**3GPP TSG- Meeting #bis *4941***

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| *CR-Form-v12.3* |
| **CHANGE REQUEST** |
|  |
|  | **8.101-5** | **CR** |  | **rev** |  | **Current version:** | **18.5.0** |  |
|  |
| *For* [***HE******LP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* |
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| ***Proposed change affects:*** | UICC apps |  | ME | **X** | Radio Access Network |  | Core Network |  |

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|  |
| ***Title:***  | Draft CR to TS 38.101-5 on top of the running CR R4-2401116: Tx requirements |
|  |  |
| ***Source to WG:*** | , Thales, Samsung |
| ***Source to TSG:*** | R4 |
|  |  |
| ***Work item code:*** |  |  | ***Date:*** | 2024-04-15 |
|  |  |  |  |  |
| ***Category:*** | **B** |  | ***Release:*** | Rel-18 |
|  | *Use one of the following categories:****F*** *(correction)****A*** *(mirror corresponding to a change in an earlier release)****B*** *(addition of feature),* ***C*** *(functional modification of feature)****D*** *(editorial modification)*Detailed explanations of the above categories canbe found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | *Use one of the following releases:Rel-8 (Release 8)Rel-9 (Release 9)Rel-10 (Release 10)Rel-11 (Release 11)…Rel-16 (Release 16)Rel-17 (Release 17)Rel-18 (Release 18)Rel-19 (Release 19)* *Rel-20 (Release 20)* |
| ***7*** |  |
| ***Reason for change:*** | This draft CR further updates the endorsed running CR R4-2401116 for Tx requirements. |
|  |  |
| ***Summary of change:*** | Definition of a generic name (NTN VSAT) which would indicate any UE classe/type to simplify some wording in sub-clauses.Introduction of max TRP requirement, needed for OoBE.Simplification of the SEMAddition of FCC 25.209 which was missing. |
|  |  |
| ***Consequences if not approved:*** | The NTN Ka-band won’t be correctly supported |
|  |  |
| ***Clauses affected:*** |  |
|  |  |
|  | **Y** | **N** |  |  |
| ***Other specs*** |  | **X** |  Other core specifications  | TS/TR ... CR ... |
| ***affected:*** |  | **X** |  Test specifications | TS/TR ... CR ... |
| ***(show related CRs)*** |  | **X** |  O&M Specifications | TS/TR ... CR ...  |
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| ***Other comments:*** |  |
|  |  |
| ***This CR's revision history:*** |  |

*<Start of the change>*

# 1 Scope

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

The Mobile VSAT communicating with non-GSO is not considered in this release.

*<End of the change>*

*<Start of the change>*

# 2 References

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[15] IEEE Std 149: "IEEE Standard Test Procedures for Antennas", IEEE.

[16] 3GPP TS 38.101-2: "NR; User Equipment (UE) radio transmission and reception; Part 2: Range 2 Standalone"

[17] ITU-R Recommendation SM.329-12, "Unwanted emissions in the spurious domain"

[18] EN 303 978, Satellite Earth Stations and Systems (SES);Harmonised Standard for Earth Stations on Mobile Platforms (ESOMP) transmitting towards satellites in geostationary orbit, operating in the 27,5 GHz to 30,0 GHz frequency bands covering the essential requirements of article 3.2 of the Directive 2014/53/EU, v2.1.2, 2016-10

[19] EN 301 459, Satellite Earth Stations and Systems (SES);Harmonised Standard for Satellite Interactive Terminals (SIT) and Satellite User Terminals (SUT) transmitting towards satellites in geostationary orbit, operating in the 29,5 GHz to 30,0 GHz frequency bands covering the essential requirements of article 3.2 of the Directive 2014/53/EU, v2.1.1, 2016-05

*<End of the change>*

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## 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].

**"Carrier‑off” state:** radio state in which the NTN VSAT may transmit but does not transmit any carrier

NOTE: "NTN VSAT may transmit" means that all the conditions for transmission are satisfied (e.g. in a state where transmissions are permitted, no failure detected, and the NTN VSAT is correctly pointed towards the satellite).

NOTE: The existence of a "Carrier‑off" radio state depends on the system of transmission used. For NTN VSATs designed for continuous transmission mode there may be no "Carrier‑off" state.

**“Carrier‑on” state:** Radio state in which the NTN VSAT may transmit and transmits a carrier.

**Co-polarized transmission:** when the DUT transmission antenna polarization is aligned with test antenna polarization.

**Cross-polarized transmission:** when the DUT transmission antenna polarization is aligned with the tangent of the test antenna polarization.

**“Emissions disabled” state:** Radio state in which the ESOMP is not emitting (e.g. before system monitoring pass, before the control channel is received, when a failure is detected, when an ESOMP is commanded to disable, and

when the ESOMP is in a location requiring cessation of emissions).

