**3GPP TSG-RAN4 Meeting #109 *R4-2321031***

**Chicago, United States, 13th Nov 2023 - 17th Nov 2023**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *CR-Form-v12.2* | | | | | | | | |
| **CHANGE REQUEST** | | | | | | | | |
|  | | | | | | | | |
|  | **38.108** | **CR** | **0047** | **rev** | **1** | **Current version:** | **18.0.0** |  |
|  | | | | | | | | |
| *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 |  | Radio Access Network | **X** | Core Network |  |

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|  | | | | | | | | | | |
| ***Title:*** | NTN enhancement: Running CR to TS 38.108 NTN Ka-band | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Source to WG:*** | Ericsson, Huawei, Thales, CATT | | | | | | | | | |
| ***Source to TSG:*** | R4 | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** | NR\_NTN\_enh-Core | | | | |  | ***Date:*** | | | 2023-11-03 |
|  |  | | | |  | |  | | |  |
| ***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 can be 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)* | |
|  |  | | | | | | | | | |
| ***Reason for change:*** | | This running big CR merges all endorsed draft CR in the scope of the NR\_NTN\_enh-Core WI. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Summary of change:*** | | Endorsed draft CRs:   * RAN4#108bis: R4-2316848, R4-2316853, R4-2316888, R4-2316889, R4-2316891 * RAN4#109: R4-2318300, R4-2319577, R4-2319578, R4-2319579, R4-2320153, R4-2321026, R4-2321030, R4-2321148, R4-2321151, R4-2321194 | | | | | | | | |
|  | |  | | | | | | | | |
| ***Consequences if not approved:*** | | FR2-NTN SAN will not be supported. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Clauses affected:*** | | 4.3, 4.6, 5.1, 5.2, 5.3, 5.4, 6.5.2.2, 9.2.1, 9.2.2, 9.2.3 (new), 9.3.1, 9.3.2, 9.3.3 (new), 9.4.3.3 (new), 9.6.1.2, 9.6.1.3 (new), 9.6.2.1, 9.6.2.2, 9.6.2.3 (new), 9.7.1, 9.7.2.2, 9.7.3.3 (new), 9.7.4.2, 9.7.4.3 (new), 9.7.5.2.1, 9.7.5.2.2, 9.7.5.3 (new), 10.1, 10.3.3 (new), 10.5.1.3 (new), Annex A, Annex E (new) | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **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 ... | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***This CR's revision history:*** | |  | | | | | | | | |

*<Start of the change>*

## 4.3 Requirement reference points

### 4.3.1 SAN type 1-H

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

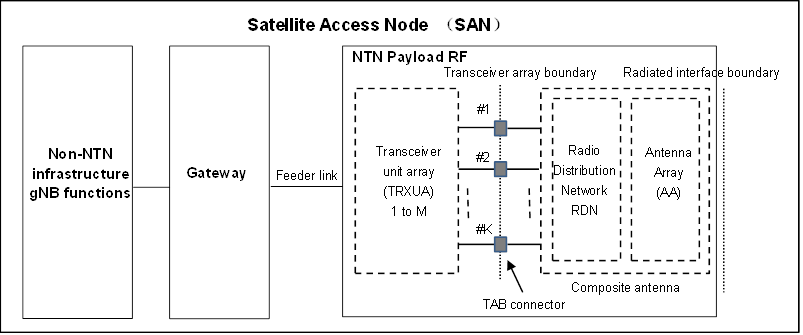


Figure 4.3.1-1: Radiated and conducted reference points for *SAN type 1-H*

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

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

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

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

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

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

### 4.3.2 SAN type 1-O and SAN type 2-O

For *SAN type 1-O* and *SAN type 2-O*, the radiated characteristics are defined over the air (OTA), where the *operating band* specific radiated interface is referred to as the *Radiated Interface Boundary* (RIB). Radiated requirements are also referred to as OTA requirements. The (spatial) characteristics in which the OTA requirements apply are detailed for each requirement.

