.5dB value.				

Table 7.6.2-2: In-band blocking for NR satellite bands with F_{DL_high} < 2700 MHz and F_{UL_high} < 2700 MHz

Operating Band	Parameter	Unit	Case 1	Case 2
	$P_{interferer}$	dBm	-56	-44
n255, n256	$F_{interferer}$ (offset)	MHz	$-BW_{Channel}/2 - F_{loffset,\ case\ 1}$ and $BW_{Channel}/2 + F_{loffset,\ case\ 1}$	$\leq -BW_{Channel}/2 - F_{loffset,\ case\ 2}$ and $\geq BW_{Channel}/2 + F_{loffset,\ case\ 2}$
	$F_{interferer}$	MHz	NOTE 2	$F_{DL\_low} - 15$ to $F_{DL\_high} + 15$
NOTE 1: The absolute value of the interferer offset $F_{interferer}$ (offset) shall be further adjusted to $(\lceil \lvert F_{interferer} \rvert / SCS \rceil + 0.5)SCS$ MHz with SCS the sub-carrier spacing of the wanted signal in MHz. The interferer is an NR signal with 15 kHz SCS. NOTE 2: For each carrier frequency, the requirement applies for two interferer carrier frequencies: a: $-BW_{Channel}/2 - F_{loffset,\ case\ 1}$; b: $BW_{Channel}/2 + F_{loffset,\ case\ 1}$				

7.6.3 Out-of-band blocking

For NR satellite bands with F_{DL_high} < 2700 MHz and F_{UL_high} < 2700 MHz out-of-band band blocking is defined for an unwanted CW interfering signal falling outside a frequency range 15 MHz below or above the UE receive band.

The throughput of the wanted signal shall be ≥ 95% of the maximum throughput of the reference measurement channels as specified in 3GPP TS 38.101-1 [5] Annexes A.2.2 and A.3.2 (with one sided dynamic OCNG Pattern OP.1 FDD for the DL-signal as described in Annex A.5.1.1) with parameters specified in Table 7.6.3-1 and Table 7.6.3-2. The relative throughput requirement shall be met for any SCS specified for the channel bandwidth of the wanted signal.

Table 7.6.3-1: Out-of-band blocking parameters for NR satellite bands with F_{DL_high} < 2700 MHz and F_{UL_high} < 2700 MHz

RX parameter	Units	Channel bandwidth (MHz)		
		5, 10	15	20
Power in transmission bandwidth configuration[2]	dBm	REFSENS + 6 dB	REFSENS + 7 dB	REFSENS + 9 dB
NOTE 1: The transmitter shall be set to 4 dB below $P_{CMAX\_L,f,c}$ at the minimum UL configuration specified in clause 7.3.2 with $P_{CMAX\_L,f,c}$ defined in clause 6.2.4. NOTE 2: Power in transmission bandwidth configuration shall be rounded to the next higher 0.5dB value.				

Table 7.6.3-2: Out of-band blocking for NR satellite bands with F_{DL_high} < 2700 MHz and F_{UL_high} < 2700 MHz

Operating Band	Parameter	Unit	Range 1	Range 2	Range 3
	$P_{interferer}$	dBm	-44	-30	-15
n255	$F_{interferer}$ (CW)	MHz	$-60 < f - F_{DL\_low} < -15$ or $15 < f - F_{DL\_high} < 60$	$-85 < f - F_{DL\_low} \leq -60$ or $60 \leq f - F_{DL\_high} < 85$	$1 \leq f \leq F_{DL\_low} - 85$ or $F_{DL\_high} + 85 \leq f \leq 12750$
n256[1]	$F_{interferer}$ (CW)	MHz	$-100 < f - F_{DL\_low} < -15$ or $15 < f - F_{DL\_high} < 60$	$-145 < f - F_{DL\_low} \leq -100$ or $60 \leq f - F_{DL\_high} < 85$	$1 \leq f \leq F_{DL\_low} - 145$ or $F_{DL\_high} + 85 \leq f \leq 12750$
NOTE 1: Band n256 lower frequency ranges are modified to enable specific implementations NOTE 2: void NOTE 3: void NOTE 4: void					

For interferer frequencies across ranges 1, 2 and 3 in Table 7.6.3-1, a maximum of

$$\left\lfloor \max\left\{24,6\cdot\left\lceil n\cdot N_{RB}/6\right\rceil\right\}/\min\left\{\left\lfloor n\cdot N_{RB}/10\right\rfloor,5\right\}\right\rfloor$$

exceptions are allowed for spurious response frequencies in each assigned frequency channel when measured using a step size of $min(\lfloor BW_{channel}/2\rfloor, 5)$ MHz with N_{RB} the number of resource blocks in the downlink transmission bandwidth configuration, $BW_{Channel}$ the bandwidth of the frequency channel in MHz and n = 1, 2, 3 for SCS = 15, 30, 60 kHz, respectively. For these exceptions, the requirements in clause 7.7 apply.

7.6.4 Narrow band blocking

This requirement is measure of a receiver's ability to receive a NR signal at its assigned channel frequency in the presence of an unwanted narrow band CW interferer at a frequency, which is less than the nominal channel spacing. The relative throughput shall be ≥ 95 % of the maximum throughput of the reference measurement channels as specified in 3GPP TS 38.101-1 [5] Annexes A.2.2 and A.3.2 (with one sided dynamic OCNG Pattern OP.1 FDD for the DL-signal as described in Annex A.5.1.1) with parameters specified in Table 7.6.4-1.