**Enhanced channel raster**: channel raster with a 10 kHz granularity in bands with a 100 kHz channel raster.

**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.

**NTN VSAT**: a UE operating in FR2-NTN which could be a Fixed VSAT or a Mobile VSAT.

**Plane perpendicular to the GSO arc:** The plane that is perpendicular to the “plane tangent to the GSO arc,” as defined below, and includes a line between the [earth station](https://www.law.cornell.edu/definitions/index.php?width=840&height=800&iframe=true&def_id=78b6a8b2410df19c2611058edc75e85f&term_occur=999&term_src=Title:47:Chapter:I:Subchapter:B:Part:25:Subpart:A:25.103) in question and the GSO [space station](https://www.law.cornell.edu/definitions/index.php?width=840&height=800&iframe=true&def_id=0b6c8478b2f4db9e2b4a8a65a86a965f&term_occur=999&term_src=Title:47:Chapter:I:Subchapter:B:Part:25:Subpart:A:25.103) that it is communicating with (FCC 47 CFR 25.103).

**Plane tangent to the GSO arc:** The plane defined by the location of an [earth station](https://www.law.cornell.edu/definitions/index.php?width=840&height=800&iframe=true&def_id=78b6a8b2410df19c2611058edc75e85f&term_occur=999&term_src=Title:47:Chapter:I:Subchapter:B:Part:25:Subpart:A:25.103)'s transmitting antenna and a line in the equatorial plane that is tangent to the GSO arc at the location of the GSO [space station](https://www.law.cornell.edu/definitions/index.php?width=840&height=800&iframe=true&def_id=0b6c8478b2f4db9e2b4a8a65a86a965f&term_occur=999&term_src=Title:47:Chapter:I:Subchapter:B:Part:25:Subpart:A:25.103) that the [earth station](https://www.law.cornell.edu/definitions/index.php?width=840&height=800&iframe=true&def_id=78b6a8b2410df19c2611058edc75e85f&term_occur=999&term_src=Title:47:Chapter:I:Subchapter:B:Part:25:Subpart:A:25.103) is communicating with (FCC 47 CFR 25.103).

**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).

## 3.2 Symbols

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

ΔFGlobal Granularity of the global frequency raster

ΔFRaster Band dependent channel raster granularity

BWChannel Channel bandwidth

BWinterferer Bandwidth of the interferer

FDL\_low The lowest frequency of the downlink *operating band*

FDL\_high The highest frequency of the downlink *operating band*

FUL\_low The lowest frequency of the uplink *operating band*

FUL\_high The highest frequency of the uplink *operating band*

FInterferer Frequency of the interferer

FInterferer (offset) Frequency offset of the interferer (between the center frequency of the interferer and the carrier frequency of the carrier measured)

FIoffset Frequency offset of the interferer (between the center frequency of the interferer and the closest edge of the carrier measured)

FOOB The boundary between the NR out of band emission and spurious emission domains

FREF RF reference frequency

FREF-Offs Offset used for calculating FREF

Fuw (offset) The frequency separation of the center frequency of the carrier closest to the interferer and the center frequency of the interferer

NRB Transmission bandwidth configuration, expressed in units of resource blocks

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

NREF-Offs Offset used for calculating NREF

PInterferer Modulated mean power of the interferer

PUEType Minimum UE type peak EIRP (i.e. no tolerance) as specified in sub-clause 9.2.1

Puw Power of an unwanted DL signal

θ Angle in degrees from a line from the [earth station](https://www.law.cornell.edu/definitions/index.php?width=840&height=800&iframe=true&def_id=78b6a8b2410df19c2611058edc75e85f&term_occur=999&term_src=Title:47:Chapter:I:Subchapter:B:Part:25:Subpart:C:25.218) antenna to the assigned orbital location of the target satellite

TRPmax The maximum TRP for the NTN VSAT as specified in sub-clause 9.2.1

*<End of the change>*

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## 9.2 Transmitter power

### 9.2.1 NTN VSAT maximum output power

#### 9.2.1.0 General

The NTN VSAT classes are specified based on the assumptions of certain NTN VSAT types with specific device architectures including antenna beam steering types. The requirements are specified for different NTN VSAT types. And for the the hybrid beam steering capable NTN VSAT, which can adjust its antenna(s) or beam(s) in both electronic steering and mechanical steering ways, the applicable requirements should follow either electronic or mechanical beam steering requirements depending on the NTN VSAT type it declared. The NTN VSAT types can be found in Table 9.2.1.0-1 below.