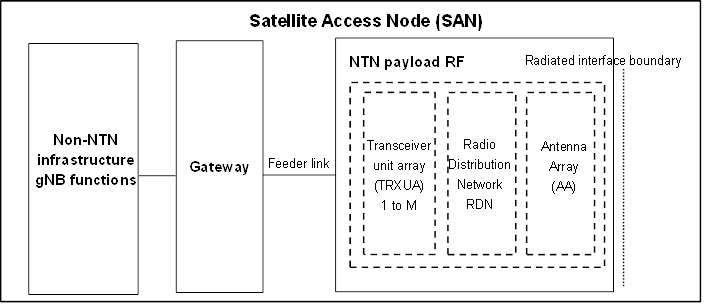


Figure 4.3.2-1: Radiated reference points for *SAN type 1-O* and *SAN type 2-O*

*<End of the change>*

*<Start of the change>*

## 4.6 Applicability of minimum requirements

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

Table 4.6-1: Requirement set applicability

|  |  |  |  |
| --- | --- | --- | --- |
| Requirement | Requirement set | | |
|  | *SAN type 1-H* | *SAN type 1-O* | *SAN type 2-O* |
| SAN output power | 6.2 |  |  |
| Output power dynamics | 6.3 |  |  |
| Transmit ON/OFF power | NA |  |  |
| Frequency error | 6.5.1 |  |  |
| Modulation quality | 6.5.2 |  |  |
| Time alignment error | NA |  |  |
| Occupied bandwidth | 6.6.2 |  |  |
| ACLR | 6.6.3 |  |  |
| Operating band unwanted emissions | 6.6.4 |  |  |
| Transmitter spurious emissions | 6.6.5 |  |  |
| Transmitter intermodulation | NA | NA | NA |
| Reference sensitivity level | 7.2 |  |  |
| Dynamic range | 7.3 |  |  |
| ACS | 7.4.1 |  |  |
| In-band blocking | NA |  |  |
| Out-of-band blocking | 7.5 |  |  |
| Receiver spurious emissions | NA |  |  |
| Receiver intermodulation | NA |  |  |
| In-channel selectivity | 7.8 |  |  |
| Performance requirements | 8 |  |  |
| Radiated transmit power | 9.2 | 9.2 | 9.2 |
| OTA SAN output power |  | 9.3 | 9.3 |
| OTA output power dynamics |  | 9.4 | 9.4 |
| OTA transmit ON/OFF power |  | NA | NA |
| OTA frequency error |  | 9.6.1 | 9.6.1 |
| OTA modulation quality |  | 9.6.2 | 9.6.2 |
| OTA time alignment error |  | NA | NA |
| OTA occupied bandwidth |  | 9.7.2 | 9.7.2 |
| OTA ACLR | NA | 9.7.3 | 9.7.3 |
| OTA out-of-band emission |  | 9.7.4 | 9.7.4 |
| OTA transmitter spurious emission |  | 9.7.5 | 9.7.5 |
| OTA transmitter intermodulation |  | NA | NA |
| OTA sensitivity | 10.2 | 10.2 | 10.2 |
| OTA reference sensitivity level |  | 10.3 | 10.3 |
| OTA dynamic range |  | 10.4 | NA |
| OTA ACS |  | 10.5.1 | 10.5.1 |
| OTA in-band blocking |  | NA | NA |
| OTA out-of-band blocking | NA | 10.6 | 10.6 |
| OTA receiver spurious emission |  | NA | NA |
| OTA receiver intermodulation |  | NA | NA |
| OTA in-channel selectivity |  | 10.9 | 10.9 |
| Radiated performance requirements |  | 11 | 11 |

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

*<End of the change>*

*<Start of the change>*

## 5.1 General

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

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

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

Table 5.1-1: Definition of NTN frequency ranges

|  |  |
| --- | --- |
| Frequency range designation | Corresponding frequency range |
| FR1-NTN1 | 410 MHz – 7125 MHz |
| FR2-NTN2 | 17300 MHz – 30000 MHz |
| NOTE 1: [NTN bands within this frequency range are regarded as a FR1 band when references from other specifications.]  NOTE 2: [NTN bands within this frequency range are regarded as a FR2 band when references from other specifications.] | |

## 5.2 Operating bands

Satellite is designed to operate in the *operating bands* defined in table 5.2-1 and 5.2-2.