Table 7.6.4-1: Narrow Band Blocking

Operating Band	Parameter	Unit	Channel Bandwidth (MHz)			
			5	10	15	20
n255, n256	P_w	dBm	$P_{REFSENS}$ + channel-bandwidth specific value below			
			16	13	14	16
	P_{uw} (CW)	dBm	-55			
	F_{uw} (offset SCS= 15 kHz) [3]	MHz	$\left(\left\lfloor\frac{\frac{BW_{Channel}}{2}+0.2}{SCS}+0.5\right\rfloor+0.5\right)SCS$			
	F_{uw} (offset SCS= 30 kHz)[3]	MHz	NA			
NOTE 1: The transmitter shall be set a 4 dB below $P_{CMAX\_L,f,c}$ at the minimum UL configuration specified in clause 7.3.2 with $P_{CMAX\_L,f,c}$ defined in clause 6.2.4 NOTE 2: The $P_{REFSENS}$ power level is specified in clause 7.3.2. NOTE 3: F_{uw} shall be rounded to half of SCS.						

7.7 Spurious response

Spurious response is a measure of the ability of the receiver to receive a wanted signal on its assigned channel frequency without exceeding a given degradation due to the presence of an unwanted CW interfering signal at any other frequency for which a response is obtained, i.e. for which the out-of-band blocking limit as specified in clause 7.6.3 is not met.

The throughput shall be ≥ 95 % of the maximum throughput of the reference measurement channels as specified in 3GPP TS 38.101-1 [5] Annexes A.2.2 and A.3.2 (with one sided dynamic OCNG Pattern OP.1 FDD for the DL-signal as described in Annex A.5.1.1) with parameters for the wanted signal as specified in Table 7.7-1 for NR bands with F_{DL_high} < 2700 MHz and F_{UL_high} < 2700 MHz for the interferer as specified in Table 7.7-2. The relative throughput requirement shall be met for any SCS specified for the channel bandwidth of the wanted signal.

Table 7.7-1: Spurious response parameters for NR bands with F_{DL_high} < 2700 MHz and F_{UL_high} < 2700 MHz

RX parameter	Units	Channel bandwidth (MHz)		
		5, 10	15	20
Power in transmission bandwidth configuration[2]	dBm	REFSENS + 6 dB	REFSENS + 7 dB	REFSENS + 9 dB
NOTE 1: The transmitter shall be set to 4 dB below $P_{CMAX\_L,f,c}$ at the minimum UL configuration specified in Table 7.3.2-3 with $P_{CMAX\_L,f,c}$ defined in clause 6.2.4. NOTE 2: Power in transmission bandwidth configuration value is rounded to the next higher 0.5dB value.				

Table 7.7-2: Spurious response

Parameter	Unit	Level
$P_{Interferer}$ (CW)	dBm	-44
$F_{Interferer}$	MHz	Spurious response frequencies

7.8 Intermodulation characteristics

The definition and requirements for intermodulation characteristics specified in 3GPP TS 38.101-1 [5] clause 7.8 shall apply for NTN satellite UE.

7.9 Spurious emissions

The spurious emissions power is the power of emissions generated or amplified in a receiver that appear at the UE antenna connector.

The power of any narrow band CW spurious emission shall not exceed the maximum level specified in Table 7.9-1

Table 7.9-1: General receiver spurious emission requirements

Frequency range	Measurement bandwidth	Maximum level	NOTE
30 MHz ≤ f < 1 GHz	100 kHz	-57 dBm	
1 GHz ≤ f ≤ 12.75 GHz	1 MHz	-47 dBm	
NOTE: Unused PDCCH resources are padded with resource element groups with power level given by PDCCH as defined in 3GPP TS 38.101-1 [5] Annex C.3.1.			

8 Conducted performance requirements

8.1 General

8.1.1 Relationship between minimum requirements and test requirements

The present document is a Single-RAT and interwork specification for NR UE, covering minimum performance requirements of both conducted and radiated requirements. Conformance to the present specification is demonstrated by fulfilling the test requirements specified in the conformance specification TS TBD [TBD].

The Minimum Requirements given in this specification make no allowance for measurement uncertainty. The test specification TS TBD [TBD] defines 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.

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 [TBD].

The applicability of each requirement is described under each sub-clause in [8.2.1] and [8.3.1].

8.1.2 Applicability of minimum requirements

The conducted minimum requirements specified in this specification shall be met in all applicable scenarios for FR1.

Unless otherwise stated, all minimum performance requirements defined in Clauses 8 are applicable to UE power class 3 only.

8.1.3 Conducted requirements

8.1.3.1 Introduction

The requirements are defined for the following modes:

- Mode 1: Conditions with external noise source
  - Wanted signal with power level Es is transmitted.
  - External white noise source with power spectral density Noc is used.
  - *Es* and *Noc* levels are selected to achieve target SNR as described in Clause 8.1.3.3.

8.1.3.2 Reference point

The reference point for SNR, Es and Noc of DL signal is the UE antenna connector or connectors.