Table 9.2.1.0-1: Assumptions of NTN VSAT Types

|  |  |  |
| --- | --- | --- |
| **NTN VSAT class** | **NTN VSAT type** | Type description |
| Fixed VSAT | 1 | Fixed VSAT communicating with GSO and LEO with mechanical steering antenna. |
| 2 | Fixed VSAT communicating with GSO and LEO with electronic steering antenna. |
| 3 | Fixed VSAT communicating with LEO only with electronic steering antenna. |
| Mobile VSAT | 4 | Mobile VSAT communicating with GSO with mechanical steering antenna. |
| 5 | Mobile VSAT communicating with GSO with electronic steering antenna. |
| Note 1: The NTN VSAT types are assuming NTN VSAT has only one antenna beam towards one satellite at a given time in this document. |

#### 9.2.1.1 Minimum requirements for Fixed VSAT

The following requirements define the maximum output power radiated by the Fixed VSAT for any transmission bandwidth within the channel bandwidth for non-CA configuration, unless otherwise stated. The period of measurement shall be at least one sub frame (1ms). The minimum output power values for EIRP are found in Table 9.2.1.1-1. The requirement is verified with the test metric of EIRP (Link=[Spherical coverage grid], Meas=Link angle).

[Note: VSAT spherical coverage grid should cover the areas with its declared supported elevation angles in the reference coordinates system in Annex J.1.]

Table 9.2.1.1-1: Minimum peak EIRP for Fixed VSAT

|  |  |  |
| --- | --- | --- |
| Operating band | UE Type | Min peak EIRP (dBm) |
| n512, n511, n510 | 1 | 70 |
| 2 | 70 |
| 3 | 61 |
| Note: Minimum peak EIRP is defined as the lower limit without tolerance. |

The maximum output power values for TRP and EIRP are found in Table 9.2.1.1-2 below.

Table 9.2.1.1-2: Maximum output power limits for Fixed VSAT

|  |  |
| --- | --- |
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| --- | --- | --- | --- |
| Operating band | UE Type | TRPMAX (dBm) | EIRPmax (dBm) |
| n512, n511, n510 | 1 | 35 | 76.2 |
| 2, 3 | TBD | 76.2 |

#### 9.2.1.2 Minimum requirements for Mobile VSAT

The following requirements define the maximum output power radiated by the Mobile VSAT for any transmission bandwidth within the channel bandwidth for non-CA configuration, unless otherwise stated. The period of measurement shall be at least one sub frame (1ms). The minimum output power values for EIRP are found in Table 9.2.1.2-1. The requirement is verified with the test metric of EIRP (Link=[Spherical coverage grid], Meas=Link angle).

[Note: VSAT spherical coverage grid should cover the areas with its declared supported elevation angles in the reference coordinates system in Annex J.1.]Table 9.2.1.2-1: Minimum peak EIRP for Mobile VSAT

|  |  |  |
| --- | --- | --- |
| Operating band | UE Type | Min peak EIRP (dBm) |
| n512, n511 | 4 | 70 |
| 5 | 70 |
| Note: Minimum peak EIRP is defined as the lower limit without tolerance. |

The maximum output power values for TRP and EIRP are found in Table 9.2.1.2-2 below.

Table 9.2.1.2-2: Maximum output power limits for Mobile VSAT

|  |  |
| --- | --- |
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|  |  |  |  |
| --- | --- | --- | --- |
| Operating band | UE Type | TRPMAX (dBm) | EIRPmax (dBm) |
| n512, n511, n510 | 4 | 35 | 76.2 |
| 5 | TBD | 76.2 |

### 9.2.2 Off-axis EIRP limit

#### 9.2.2.1 General

The Off-axis EIRP density envelope is applicable within the band to NTN VSAT transmitting to a SAN.

#### 9.2.2.2 Minimum requirement for bands n510 and n511

For co-polarized transmissions in the plane tangent to the GSO arc, the requirements specified in table 9.2.2.2-1 apply to NTN VSAT.

**Table 9.2.2.2-1: Off-axis EIRP density limits for co-polarized transmissions in the plane tangent to the GSO arc**

|  |  |  |
| --- | --- | --- |
| θ value | Maximum Off-axis EIRP (dBm) | Measurement bandwidth (MHz) |
| 2.0° ≤ θ ≤ 7° | 62.5 – 25log(θ) | 1 |
| 7° ≤ θ ≤ 9.2° | 41.5 | 1 |
| 9.2° ≤ θ ≤ 19.1° | 65.5 – 25log(θ) | 1 |
| 19.1° < θ ≤ 180° | 33.5 | 1 |

For co-polarized transmissions in the plane perpendicular to the GSO arc, the requirements specified in table 9.2.2.2-2 apply to NTN VSAT.