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

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

Table 5.2-2: Satellite *operating bands* in FR2-NTN

|  |  |  |  |
| --- | --- | --- | --- |
| **Satellite *operating band*** | Uplink (UL) *operating band* SAN receive / UE transmit  **FUL,low – FUL,high** | Downlink (DL) *operating band* SAN transmit / UE receive  **FDL,low – FDL,high** | **Duplex mode** |
| n5121 | 27500 MHz - 30000 MHz | 17300 MHz - 20200 MHz | FDD |
| n5112 | 28350 MHz - 30000 MHz | 17300 MHz - 20200 MHz | FDD |
| n5103 | 27500 MHz - 28350 MHz | 17300 MHz - 20200 MHz | FDD |
| NOTE 1: This band is applicable in the countries subject to CEPT ECC Decision(05)01 and ECC Decision (13)01.  NOTE 2: This band is applicable in the USA subject to FCC 47 CFR part 25.  NOTE 3: This band is applicable for Earth Station operations in the USA subject to FCC 47 CFR part 25. FCC rules currently do not include ESIM operations in this band (47 CFR 25.202). | | | |

## 5.3 Satellite Access Node channel bandwidth

### 5.3.1 General

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

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

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

### 5.3.2 Transmission bandwidth configuration

The *transmission bandwidth configuration* NRB for each *SAN channel bandwidth* and subcarrier spacing is specified in table 5.3.2.-1 for FR1-NTN and table 5.3.2-2 for FR2-NTN.

Table 5.3.2-1: Transmission bandwidth configuration NRB for FR1-NTN

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| SCS (kHz) | 5 MHz | 10 MHz | 15 MHz | 20 MHz | 30 MHz |
| **NRB** | **NRB** | **NRB** | **NRB** | **NRB** |
| 15 | 25 | 52 | 79 | 106 | 160 |
| 30 | 11 | 24 | 38 | 51 | 78 |
| 60 | N/A | 11 | 18 | 24 | 38 |

Table 5.3.2-2: Transmission bandwidth configuration NRB for FR2-NTN

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SCS (kHz) | 50 MHz | 100 MHz | 200 MHz | 400 MHz |
|  | NRB | NRB | NRB | NRB |
| 60 | 66 | 132 | 264 | N/A |
| 120 | 32 | 66 | 132 | 264 |

NOTE: All Tx and Rx requirements are defined based on *transmission bandwidth configuration* specified in table 5.3.2-1 for FR1-NTN and table 5.3.2-2 for FR2-NTN.

### 5.3.3 Minimum guardband and transmission bandwidth configuration

The minimum guard band for each *SAN channel bandwidth* and SCS is specified in table 5.3.3-1 for FR1-NTN and in table 5.3.3-2 for FR2-NTN.

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

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| SCS (kHz) | 5 MHz | 10 MHz | 15 MHz | 20 MHz | 30 MHz |
| 15 | 242.5 | 312.5 | 382.5 | 452.5 | 592.5 |
| 30 | 505 | 665 | 645 | 805 | 945 |
| 60 | N/A | 1010 | 990 | 1330 | 1290 |

Table 5.3.3-2: Minimum guardband (kHz) (FR2-NTN)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SCS (kHz) | 50 MHz | 100 MHz | 200 MHz | 400 MHz |
| 60 | 1210 | 2450 | 4930 | N/A |
| 120 | 1900 | 2420 | 4900 | 9860 |

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



Figure 5.3.3-1: SAN PRB utilization

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



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

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

### 5.3.4 RB alignment

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

For each numerology, its common resource blocks are specified in clause 4.4.4.3 in TS 38.211 [5], and the starting point of its *transmission bandwidth configuration* on the common resource block grid for a given channel bandwidth is indicated by an offset to “Reference point A” in the unit of the numerology.

For each numerology, all *UE transmission bandwidth configurations* indicated to UEs served by the SAN by higher layer parameter *carrierBandwidth* defined in TS 38.331 [6] shall fall within the *SAN transmission bandwidth configuration*.