8.1.3.3 SNR definition

For Mode 1 conditions conducted UE demodulation and CSI requirements the SNR is defined as:

$$SNR = \frac{\sum_{j=1}^{N_{RX}} E_s^{(j)}}{\sum_{j=1}^{N_{RX}} N_{oc}^{(j)}}$$

Where

- N_{RX} denotes the number of receiver antenna connectors and the superscript receiver antenna connector *j*.
- The above SNR definition assumes that the REs are not precoded, and does not account for any gain which can be associated to the precoding operation.
- Unless otherwise stated, the SNR refers to the SSS wanted signal.
- The downlink SSS transmit power is defined as the linear average over the power contributions in [W] of all resource elements that carry the SSS within the operating system bandwidth.
- The power ratio of other wanted signals to the SSS is defined in clause [C.3.1].

8.1.3.4 Noc

8.1.3.4.1 Introduction

This clause describes the Noc power level for Mode 1 conditions conducted testing of demodulation and CSI requirements.

8.1.3.4.2 Noc for NR operating bands in FR1

The Noc power spectrum density shall be larger or equal to the minimum Noc power level for each operating band supported by the UE as defined in clause 8.1.3.4.2.1.

Unless otherwise stated, a fixed Noc power level of -145 dBm/Hz shall be used for all operating bands.

8.1.3.4.2.1 Derivation of Noc values for NR operating bands in FR1

The minimum Noc power level for an operating band, subcarrier spacing and channel bandwidth is derived based on the following equation:

$Noc_{Band\_X,\ SCS\_Y,\ CBW\_Z} = REFSENS_{Band\_X,\ SCS\_Y,\ CBW\_Z} - 10*\log10(12*SCS\_Y*nPRB) + D - SNR_{REFSENS} + \Delta_{thermal}$

where

- $REFSENS_{Band\_X, SCS\_Y, CBW\_Z}$ is the REFSENS value in dBm for Band X, SCS Y and CBW Z specified in Table 7.3.2-1 of TS 38.101-5 [TBD]
- 12 is the number of subcarriers in a PRB
- SCS Y is the subcarrier spacing associated with the REFSENS value
- nPRB is the maximum number of PRB for SCS Y and CBW Z associated with the REFSENS value, and is specified in Table 5.3.2-1 of TS 38.101-5 [TBD]
- D is diversity gain equal to 3 dB
- $SNR_{REFSENS}$ = -1 dB is the SNR used for simulation of REFSENS
- $\Delta_{thermal}$ is the amount of dB that the wanted noise is set above UE thermal noise, giving a defined rise in total noise. $\Delta_{thermal}$ = 16dB, giving a rise in total noise of 0.1dB, regarded as insignificant.

The calculated Noc value for the baseline of Band n256, 15 kHz SCS, 10 MHz CBW is -146.5 dBm/Hz.

An allowance of 1.5dB is made for future bands, giving an Noc power level of -145 dBm/Hz.

8.2 Demodulation performance requirements

8.2.1 General

8.2.1.1 Applicability of requirements

8.2.1.1.1 General

The minimum performance requirements are applicable to all FR1 operating bands defined in clause 5.2.

If same test is listed for different UE features/capabilities in Clauses 8.2.1.1.2, then this test shall apply for UEs which support all corresponding UE features/capabilities.

8.2.1.1.2 Applicability of requirements for optional UE features

The performance requirements in Table 8.2.1.1.2-1 shall apply for UEs which support optional UE features only.

Table 8.2.1.1.2-1: Requirements applicability for optional UE features

UE feature/capability [11]	Test type		Test list	Applicability notes
NR NTN access (nonTerrestrialNetwork-r17)	FR1 FDD	PDSCH	Clause 8.2.1.2.2.1 (Test 1-1, Test 1-2, Test 1-3, Test 1-4)	
NR NTN scenario support (ntn-ScenarioSupport-r17)	FR1 FDD	PDSCH	Clause 8.2.1.2.2.1 (Test 1-1, Test 1-2, Test 1-3, Test 1-4)	The requirements apply only when *ntn-ScenarioSupport-r17* is “ngso” or is not configured.
Increasing the number of HARQ processes (max-HARQ-ProcessNumber-r17)	FR1 FDD	PDSCH	Clause 8.2.1.2.2.1 (Test 1-3)	
Disabled HARQ feedback for downlink transmission (harq-FeedbackDisabled-r17)	FR1 FDD	PDSCH	Clause 8.2.1.2.2.1 (Test 1-4)	
Note: For UE supporting NR NTN access (nonTerrestrialNetwork-r17), the requirements in TS38.101-4 also applies to UE according to applicability rules in TS38.101-4 Clause 5.1, 6.1, 7.1 and 8.1				

8.2.1.2 PDSCH demodulation requirements

The parameters specified in Table 8.2.1.2-1 are valid for all PDSCH tests unless otherwise stated.