**Table 9.2.2.2-2: Off-axis EIRP density limits for co-polarized transmissions in the plane perpendicular to the GSO arc**

|  |  |  |
| --- | --- | --- |
| θ value | Maximum Off-axis EIRP (dBm) | Measurement bandwidth (MHz) |
| 3.5° ≤ θ ≤ 7° | 65.5 – 25log(θ) | 1 |
| 7° ≤ θ ≤ 9.2° | 44.5 | 1 |
| 9.2° ≤ θ ≤ 19.1° | 68.5 – 25log(θ) | 1 |
| 19.1° < θ ≤ 180° | 36.5 | 1 |

The EIRP density levels specified in table 9.2.2.2-1 and table 9.2.2.2-2 may be exceeded by up to 3 dB, for values of θ > 7°, over 10% of the range of theta (θ) angles from 7–180° on each side of the line from the  NTN VSAT to the target SAN.

For cross-polarized transmissions in the plane tangent to the GSO arc and in the plane perpendicular to the GSO arc, the requirements specified in table 9.2.2.2-3 apply to NTN VSAT.

**Table 9.2.2.2-2: Off-axis EIRP density limits for cross-polarized transmissions in the plane tangent to the GSO arc and in the plane perpendicular to the GSO arc**

|  |  |  |
| --- | --- | --- |
| θ value | Maximum Off-axis EIRP (dBm) | Measurement bandwidth (MHz) |
| 2.0° ≤ θ ≤ 7° | 52.5 – 25log(θ) | 1 |

#### 9.2.2.3 Minimum requirement for band n512

##### 9.2.2.3.1 Fixed VSAT

For co-polarized transmissions, the requirements specified in table 9.2.2.3.1-1 apply to Fixed VSAT.

**Table 9.2.2.3.1-1: Off-axis EIRP density limits for co-polarized transmissions**

|  |  |  |
| --- | --- | --- |
| θ value | Maximum Off-axis EIRP (dBm) | Measurement bandwidth (kHz) |
| 1.8° ≤ θ ≤ 7° | 49 – 25log(θ) – K | 40 |
| 7° ≤ θ ≤ 9.2° | 28 - K | 40 |
| 9.2° ≤ θ ≤ 48° | 52 – 25log(θ) - K | 40 |
| 48° < θ ≤ 180° | 20 - K | 40 |
| Note: K=10log(N) with N the number of terminals simultaneously transmitting at the same EIRP on a given carrier frequency in the same measurement bandwidth. K = 0 if only one Fixed VSAT transmits at any one time on a given carrier frequency. See sub-clause 4.2.4.2 in [19]. |

For cross-polarized transmissions, the requirements specified in table 9.2.2.3.1-2 apply to Fixed VSAT.

**Table 9.2.2.3.1-2: Off-axis EIRP density limits for cross-polarized transmissions**

|  |  |  |
| --- | --- | --- |
| θ value | Maximum Off-axis EIRP (dBm) | Measurement bandwidth (kHz) |
| 1.8° ≤ θ ≤ 7° | 39 – 25log(θ) - K | 40 |
| 7° ≤ θ ≤ 9.2° | 18 - K | 40 |
| Note: K=10log(N) with N the number of terminals simultaneously transmitting at the same EIRP on a given carrier frequency in the same measurement bandwidth. K = 0 if only one Fixed VSAT transmits at any one time on a given carrier frequency. See sub-clause 4.2.4.2 in [19]. |

##### 9.2.2.3.2 Mobile VSAT

For co-polarized transmissions, the requirements specified in table 9.2.2.3.2-1 apply to Mobile VSAT.

**Table 9.2.2.3.2-1: Off-axis EIRP density limits for co-polarized transmissions**

|  |  |  |
| --- | --- | --- |
| θ value | Maximum Off-axis EIRP (dBm) | Measurement bandwidth (kHz) |
| 2.0° ≤ θ ≤ 7° | 49 – 25log(θ) - K | 40 |
| 7° ≤ θ ≤ 9.2° | 28 - K | 40 |
| 9.2° ≤ θ ≤ 48° | 52 – 25log(θ) - K | 40 |
| 48° < θ ≤ 180° | 20- K | 40 |
| Note: K=10log(N) with N the number of terminals simultaneously transmitting at the same EIRP on a given carrier frequency in the same measurement bandwidth. K = 0 if only one Mobile VSAT transmits at any one time on a given carrier frequency. See sub-clause 4.2.2.2.1 in [18]. |

Mobile VSAT with low elevation angles may exceed the limits specified in Table 9.2.2.3.2-1 by the amount specified in Table 9.2.2.3.2-2

**Table 9.2.2.3.2-2: Off-axis EIRP density limits for co-polarized transmissions**

|  |  |
| --- | --- |
| Elevation angle to Satellite (ε) | Increase in EIRP density (dB) |
| ε < 5o | 2.5 |
| 5o < ε < 30o | 3 – 0.1 \* ε |

For cross-polarized transmissions, the requirements specified in table 9.2.2.3.2-3 apply to Mobile VSAT.