### 5.3.5 SAN channel bandwidth per operating band

The requirements in this specification apply to the combination of *SAN channel bandwidths*, SCS and *operating bands* shown in table 5.3.5-1 for FR1-NTN and table 5.3.5-2 for FR2-NTN. The *transmission bandwidth configuration* in table 5.3.2-1 and table 5.3.2-2 shall be supported for each of the *SAN channel bandwidths* within the SAN capability. The *SAN channel bandwidths* are specified for both the Tx and Rx path.

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

| SAN Operating Band | SCS (kHz) | *SAN channel bandwidth* (MHz) | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| 5 | 10 | 15 | 20 | 30  (NOTE) |
|  | 15 | 5 | 10 | 15 | 20 |  |
| n256 | 30 |  | 10 | 15 | 20 |  |
|  | 60 |  | 10 | 15 | 20 |  |
|  | 15 | 5 | 10 | 15 | 20 |  |
| n255 | 30 |  | 10 | 15 | 20 |  |
|  | 60 |  | 10 | 15 | 20 |  |
| NOTE: Deployment of 30 MHz channel bandwidth for NTN SAN needs to be preceded by introduction of all applicable Tx RF, Rx RF, and demodulation requirements. | | | | | | |

Table 5.3.5-2: *SAN channel bandwidths* and SCS per *operating band* in FR2-NTN

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| SAN Operating Band | SCS (kHz) | *SAN channel bandwidth* (MHz) | | | |
| 50 | 100 | 200 | 400 |
| n512 | 60 | 50 | 100 | 200 |  |
|  | 120 | 50 | 100 | 200 | 400 |
| n511 | 60 | 50 | 100 | 200 |  |
|  | 120 | 50 | 100 | 200 | 400 |
| n510 | 60 | 50 | 100 | 200 |  |
|  | 120 | 50 | 100 | 200 | 400 |

## 5.4 Channel arrangement

### 5.4.1 Channel spacing

#### 5.4.1.1 Channel spacing for adjacent carriers

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

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

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

- For SAN FR2-NTN *operating bands* with 60 kHz channel raster,

▪ Nominal Channel spacing = (BWChannel(1) + BWChannel(2))/2 + {-20 kHz, 0 kHz, 20 kHz} for ∆FRaster equals to 60 kHz

▪ Nominal Channel spacing = (BWChannel(1) + BWChannel(2))/2 + {-40 kHz, 0 kHz, 40 kHz} for ∆FRaster equals to 120 kHz

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

### 5.4.2 Channel raster

#### 5.4.2.1 NR-ARFCN and channel raster

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

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

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

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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Range of frequencies (MHz) | ΔFGlobal (kHz) | FREF-Offs (MHz) | NREF-Offs | Range of NREF |
| 0 – 3000 | 5 | 0 | 0 | 0 – 599999 |
| 3000 – 24250 | 15 | 3000 | 600000 | 600000 – 2016666 |
| 24250 – 30000 | 60 | 24250.08 | 2016667 | 2016667 – 2112499 |

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

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

#### 5.4.2.2 Channel raster to resource element mapping

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

Table 5.4.2.2-1: Channel Raster to Resource Element Mapping

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

k,  and NRB are as defined in TS 38.211 [5].

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

The RF channel positions on the channel raster in each SAN *operating band* are given through the applicable NR-ARFCN in table 5.4.2.3-1 for FR1-NTN and table 5.4.2.3-2 for FR2-NTN, using the channel raster to resource element mapping in clause 5.4.2.2.

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

For SAN *operating bands* with 60 kHz channel raster above 3 GHz, ΔFRaster = *I* ×ΔFGlobal, where *I* ϵ {4, 8}. In this case, every *Ith* 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 5.4.2.3-2 is given as <*I*>.