Table 8.2.1.2-1: Common test parameters

Parameter		Unit	Value
PDSCH transmission scheme			Transmission scheme 1
Carrier configuration	Offset between Point A and the lowest usable subcarrier on this carrier (Note 2)	RBs	0
	Subcarrier spacing	kHz	15
DL BWP configuration #1	Cyclic prefix		Normal
	RB offset	RBs	0
	Number of contiguous PRB	PRBs	Maximum transmission bandwidth configuration as specified in clause 5.3.2 of TS 38.101-1 [6] for tested channel bandwidth and subcarrier spacing
Common serving cell parameters	Physical Cell ID		0
	SSB position in burst		First SSB in Slot #0
	SSB periodicity	ms	20
PDCCH configuration	Slots for PDCCH monitoring		Each slot
	Symbols with PDCCH	Symbols	0, 1
	Number of PRBs in CORESET		Table 5.2-2 of 38.101-4 for tested channel bandwidth and subcarrier spacing
	Number of PDCCH candidates and aggregation levels		1/AL8
	CCE-to-REG mapping type		Non-interleaved
	DCI format		1_1
	TCI state		TCI state #1
	PDCCH & PDCCH DMRS Precoding configuration		Single Panel Type I, Random per slot with equal probability of each applicable i_1, i_2 combination, and with REG bundling granularity for number of Tx larger than 1
Cross carrier scheduling			Not configured
CSI-RS for tracking	First subcarrier index in the PRB used for CSI-RS		k_0=0 for CSI-RS resource 1,2,3,4
	First OFDM symbol in the PRB used for CSI-RS		l_0 = 6 for CSI-RS resource 1 and 3 l_0 = 10 for CSI-RS resource 2 and 4
	Number of CSI-RS ports (X)		1 for CSI-RS resource 1,2,3,4
	CDM Type		'No CDM' for CSI-RS resource 1,2,3,4
	Density (ρ)		3 for CSI-RS resource 1,2,3,4
	CSI-RS periodicity	Slots	15 kHz SCS: 20 for CSI-RS resource 1,2,3,4
	CSI-RS offset	Slots	15 kHz SCS: 10 for CSI-RS resource 1 and 2 11 for CSI-RS resource 3 and 4
	Frequency Occupation		Start PRB 0 Number of PRB = ceil(BWP size/4)*4
	QCL info		TCI state #0
NZP CSI-RS for CSI acquisition	Row index (Note 3)		3 for 2 CSI-RS ports and 5 for 4 CSI-RS ports
	First subcarrier index in the PRB used for CSI-RS		k_0 = 0
	First OFDM symbol in the PRB used for CSI-RS		l_0 = 12
	Number of CSI-RS ports (X)		Same as number of transmit antenna
	CDM Type		'No CDM' for 1 transmit antenna 'FD-CDM2' for 2 and 4 transmit antenna
	Density (ρ)		1
	CSI-RS periodicity	Slots	15 kHz SCS: 20
	CSI-RS offset	Slots	0
	Frequency Occupation		Start PRB 0 Number of PRB = ceil(BWP size/4)*4
	QCL info		TCI state #1
ZP CSI-RS for CSI acquisition	Row index (Note 3)		5
	First subcarrier index in the PRB used for CSI-RS		k_0 = 4
	First OFDM symbol in the PRB used for CSI-RS		l_0 = 12

	Number of CSI-RS ports (X)			4
	CDM Type			'FD-CDM2'
	Density (ρ)			1
	CSI-RS periodicity		Slots	15 kHz SCS: 20
	CSI-RS offset		Slots	0
	Frequency Occupation			Start PRB 0 Number of PRB = ceil(BWP size/4)*4
PDSCH DMRS configuration	Antenna ports indexes			{1000} for Rank 1 tests
	Position of the first DMRS for PDSCH mapping type A			2
	Number of PDSCH DMRS CDM group(s) without data			1 for Rank 1
TCI state #0	Type 1 QCL information	SSB index		SSB #0
		QCL Type		Type C
	Type 2 QCL information	SSB index		N/A
		QCL Type		N/A
TCI state #1	Type 1 QCL information	CSI-RS resource		CSI-RS resource 1 from 'CSI-RS for tracking' configuration
		QCL Type		Type A
	Type 2 QCL information	CSI-RS resource		N/A
		QCL Type		N/A
PT-RS configuration				PT-RS is not configured
Maximum number of code block groups for ACK/NACK feedback				1
Maximum number of HARQ transmission				4
HARQ ACK/NACK bundling				Multiplexed
Redundancy version coding sequence				{0,2,3,1}
PDSCH & PDSCH DMRS Precoding configuration				Single Panel Type I, Random precoder selection updated per slot, with equal probability of each applicable i_1, i_2 combination, and with PRB bundling granularity
Symbols for all unused REs				OP.1 FDD as defined in Annex A.5.1.1 of 38.101-4
Physical signals, channels mapping and precoding				As specified in Annex B.4.1 of 38.101-4
Note 1: UE assumes that the TCI state for the PDSCH is identical to the TCI state applied for the PDCCH transmission. Note 2: Point A coincides with minimum guard band as specified in Table 5.3.3-1 from TS 38.101-1 [6] for tested channel bandwidth and subcarrier spacing. Note 3: Refer to Table 7.4.1.5.3-1 in [9]				

8.2.1.2.1 1RX requirements

8.2.1.2.2 2RX requirements

8.2.1.2.2.1 FDD

8.2.1.2.2.1.1 Minimum requirements for PDSCH Mapping Type A

The performance requirements are specified in Table 8.2.1.2.2.1.1-3 with the addition of test parameters in Table 8.2.1.2.2.1.1-2 and the downlink physical channel setup according to Annex A.3.

The test purposes are specified in Table 8.2.1.2.2.1.1-1.