**Table 9.2.2.3.2-3: Off-axis EIRP density limits for cross-polarized transmissions**

|  |  |  |
| --- | --- | --- |
| θ value | Maximum Off-axis EIRP (dBm) | Measurement bandwidth (kHz) |
| 2.0° ≤ θ ≤ 7° | 39 – 25log(θ) - K | 40 |
| 7° ≤ θ ≤ 9.2° | 18 - K | 40 |
| Note: K=10log(N) with N the number of terminals simultaneously transmitting at the same EIRP on a given carrier frequency in the same measurement bandwidth. K = 0 if only one Mobile VSAT transmits at any one time on a given carrier frequency. See sub-clause 4.2.2.2.1 in [18]. |

##### 9.2.2.3.3 Additional Off-axis EIRP density requirements for protection of fixed services

For uncoordinated NTN VSAT, the requirements specified in table 9.2.2.3.3-1 apply.

**Table 9.2.2.3.3-1: Off-axis EIRP density limits for protection of fixed services**

|  |  |  |
| --- | --- | --- |
| Frequency Range (GHz) | Maximum Off-axis EIRP (dBm) | Measurement bandwidth (MHz) |
| 27.8285—28.4445 |  |  |
| 28.8365 – 28.9485 (NOTE1) | -5 | 1 |
| 28.9485 – 29.4525 |  |  |
| NOTE1: When applicable, if this frequency range is allocated to fixed service. |

### 9.2.3 Configured transmitted power

The NTN VSAT can configure its maximum output power. The configured NTN VSAT maximum output power PCMAX,f,c for carrier f of a serving cell c is defined as that available to the reference point of a given transmitter branch that corresponds to the reference point of the higher-layer filtered RSRP measurement as specified in TS 38.215 [11].

The configured NTN VSAT maximum output power PCMAX,f,c for carrier *f* of a serving cell *c* shall be set such that the corresponding measured peak EIRP PUMAX,f,c is within the following bounds

PUEType - TEIRP ≤ PUMAX,f,c ≤ EIRPmax + TEIRP

with PUEType is the NTN VSAT minimum peak EIRP as specified in sub-clause 9.2.1, EIRPmax is the applicable maximum EIRP as specified in sub-clause 9.2.1 and TEIRP is equal to 3.4 dB. The requirement is verified with the test metric of EIRP (Link=TX beam peak direction, Meas=Link angle)..

while the corresponding measured total radiated power PTMAX,f,c is bounded by the maximum TRP limit TRPMAX for NTN VSAT defined in sub-clause 9.2.1:

TRPMAX – TTRP ≤ PTMAX,f,c ≤ TRPMAX + TTRP

where, TTRP is specified as 3 dB. The PTMAX,f,c requirement is verified with the test metrics of TRP (Link=TX beam peak direction, Meas=TRP grid) in beam locked mode.

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## 9.3 Output power dynamics

### 9.3.1 Minimum output power

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

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### 9.3.2 Transmit OFF power

#### 9.3.2.1 General

The transmit OFF power is defined as the TRP in the channel bandwidth when the transmitter is OFF. The transmitter is considered OFF when the NTN VSAT is not allowed to transmit on any of its ports.

The transmit OFF power shall be less than ‑36 dBm/MHz. The requirement is verified with the test metric of TRP (Link=TX beam peak direction, Meas=TRP grid).

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### 9.3.4 Power control

#### 9.3.4.1 General

The requirements on power control accuracy apply under normal conditions and are defined as a directional requirement. The requirements are verified in beam locked mode on beam peak direction.

The applicant shall declare the method and accuracy of uplink power control.

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## 9.4 Transmitter signal quality

### 9.4.1 Frequency Error

The NTN VSAT basic measurement interval of modulated carrier frequency is 1 UL slot. The NTN VSAT 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 VSAT 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 NTN VSAT by SAN and UL pre-compensated Doppler frequency shift. For the test case, the location of the NTN VSAT is explicitly provided to the NTN VSAT from the test equipment.]

Requirement will be verified for at least two cases of which one has zero Doppler conditions.

The frequency error is defined as a directional requirement. The requirement is verified in beam locked mode with the test metric of Frequency (Link=TX beam peak direction, Meas=Link angle).

9.4.2 Transmit modulation quality

#### 9.4.2.1 General

Transmit modulation quality defines the modulation quality for expected in-channel RF transmissions from the NTN VSAT. The transmit modulation quality is specified in terms of:

- Error Vector Magnitude (EVM) for the allocated resource blocks (RBs)

All the parameters defined in clause 9.4.2 are defined using the measurement methodology specified in Annex F.