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

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

Table 5.4.2.3-2: Applicable NR-ARFCN per *operating band* in FR2-NTN

|  |  |  |  |
| --- | --- | --- | --- |
| SAN operating band | ΔFRaster  (kHz) | Uplink  range of NREF  (First – <Step size> – Last) | Downlink  range of NREF  (First – <Step size> – Last) |
| n512 | 60 | 2070833 – <1> – 2112499 | 1553336 – <4> – 1746664 |
| 120 | 2070833 – <2> – 2112499 | 1553336 – <8> – 1746664 |
| n511 | 60 | 2084999 – <1> –2112499 | 1553336 – <4> – 1746664 |
| 120 | 2084999 – <2> –2112499 | 1553336 – <8> – 1746664 |
| n510 | 60 | 2070833 – <1> – 2084999 | 1553336 – <4> – 1746664 |
| 120 | 2070833 – <2> – 2084999 | 1553336 – <8> – 1746664 |

### 5.4.3 Synchronization raster

#### 5.4.3.1 Synchronization raster and numbering

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

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

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

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

|  |  |  |  |
| --- | --- | --- | --- |
| Range of frequencies (MHz) | SS block frequency position SSREF | GSCN | Range of GSCN |
| 0 – 3000 | N \* 1200 kHz + M \* 50 kHz,  N = 1:2499, M ϵ {1,3,5} (Note) | 3N + (M-3)/2 | 2 – 7498 |
| 3000 – 24250 | 3000 MHz + N \* 1.44 MHz,  N = 0:14756 | 7499 + N | 7499 – 22255 |
| NOTE: The default value for *operating bands* which only support SCS spaced channel raster(s) is M=3. | | | |

#### 5.4.3.2 Synchronization raster to synchronization block resource element mapping

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

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

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

*k* is the subcarrier number of SS/PBCH block defined in TS 38.211 clause 7.4.3.1 [5].

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

The synchronization raster for each band is given in table 5.4.3.3-1 and table 5.4.3.3-2. The distance between applicable GSCN entries is given by the <Step size> indicated in table 5.4.3.3-1 for FR1-NTN and table 5.4.3.3-2 for FR2-NTN.

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

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

Table 5.4.3.3-2: Applicable SS raster entries per *operating band* (FR2-NTN)

|  |  |  |  |
| --- | --- | --- | --- |
| **SAN operating band** | **SS Block SCS** | **SS Block pattern (NOTE)** | Range of GSCN  **(First – <Step size> – Last)** |
| n512 | 120 kHz | Case D | 17448 – <12> – 19428 |
|  | 240 kHz | Case E | 17472 – <24> – 19416 |
| n511 | 120 kHz | Case D | 17448 – <12> – 19428 |
|  | 240 kHz | Case E | 17472 – <24> – 19416 |
| n510 | 120 kHz | Case D | 17448 – <12> – 19428 |
|  | 240 kHz | Case E | 17472 – <24> – 19416 |
| NOTE: SS Block pattern is defined in section 4.1 in TS 38.213 [7]. | | | |

*<End of the change>*

*<Start of the change>*

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

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

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

|  |  |
| --- | --- |
| Modulation scheme for PDSCH | Required EVM |
| QPSK | 17.5 % |
| 16QAM | 12.5 % |
| 64QAM | 8 % |

*<End of the change>*

*<Start of the change>*

## 9.2 Radiated transmit power

### 9.2.1 General

*SAN type 1-H, SAN type 1-O* and *SAN type 2-O* are declared to support one or more beams, as per manufacturer's declarations specified in TS 38.181 [3]. Radiated transmit power is defined as the EIRP level for a declared beam at a specific *beam peak direction*.

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

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

For each *beam peak direction* associated with a *beam direction pair* within the *OTA peak directions set*, a specific *rated beam EIRP* level may be claimed. Any claimed value shall be met within the accuracy requirement as described below. *Rated beam EIRP* is only required to be declared for the *beam direction pairs* subject to conformance testing as detailed in TS 38.181 [3].

NOTE 1: *OTA peak directions set* is set of *beam peak directions* for which the EIRP accuracy requirement is intended to be met. The *beam peak directions* are related to a corresponding contiguous range or discrete list of *beam centre directions* by the *beam direction pairs* included in the set.

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

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

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

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

Normal conditions are defined in TS 38.181, annex B [3].

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

### 9.2.3 Minimum requirement for *SAN type 2-O*

For each declared beam, in normal conditions, for any specific *beam peak direction* associated with a *beam direction pair* within the *OTA peak directions set*, a manufacturer claimed EIRP level in the corresponding *beam peak direction* shall be achievable to within ± 3.4 dB of the claimed value.