Table 8.2.1.2.2.1.1-1: Tests purpose

Purpose	Test index
Verify the PDSCH mapping Type A normal performance under 2 receive antenna conditions and with different channel models and MCS	1-1, 1-2, 1-3, 1-4

Table 8.2.1.2.2.1.1-2: Test parameters

Parameter		Unit	Value
Duplex mode			FDD
Active DL BWP index			1
PDSCH configuration	Mapping type		Type A
	k0		0
	Starting symbol (S)		2
	Length (L)		12
	PDSCH aggregation factor		1
	PRB bundling type		Static
	PRB bundling size		2
	Resource allocation type		Type 0
	RBG size		Config2
	VRB-to-PRB mapping type		Non-interleaved
	VRB-to-PRB mapping interleaver bundle size		N/A
PDSCH DMRS configuration	DMRS Type		Type 1
	Number of additional DMRS		1
	Maximum number of OFDM symbols for DL front loaded DMRS		1
CSI-RS for tracking	CSI-RS periodicity	Slots	20 for CSI-RS resource 1,2,3,4.
	CSI-RS offset	Slots	10 for CSI-RS resource 1 and 2 11 for CSI-RS resource 3 and 4.
Number of HARQ Processes			16 for Test 1-1, Test 1-2 32 for Test 1-3 4 with feedback disabled, 12 with feedback enabled in 16 HARQ processes with re-Tx disable for all HARQ for Test 1-4 in which 4 disabled processes are randomly select at test configuration
The number of slots between PDSCH and corresponding HARQ-ACK information			10 for Test 1-1, Test 1-2, Test 1-3 N/A for Test 1-4
Maximum number of HARQ transmission			4 for Test 1-1, Test 1-2, Test 1-3 Disabled for all HARQ processes for Test 1-4

Table 8.2.1.2.2.1.1-3: Minimum performance for Rank 1

Test num.	Reference channel	Bandwidth (MHz) / Subcarrier spacing (kHz)	Modulation format and code rate	Propagation condition	Correlation matrix and antenna configuration	Reference value	
						Fraction of maximum throughput (%)	SNR (dB)
1-1	R.PDSCH.1-1.1 FDD	10 / 15	QPSK, 0.30	NTN-TDLA100-200	1x2, ULA Low	70	0.3
1-2	R.PDSCH.1-2.1 FDD	10 / 15	16QAM, 0.48	NTN-TDLC5-200	1x2, ULA Low	70	7.6
1-3	R.PDSCH.1-1.1 FDD	10 / 15	QPSK, 0.30	NTN-TDLC5-200	1x2, ULA Low	70	-0.4
1-4	R.PDSCH.1-1.1 FDD	10 / 15	QPSK, 0.30	NTN-TDLA100-200	1x2, ULA Low	70*	1.1

8.3 CSI reporting requirements

[To be updated]

Annex A (normative): Measurement channels

A.1 General

A.1.1 Throughput definition

The throughput values defined in the measurement channels specified in Annex A, are calculated and are valid per codeword. For multi-codeword transmissions, the throughput referenced in the minimum requirements is the sum of throughputs of all codewords.

A.2 UL reference measurement channels

A.3 DL reference measurement channels

A.3.1 General

The transport block size (TBS) determination procedure is described in clause 5.1.3.2 of TS 38.214 [12].

Unless otherwise stated, no user data is scheduled on slot #0 within 20 ms in order to avoid SSB and PDSCH transmissions in one slot and simplify test configuration.

A.3.2 Reference measurement channels for PDSCH performance requirements

For PDSCH reference channels if more than one Code Block is present, an additional CRC sequence of L = 24 Bits is attached to each Code Block (otherwise L = 0 Bit).

A.3.2.1 FDD

A.3.2.1.1 Reference measurement channels for SCS 15 kHz FR1

Table A.3.2.1.1-1: PDSCH Reference Channel for FDD (QPSK)

Parameter	Unit	Value				
Reference channel		R.PDSCH.1-1.1 FDD				
Channel bandwidth	MHz	10				
Subcarrier spacing	kHz	15				
Number of allocated resource blocks	PRBs	52				
Number of consecutive PDSCH symbols		12				
Allocated slots per 2 frames	Slots	19				
MCS table		64QAM				
MCS index		4				
Modulation		QPSK				
Target Coding Rate		0.30				
Number of MIMO layers		1				
Number of DMRS REs		12				
Overhead for TBS determination		0				
Information Bit Payload per Slot						
For Slot i = 0	Bits	N/A				
For Slots i = 1,…, 19	Bits	4096				
Transport block CRC per Slot						
For Slot i = 0	Bits	N/A				
For Slots i = 1,…, 19	Bits	24				
Number of Code Blocks per Slot						
For Slot i = 0	CBs	N/A				
For Slots i = 1,…, 19	CBs	1				
Binary Channel Bits Per Slot						
For Slot i = 0	Bits	N/A				
For Slots i = 10, 11	Bits	13104				
For Slots i =1,…, 9, 12, …, 19	Bits	13728				
Max. Throughput averaged over 2 frames	Mbps	3.891				
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames						

Table A.3.2.1.1-2: PDSCH Reference Channel for FDD (16QAM)