All the requirements in 9.4.2 are defined as directional requirement. The requirements are verified in beam locked mode on beam peak direction, with parameter *maxRank* (as defined in TS 38.331 [11]) set to 1. The requirements are applicable to UL transmission from each configurable antenna port (as defined in TS 38.331 [11]) of UE, enabled one at a time.

#### 9.4.2.2 Error vector magnitude

The Error Vector Magnitude is a measure of the difference between the reference waveform and the measured waveform. This difference is called the error vector. Before calculating the EVM, the measured waveform is corrected by the sample timing offset and RF frequency offset. Then the carrier leakage shall be removed from the measured waveform before calculating the EVM.

For DFT-s-OFDM waveforms, the EVM result is defined after the front-end FFT and IDFT as the square root of the ratio of the mean error vector power to the mean reference power expressed as a %. For CP-OFDM waveforms, the EVM result is defined after the front-end FFT as the square root of the ratio of the mean error vector power to the mean reference power expressed as a %.

The basic EVM measurement interval in the time domain is one preamble sequence for the PRACH and one slot for PUCCH and PUSCH in the time domain. The EVM measurement interval is reduced by any symbols that contains an allowable power transient in the measurement interval as as defined in clause 9.3.3.

The RMS average of the basic EVM measurements over 10 subframes for the average EVM case, and over 60 subframes for the reference signal EVM case, for the different modulation schemes shall not exceed the values specified in Table 9.4.2.2-1 for the parameters defined in Table 9.4.2.2-2. For EVM evaluation purposes, all 13 PRACH preamble formats and all 5 PUCCH fo rmats are considered to have the same EVM requirement as QPSK modulated.

The requirement is verified with the test metric of EVM (Link=TX beam peak direction, Meas=Link angle).

Table 9.4.2.2-1: Minimum requirements for error vector magnitude

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Unit | Average EVM level | Reference signal EVM level |
| Pi/2 BPSK  | % | 30.0 | 30.0 |
| QPSK  | % | 17.5 | 17.5 |
| 16 QAM  | % | 12.5 | 12.5 |
| 64 QAM  | % | 8.0 | 8.0 |

Table 9.4.2.2-2: Parameters for Error Vector Magnitude

|  |  |  |
| --- | --- | --- |
| Parameter | Unit | Level |
| NTN VSAT EIRP | dBm | ≥ -13 |
| NTN VSAT EIRP for UL 16 QAM | dBm | ≥ -10 |
| NTN VSAT EIRP for UL 64 QAM | dBm | ≥ -6 |
| Operating conditions |  | Normal conditions |

## 9.5 Output RF spectrum emissions

### 9.5.1 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 9.5.1-1.

The occupied bandwidth is defined as a directional requirement. The requirement is verified in beam locked mode with the test metric of OBW (Link=TX beam peak direction, Meas=Link angle).

**Table 9.5.1-1: Occupied channel bandwidth**

|  |  |
| --- | --- |
|  | **Occupied channel bandwidth / Channel bandwidth** |
|  | **50****MHz** | **100****MHz** | **200****MHz** | **400****MHz** |
| **Channel bandwidth (MHz)** | 50 | 100 | 200 | 400 |

### 9.5.2 Out of Band Emissions

9.5.2.1 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. Additional requirements to protect specific bands are also considered.

The requirements in clause 9.5.2.2 only apply when both UL and DL of a NTN VSAT are configured for single CC operation, and they are of the same bandwidth.

All out of band emissions for FR2-NTN are TRP.

The spectrum emission mask of the NTN VSAT applies to frequencies starting from the ± edge of the assigned NR channel bandwidth. 9.5.2.2 Spectrum emission mask

9.5.2.2.1 General NR spectrum emission mask

The power of any NTN VSAT emission shall not exceed the levels specified in Table 9.5.2.2-1 for the specified channel bandwidth. The requirement is verified in beam locked mode with the test metric of TRP (Link=TX beam peak direction, Meas=TRP grid).

**Table 9.5.2.2.1-1: General NR spectrum emission mask for NTN-FR2**

|  |  |  |  |
| --- | --- | --- | --- |
| **Frequency offset of measurement filter ‑3dB point, Δf** | **Frequency offset of measurement filter centre frequency, f\_offset** | **Basic limits****(dBm)** | **Measurement bandwidth** |
| 0 MHz ≤ Δf < 2× BW | 0.5 MHz ≤ f\_offset < 2× BW + 0.5 MHz |  | 1 MHz |
| NOTE 1: TRPmax is specified in clause 9.2.1.NOTE 2: Transmission BW is in the unit of MHz.NOTE 3: The 11dBm/1MHz value corresponds to the spurious emission limit specified in spurious emission clause 9.5.3, and is converted from the SE limit requirement defined on 4 kHz to a value defined over 1 MHz.NOTE 4: PSD attenuation as in ITU-R SM.1541-6 [6], Annex 5 OoB domain emission limits for earth stations. |

9.5.2.2.2 Additional spectrum emission mask

For bands n511 and n510 the mean power of emissions shall be attenuated below the mean output power of the transmitter (measured in dBm) in accordance with [FCC 25.202].