Normal conditions are defined in TS 38.181, annex B [3].

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

## 9.3 OTA Satellite Access Node output power

### 9.3.1 General

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

The SAN *rated carrier TRP output power* for *SAN type 1-O and SAN type 2-O* shall be based on manufacturer declaration.

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

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

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

Normal conditions are defined in TS 38.181, annex B [3].

### 9.3.3 Minimum requirement for *SAN type 2-O*

In normal conditions, the *SAN type 2-O* *maximum carrier TRP output power*, Pmax,c,TRP measured at the RIB shall remain within ±3 dB of the *rated carrier TRP output power* Prated,c,TRP, as declared by the manufacturer.

Normal conditions are defined in TS 38.181, annex B [3].

*<End of the change>*

*<Start of the change>*

## 9.4 OTA output power dynamics

### 9.4.1 General

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

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

### 9.4.2 OTA RE power control dynamic range

#### 9.4.2.1 General

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

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

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

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

### 9.4.3 OTA total power dynamic range

#### 9.4.3.1 General

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

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

NOTE 1: The upper limit of the dynamic range is the OFDM symbol power for a SAN at maximum output power. The lower limit of the dynamic range is the OFDM symbol power for a SAN when one resource block is transmitted.

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

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

#### 9.4.3.3 Minimum requirement for *BS type 2-O*

OTA total power dynamic range minimum requirement for SAN *type 2-O* is specified such as for each NR carrier it shall be larger than or equal to the levels specified in table 9.4.3.3-1 in FR2-NTN.

**Table 9.4.3.3-1: Minimum requirement for SAN type 2-O total power dynamic range in FR2-NTN**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SCS** | **OTA total power dynamic range (dB)** | | | |
| **(kHz)** | 50 MHz | 100 MHz | 200 MHz | 400 MHz |
| 60 | 18.1 | 21.2 | 24.2 | N/A |
| 120 | 15.0 | 18.1 | 21.2 | 24.2 |

*<End of the change>*

*<Start of the change>*

## 9.6 OTA transmitted signal quality

### 9.6.1 OTA frequency error

#### 9.6.1.1 General

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

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

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

For *SAN type 1-O*, the modulated carrier frequency of each carrier configured by the SAN shall be accurate to within 0.05 ppm observed over 1 ms.

#### 9.6.1.3 Minimum requirement for *SAN type 2-O*

For *SAN type 2-O*, the modulated carrier frequency of each carrier configured by the SAN shall be accurate to within 0.05 ppm observed over 1 ms.

### 9.6.2 OTA modulation quality

#### 9.6.2.1 General

Modulation quality is defined by the difference between the measured carrier signal and an ideal signal. Modulation quality can e.g. be expressed as Error Vector Magnitude (EVM). Details about how the EVM is determined are specified in annex B for FR1-NTN and annex E for FR2-NTN..

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

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

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

#### 9.6.2.3 Minimum requirement for *SAN type 2-O*

For *SAN type 2-O*, the EVM levels of each carrier for different modulation schemes on PDSCH outlined in table 9.6.2.3-1 shall be met.

Table 9.6.2.3-1: EVM requirements for *SAN type 2-O* carrier

|  |  |  |
| --- | --- | --- |
| Applicability | Modulation scheme for PDSCH | Required EVM (%) |
| FR2-NTN | QPSK | 17.5 |
| FR2-NTN | 16QAM | 12.5 |
| FR2-NTN | 64QAM | 8 |

##### 9.6.2.3.1 EVM frame structure for measurement

EVM requirements shall apply for each carrier over all allocated resource blocks. Different modulation schemes listed in table 9.6.2.3-1 shall be considered for rank 1.

*<End of the change>*

*<Start of the change>*

## 9.7 OTA unwanted emissions

### 9.7.1 General

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

The OTA out-of-band emissions requirement for the *SAN type 1-O* is specified both in terms of Adjacent Channel Leakage power Ratio (ACLR) and out-of-band emissions (OOBE). The unwanted emission requirements are applied per cell for all the configurations. Requirements for OTA unwanted emissions are captured as TRP requirements or *directional requirements*, as described per requirement.