Parameter	Unit	Value					
Reference channel		R.PDSCH.1-2.1 FDD					
Channel bandwidth	MHz	10					
Subcarrier spacing	kHz	15					
Number of allocated resource blocks	PRBs	52					
Number of consecutive PDSCH symbols		12					
Allocated slots per 2 frames	Slots	19					
MCS table		64QAM					
MCS index		13					
Modulation		16QAM					
Target Coding Rate		0.48					
Number of MIMO layers		1					
Number of DMRS REs		12					
Overhead for TBS determination		0					
Information Bit Payload per Slot							
For Slot i = 0	Bits	N/A					
For Slots i = 1,…, 19	Bits	13064					
Transport block CRC per Slot							
For Slot i = 0	Bits	N/A					
For Slots i = 1,…, 19	Bits	24					
Number of Code Blocks per Slot							
For Slot i = 0	CBs	N/A					
For Slots i = 1,…, 19	CBs	2					
Binary Channel Bits Per Slot							
For Slot i = 0	Bits	N/A					
For Slots i = 10, 11	Bits	26208					
For Slots i = 1,…, 9, 12, …, 19	Bits	27456					
Max. Throughput averaged over 2 frames	Mbps	12.411					
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames							

A.4 Testing related to Satellite Access

A.4.1 General

The following test conditions should be maintained for Satellite Access when test equipment emulates the snapshot of the satellite link channel.

- The same ephemeris info will be maintained during each test.
- A set of ephemeris information are pre-defined for each satellite corresponding to respective epoch times in TS 38.508-1 [13].
- The range of the selected constant delay shift is as follows:
  - For NGSO an altitude of 600km and 1200km on a circular orbit are considered. The range of the one-way delay between UE and satellite is from 2ms (lowest value for LEO orbit 600km) to 6.67ms (highest value for LEO orbit 1200km).
  - For GSO the range of the one-way delay from UE to satellite is within 119.375ms to 128.79ms.
- Constant delay value is derived from ephemeris info (SIB19) and UE location associated to zero Doppler or non-zero Doppler value under test.

A.4.2 Test condition for transmitter characteristics

All requriements in section 6 for transmitter characteristics, other than frequency error in clause 6.4.1, shall be verified when Doppler conditions are set to zero and delay conditions are set to constant for all types of satellites.

Frequency error requirement in clause 6.4.1 shall be verified for at least two cases: one with zero Doppler condition and the other with a constant Doppler shift where the range of the absolute value of Doppler is greater than zero and up to [0.93] ppm if the IE field *ntn-ScenarioSupport-r17* is present and indicated as GSO and up to 24 ppm if the IE field *ntn-ScenarioSupport-r17* is present and indicated as NGSO or only the IE field *nonTerrestrialNetwork-r17* is present. The delay condition is a constant.

A.4.3 Test condition for receiver characteristics

All requirements in section 7 for receiver characteristics shall be verified when Doppler conditions are set to zero and delay conditions are set to constant for all types of satellites.

A.4.4 Test condition for performance requirements

All requirements in section 8 for performance requirements shall be verified when Doppler conditions related to satellite motion for DL in service link are set to zero and delay conditions are set to constant for all types of NGSO satellites.

The one-way delay between UE and satellite for NGSO at an altitude of 600km is 2ms.

Annex B (normative): Propagation conditions

B.1 Static propagation condition

B.1.1 UE Receiver with 1Rx

For 2 port transmission the channel matrix is defined in the frequency domain by

$$\mathbf{H} = [1 \quad 1].$$

B.1.2 UE Receiver with 2Rx

For 1 port transmission the channel matrix is defined in the frequency domain by

$$\mathbf{H} = \begin{pmatrix} 1 \\ 1 \end{pmatrix}.$$

For 2 port transmission the channel matrix is defined in the frequency domain by

$$\mathbf{H} = \begin{pmatrix} 1 & j \\ 1 & -j \end{pmatrix}.$$

B.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.

Initial channel matrix for LOS component of NTN-TDL-C channel model is equal to channel matrix of Static propagation conditions in Clause B.1.

B.2.1 Delay profiles

The delay profiles are derived from the TR 38.811 [12] NTN-TDL models for the desired delay spread and tap resolution. After scaling the normalized delay spread values for each tap by the desired RMS delay spread, the tap delays are quantized to a delay resolution of 5ns by rounding to the nearest multiple of the delay resolution.

Table B.2.1-1: Delay profiles for NR NTN channel models

Type	Model	Delay spread (r.m.s.)	Delay resolution
NLOS	NTN-TDLA100	100 ns	5 ns
LOS	NTN-TDLC5	5 ns	5 ns

Table B.2.1-2: 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 B.2.1-3 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
Note 1: Tap #1 follows a Rician distribution.			

B.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 B.2.2-1 show the propagation conditions that are used for the performance measurements in multi-path fading environment for NLOS and LOS propagation conditions.

Table B.2.2-1: Channel model parameters for NTN

Combination name	Model	Maximum Doppler frequency
NTN-TDLA100-200	NTN-TDLA100	200 Hz
NTN-TDLC5-200	NTN-TDLC5	200 Hz

B.2.3 MIMO Channel Correlation Matrices

The MIMO channel correlation matrices defined in B.2.3 apply for the antenna configuration using uniform linear arrays at both gNB and UE.

B.2.3.1 MIMO Correlation Matrices using Uniform Linear Array (ULA)

The MIMO channel correlation matrices defined in B.2.3.1 apply for the antenna configuration using uniform linear array (ULA) at both gNB and UE.

B.2.3.1.1 Definition of MIMO Correlation Matrices

Table B.2.3.1.1-1 defines the correlation matrix for the gNB.