The power of any NTN VSAT emission shall not exceed the levels specified in Table 9.5.2.2.2-1 for the specified channel bandwidth. The requirement is verified in beam locked mode with the test metric of TRP (Link=TX beam peak direction, Meas=TRP grid).

**Table 9.5.2.2.2-1: Additional spectrum emission mask**

|  |  |  |
| --- | --- | --- |
| **Frequency offset of measurement filter centre frequency, f\_offset** | **Basic limits****(dBm)** | **Measurement bandwidth** |
| 0.002MHz+0.5xBW ≤ f\_offset < 1xBW-0.002MHz | TRPmax (dBm) - 25 dB | 4 kHz |
| 0.002MHz+1xBW ≤ f\_offset < 2.5xBW-0.002MHz | TRPmax (dBm) - 35 dB | 4 kHz |
| 0.002MHz+2.5xBW ≤ f\_offset < 2nd harmonic of the upper frequency edge of the UL operating band in GHz | -13 dBm | 4 kHz |
| NOTE 1: TRPmax is specified in clause 9.2.1.NOTE 2: Transmission BW is in the unit of MHz.NOTE 3: *Measurement bandwidth*s as in ITU-R SM.329 [2], s4.1.NOTE 4: Upper frequency as in ITU-R SM.329 [2], s2.5 table 1. |

*<End of the change>*

*<Start of the change>*

##### 9.5.3.2.3 “Carrier-on” state

The requirements specified in tables 9.5.3.2.3-1 and 9.5.3.2.3-2 apply to NTN VSAT in “Carrier-on”.

The requirement specified in table requirements specified in table 9.5.3.2.3-1 apply outside a bandwidth of 5 times the occupied bandwidth centred on the carrier centre frequency.

The requirement specified in table requirements specified in table 9.5.3.2.3-2 apply inside a bandwidth of 5 times the occupied bandwidth centred on the carrier centre frequency, and outside the transmission bandwidth.

Note: The on-axis spurious radiations, outside the bands 27,5 GHz to 29,1 GHz and 29,5 GHz to 30,0 GHz, are

indirectly limited by subclause 9.5.3.2.3. Consequently no specification is needed.

Table 9.5.5.2.2.3-1: On-axis spurious limits in “Carrier-on” state - outside

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency range(GHz) | NTN VSAT type | EIRP Limit(dBm) | Measurement bandwidth(MHz) |
| 27.5 – 30.0 | 4, 5 | 44 - K (Note) | 1 |
| 1, 2, 3 | 4 - K (Note) | 1 |
| Note: K=10log(N) with N the number of terminals simultaneously transmitting at the same EIRP on a given carrier frequency in the same measurement bandwidth. K = 0 if only one NTN VSAT transmits at any one time on a given carrier frequency. See sub-clause 4.2.2.2.1 in [18] for mobile VSAT or sub-clause 4.2.4.2 in [19] for fixed VSAT. |

Table 9.5.5.2.2.3-2: On-axis spurious limits in “Carrier-on” state - inside

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency range(GHz) | NTN VSAT type | EIRP Limit(dBm) | Measurement bandwidth(MHz) |
| 27.5 – 30.0 | 4, 5 | 58 - K (Note) | 1 |
| 1, 2 ,3 | 48 - K (Note) | 1 |
| Note: K=10log(N) with N the number of terminals simultaneously transmitting at the same EIRP on a given carrier frequency in the same measurement bandwidth. K = 0 if only one NTN VSAT transmits at any one time on a given carrier frequency. See sub-clause 4.2.2.2.1 in [18] for mobile VSAT or sub-clause 4.2.4.2 in [19] for fixed VSAT. |

*<End of the change>*

*<Start of the change>*

## 9.6 Antenna performance and pointing accuracy

### 9.6.1 Antenna pointing accuracy

#### 9.6.1.1 Minimum requirement for Mobile VSAT

The following requirements are applicable to Mobile VSAT operating in band n512.

The applicant shall declare the peak pointing accuracy (δφ) and the associated statistical basis.