Table B.2.3.1.1-1: gNB correlation matrix

	One antenna	Two antennas
gNB Correlation	$R_{gNB}=1$	$R_{gNB}=\begin{pmatrix}1 & \alpha\\ \alpha^{*} & 1\end{pmatrix}$

Table B.2.3.1.1-2 defines the correlation matrix for the UE:

Table B.2.3.1.1-2: UE correlation matrix

	One antenna	Two antennas
UE Correlation	$R_{UE}=1$	$R_{UE}=\begin{pmatrix}1 & \beta\\ \beta^* & \mathbf{1}\end{pmatrix}$

Table B.2.3.1.1-3 defines the channel spatial correlation matrix R_{spat}. The parameters, α and β in Table B.2.3.1-3 defines the spatial correlation between the antennas at the gNB and UE.

Table B.2.3.1.1-3: R_{spat} correlation matrices

1x2 case	$R_{spat}=R_{UE}=\begin{bmatrix}1 & \beta\\ \beta^* & 1\end{bmatrix}$
2x1 case	$R_{spat}=R_{gNB}=\begin{bmatrix}1 & \alpha\\ \alpha^* & 1\end{bmatrix}$
2x2 case	$R_{spat}=R_{gNB}\otimes R_{UE}=\begin{bmatrix}1 & \alpha\\ \alpha^* & 1\end{bmatrix}\otimes\begin{bmatrix}1 & \beta\\ \beta^* & 1\end{bmatrix}=\begin{bmatrix}1 & \beta & \alpha & \alpha\beta\\ \beta^* & 1 & \alpha\beta^* & \alpha\\ \alpha^* & \alpha^*\beta & 1 & \beta\\ \alpha^*\beta^* & \alpha^* & \beta^* & 1\end{bmatrix}$

B.2.3.1.2 MIMO Correlation Matrices at High, Medium and Low Level

The α and β for different correlation types are given in Table B.2.3.1.2-1.

Table B.2.3.1.2-1: The α and β parameters for ULA MIMO correlation matrices

Correlation Model	α	β
Low correlation	0	0

The correlation matrices low correlation are defined in Table B.2.3.1.2-2 below.

Table B.2.3.1.2-2: MIMO correlation matrices for low correlation

1x2 case	$R_{low}=\mathbf{I}_2$
2x1 case	$R_{low}=\mathbf{I}_2$
2x2 case	$R_{low}=\mathbf{I}_4$
Note: $\mathbf{I}_d$ is the $d\times d$ identity matrix.	

Annex C (normative): Downlink physical channels

C.1 General

This annex specifies the downlink physical channels that are needed for setting a connection and channels that are needed during a connection.

C.2 Setup (Conducted)

Table C.2-1 describes the downlink Physical Channels that are required for connection set up.

Table C.2-1: Downlink Physical Channels required for connection set-up

Physical Channel
PBCH
SSS
PSS
PDCCH
PDSCH
PBCH DMRS
PDCCH DMRS
PDSCH DMRS
CSI-RS

C.3 Connection (Conducted)

The following clauses, describes the downlink Physical Channels that are transmitted during a connection i.e., when measurements are done.

C.3.1 Measurement of Performance requirements

Table C.3.1-1 is applicable for measurements in which uniform RS-to-EPRE boosting for all downlink physical channels, unless otherwise stated.

Table C.3.1-1: Downlink Physical Channels transmitted during a connection (FDD and TDD)

Parameter	Unit	Value (Note 2)
SSS transmit power	W	Test specific
EPRE ratio of PSS to SSS	dB	0
EPRE ratio of PBCH to SSS	dB	0
EPRE ratio of PBCH to PBCH DMRS	dB	0
EPRE ratio of PDCCH to SSS	dB	0
EPRE ratio of PDCCH to PDCCH DMRS	dB	0
EPRE ratio of PDSCH to SSS	dB	0
EPRE ratio of PDSCH to PDSCH DMRS	dB	Test specific (Note 1)
EPRE ratio of CSI-RS to SSS	dB	-10*log10(L) (Note 3)
EPRE ratio of OCNG to SSS	dB	0
EPRE ratio of PDCCH OCNG to SSS	dB	0
EPRE ratio of LTE CRS to NR SSS	dB	0 (Note 4)

Note 1: Value is derived from Table 4.1-1 in TS 38.214 [12] based on "Number of DM-RS CDM groups without data" and "DMRS Type" parameters specified for each test.
Note 2: The value is the energy of per RE for a single antenna port before pre-coding.
Note 3: $L \in \{1,2,4,8\}$ is the CDM group size of NZP CSI-RS specified for each test.
Note 4: It is only applicable to LTE-NR coexistence tests.

Annex D (informative): Void

Annex E (normative): Environmental conditions

E.1 General

This annex specifies the environmental requirements of the UE. Within these limits the requirements of the present documents shall be fulfilled.

E.2 Environmental (Conducted)

The requirements in this clause apply to all types of UE(s).

E.2.1 Temperature

The UE shall fulfil all the requirements in the temperature range defined in Table E.2.1-1.

Table E.2.1-1: Temperature conditions

Temperature	Temperature conditions
+15°C to +35°C	For normal conditions (with relative humidity of 25 % to 75 %)

Outside this temperature range the UE, if powered on, shall not make ineffective use of the radio frequency spectrum. In no case shall the UE exceed the transmitted levels as defined in clause 6.2 of TS 38.101-1 [6] for extreme operation.