The antenna shall maintain the declared peak pointing accuracy (δφ), such that the off-axis EIRP emission density pattern projected onto the geostationary arc remains within the mask specified in clauses 9.2.2.2 and 9.2.2.3 when shifted by an angle of ±(δφ°), taking into account the following factors [EN 303 978]:

* the worst case operational environmental conditions;
* maximum ESOMP dynamics; and
* the range of latitude, longitude and altitude relative to the satellite orbital position.
* For linearly polarized ESOMPs, the following specification is required. The applicant shall declare the on-axis cross polarization isolation of the ESOMP [EN 303 978]:
* The polarization angle shall be continuously adjustable within the operational range as declared by the applicant.
* It shall be possible to fix the transmit antenna polarization angle with an accuracy of at least 1°.
* When linear polarization is used for both transmission and reception, the angle between the receive and corresponding transmit polarization planes shall not deviate by more than 1° from the nominal value declared by the applicant.

For circularly polarized ESOMPs, the applicant shall declare the voltage axial ratio.

#### 9.6.1.2 Minimum requirement for Fixed VSAT

The following requirements are applicable to Fixed VSAT operating in band n512.

The minimum requirements are defined in terms of a) pointing stability, b) pointing accuracy capability and c) polarization angle alignment capability for linear polarization, as follows:

a) Pointing stability: Under the condition of 100 km/h maximum wind speed, with gusts of 130 km/h lasting 3 seconds, the installation shall not show any sign of permanent distortion and shall not need repointing after the application of the wind load.

b) Pointing accuracy capability: The applicant shall declare the usage area in terms of the range of latitude and longitude relative to the satellite orbital position where the alignments specified below are possible. Two sets of specifications are further defined:

* Specification 1: Main beam pointing accuracy. The antenna sub-system alignment facilities shall enable the main beam axis to be adjusted and fixed with a pointing accuracy (δφ) of either:
	+ 1) 0,1º; or
	+ 2) a greater value declared by the applicant, subject to the following restrictions:
		- the pointing accuracy (δφ) shall not exceed 30 % of the antenna transmit main beam half power beamwidth;
		- the off-axis e.i.r.p. emission density pattern remains within the mask specified in clause 9.2.2.3 when shifted by an angle of ±(δφ - 0,1º).
* Specification 2: Alignment with the geostationary satellite orbit. For antennas with asymmetric main beam, the antenna shall be capable of having the plane defined by the antenna main beam axis and its major axis aligned with the tangent to the geostationary orbit in accordance with the method declared by the applicant.

c) Polarization angle alignment capability for linear polarization. Following conditions will apply:

- The polarization angle shall be continuously adjustable within the operational range as declared by the applicant.

- It shall be possible to fix the transmit antenna polarization angle with an accuracy of at least 1°.

- When linear polarization is used for both transmission and reception, the angle between the receive and corresponding transmit polarization planes shall not deviate by more than 1° from the nominal value declared by the applicant.

### 9.6.2 Antenna performance

The following requirements are applicable to NTN VSAT type 1, type 2, type 4 or type 5 operating in band n511 or in band n510.

The co-polarization gain in the plane tangent to the GSO arc shall not exceed the levels specified in Table 9.6.2-1. This envelope may be exceeded by up to 3 dB in 10% of the range of θ angles from ±7–180°, and by up to 6 dB in the region of main reflector spillover energy.

**Table 9.6.2-1: Co-polarization gain limit in the plane tangent to the GSO arc**

|  |  |
| --- | --- |
| θ value | Co-polarization gain (dBi) |
| 2° ≤ θ ≤ 7° | 29 – 25log(θ) |
| 7° ≤ θ ≤ 9.2° | 8 |
| 9.2° ≤ θ ≤ 19.1° | 32 – 25log(θ) |
| 19.1° < θ ≤ 180° | 0 |

The co-polarization gain in the plane perpendicular to the GSO arc shall not exceed the levels specified in Table 9.6.2-2. This envelope may be exceeded by up to 3 dB in 10% of the range of θ angles from ±7–180°, and by up to 6 dB in the region of main reflector spillover energy.

**Table 9.6.2-2: Co-polarization gain limit in the plane perpendicular to the GSO arc**

|  |  |
| --- | --- |
| θ value | Co-polarization gain (dBi) |
| 3.5° ≤ θ ≤ 7° | 32 – 25log(θ) |
| 7° ≤ θ ≤ 9.2° | 10.9 |
| 9.2° ≤ θ ≤ 19.1° | 35 – 25log(θ) |
| 19.1° < θ ≤ 180° | 3 |

The off-axis cross-polarization gain in the plane tangent and in the plane perpendicular to the GSO arc shall not exceed the levels specified in Table 9.6.2-3.

**Table 9.6.2-3: Cross-polarization gain limit**

|  |  |
| --- | --- |
| θ value | Co-polarization gain (dBi) |
| 2° ≤ θ ≤ 7° | 19 – 25log(θ) |

*<End of the change>*