E.2.2 Voltage

The UE shall fulfil all the requirements in the voltage range defined in Table E.2.2-1.

Table E.2.2-1: Voltage conditions

Power source	Normal conditions voltage
AC mains	nominal
Regulated lead acid battery	1,1 * nominal
Non regulated batteries: Leclanché Lithium Mercury/nickel & cadmium	 Nominal 1,1 * Nominal Nominal

Outside this voltage range the UE if powered on, shall not make ineffective use of the radio frequency spectrum. In no case shall the UE exceed the transmitted levels as defined in TS 38.101-1[6, Clause 6.2] for extreme operation. In particular, the UE shall inhibit all RF transmissions when the power supply voltage is below the manufacturer declared shutdown voltage.

E.2.3 Vibration

The UE shall fulfil all the requirements when vibrated at the following frequency/amplitudes.

Table E.2.3-1: Vibration conditions

Frequency	ASD (Acceleration Spectral Density) random vibration
5 Hz to 20 Hz	0,96 m^2/s^3
20 Hz to 500 Hz	0,96 m^2/s^3 at 20 Hz, thereafter –3 dB/Octave

Outside the specified frequency range the UE, if powered on, shall not make ineffective use of the radio frequency spectrum. In no case shall the UE exceed the transmitted levels as defined in TS 38.101-1[6] for extreme operation.

Annex F (informative): Change history

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2022-01	RAN4#101-bis-e	R4-2203086				Draft skeleton approved	0.0.1
2022-03	RAN4#102-e	R4-2207514				Added approved TPs in RAN4#102-e including: R4-2207332, R4-2207334, R4-2207343, R4-2207344, R4-2207391, R4-2207393, R4-2207394, R4-2207396, R4-2207400, R4-2207404, R4-2207405, R4-2207410, R4-2207411, R4-2207413, R4-2207415	0.1.0
2022-05	RAN4#103-e	R4-2208641				Added approved TPs in RAN4#103-e including: R4-2208662, TP to TS 38.101-5 on Conducted transmitter characteristics R4-2209366, TP for 38.101-5 on Output RF spectrum emissions for satellite UE except for UE coexistence R4-2210851, Draft text proposal for Clause 3 - TS 38.101-5 R4-2210874, TP to TS 38.101-5 on 7.3 Reference Sensitivity R4-2210876, Updates to TS 38.101-5 related to n255 A-MPR clause R4-2210877, TP for 38.101-5 on Spurious emissions for UE coexistence R4-2210878, TP to update TS 38.101-5 clause 7.6.3 on OOBB R4-2211220, TP for 38.101-5 on frequency error	0.2.0

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2022-06	RAN#96					Approved by plenary – Rel-17 spec under change control	17.0.0
2022-09	RAN#97	RP-222035	0001	1	F	CR to 38.101-5: Corrections on Rx requirements for NTN UE	17.1.0
2022-09	RAN#97	RP-222035	0002		F	CR to TS 38.101-5 - Tx requirements issues fixes	17.1.0
2022-09	RAN#97	RP-222035	0003	1	F	CR to TS 38.101-5 - Rx requirements issues fixes	17.1.0
2022-12	RAN#98-e	RP-223306	0005	1	F	CR: 0005 Doppler test conditions for RF requirements 38.101-5	17.2.0
2022-12	RAN#98-e	RP-223306	0006		F	CR to 38.101-5: Corrections on section 5.3.3 for NTN UE	17.2.0
2022-12	RAN#98-e	RP-223311	0010	2	F	CR to 38.101-5 for NTN UE RF requirements corrections	17.2.0
2022-12	RAN#98-e	RP-223309	0012		F	CR addition of protection for n100 and n101 into 38.101-5	17.2.0
2022-12	RAN#98-e	RP-223311	0013		F	CR to 38.101-5: Corrections on reference for NTN UE	17.2.0
2022-12	RAN#98-e	RP-223303	0015		B	Big CR for UE NTN performance requirements (TS38.101-5, Rel-17, CAT B)	17.2.0
2023-03	RAN#99	RP-230516	0017	1	F	Correction of the out-of-band blocking requirements	17.3.0
2023-06	RAN#100	RP-231344	0025		F	Correction to reference measurement channels for NTN	17.4.0
2023-09	RAN#101	RP-232494	0030		F	CR to 38.101-5: Corrections on A-MPR requirement reference	17.5.0
2023-09	RAN#101	RP-232494	0032	1	F	CR to TS38.101-5: Corrections to NR-NTN requirements (Rel-17)	17.5.0
2023-09	RAN#101	RP-232494	0034	1	F	Clarifications to 38.101-5 (Rel-17)	17.5.0
2023-12	RAN#102	RP-233349	0041	1	F	CR to 38.101-5 on clarification for NR NTN UE RF and Demod requirements test conditions	17.6.0
2023-12	RAN#102	RP-233349	0043		F	CR to 38.101-5: Correction on the reference measurement channel for NTN PDSCH requirement	17.6.0
2023-12	RAN#102	RP-233349	0045		F	[NR_NTN_solutions-Core] CR for 38.101-5 to align the understanding of GEO (R17)	17.6.0
2023-12	RAN#102	RP-233349	0051		F	Clarification for the Pi/2 BPSK modulation	17.6.0

History

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