There is in addition a requirement for occupied bandwidth.

### 9.7.2 OTA occupied bandwidth

#### 9.7.2.1 General

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

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

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

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

#### 9.7.2.2 Minimum requirement for *SAN type 1-O* and *SAN type 2-O*

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

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

#### 9.7.3.1 General

OTA Adjacent Channel Leakage power Ratio (ACLR) is the ratio of the filtered mean power centred on the assigned channel frequency to the filtered mean power centred on an adjacent channel frequency. The measured power is TRP.

The requirement shall be applied per RIB.

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

The ACLR limit specified in tables 6.6.3.2-1 for SAN GEO class and 6.6.3.2-2 for SAN LEO class shall apply.

For a RIB operating in multi-carrier, the ACLR requirements in clause 6.6.3.2 shall apply to SAN channel bandwidths of the outermost carrier for the frequency ranges defined in tables 6.6.3.2-1 and 6.6.3.2-2.

9.7.3.3 Minimum requirement for *SAN type 2-O*

The ACLR limit specified in tables 9.7.3.3-1 for SAN GEO class and 9.7.3.3-2 for SAN LEO class shall apply.

For a RIB operating in multi-carrier, the ACLR requirements in clause 9.7.3.3 shall apply to SAN channel bandwidths of the outermost carrier for the frequency ranges defined in tables 9.7.3.3-1 and 9.7.3.3-2.

Table 9.7.3.3-1: *SAN type 2-O* ACLR limit for SAN GEO class

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *SAN channel bandwidth* of *lowest/highest carrier* transmitted  BWChannel (MHz) | SAN adjacent channel centre frequency offset below the *lowest* or above the *highest carrier* centre frequency transmitted | Assumed adjacent channel carrier | Filter on the adjacent channel frequency and corresponding filter bandwidth | ACLR limit  (dB) |
| 50, 100, 200, 400 | BWChannel | NR of same BW (Note 2) | Square (BWConfig) | [12] |
| NOTE 1: BWChannel and BWConfig are the *BS channel bandwidth* and *transmission bandwidth configuration* of the *lowest/highest carrier* transmitted on the assigned channel frequency.  NOTE 2: With SCS that provides largest *transmission bandwidth configuration* (BWConfig). | | | | |

Table 9.7.3.3-2: *SAN type 2-O* ACLR limit for SAN LEO class

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *SAN channel bandwidth* of *lowest/highest carrier* transmitted  BWChannel (MHz) | SAN adjacent channel centre frequency offset below the *lowest* or above the *highest carrier* centre frequency transmitted | Assumed adjacent channel carrier | Filter on the adjacent channel frequency and corresponding filter bandwidth | ACLR limit  (dB) |
| 50, 100, 200, 400 | BWChannel | NR of same BW (Note 2) | Square (BWConfig) | [12] |
| NOTE 1: BWChannel and BWConfig are the *BS channel bandwidth* and *transmission bandwidth configuration* of the *lowest/highest carrier* transmitted on the assigned channel frequency.  NOTE 2: With SCS that provides largest *transmission bandwidth configuration* (BWConfig). | | | | |

### 9.7.4 OTA out-of-band emissions

#### 9.7.4.1 General

The OTA limits for out-of-band emissions are specified as TRP per RIB unless otherwise stated.

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

Out-of-band emissions in FR1-NTN are limited by OTA out-of-band emission limits. Unless otherwise stated, the out-of-band emission limits in FR1-NTN are defined from channel edge up to frequencies separated from the channel edge by 200% of the necessary bandwidth. The requirements shall apply whatever the type of transmitter considered and for all transmission modes foreseen by the manufacturer's specification. For a RIB operating in multi-carrier, the requirements apply to SAN channel bandwidths of the outermost carrier for the frequency ranges defined in clause 6.6.4.1.

The OTA out-of-band emissions requirement for SAN type 1-O shall not exceed each applicable limit in clause 6.6.4.2.

9.7.4.3 Minimum requirement for *SAN type 2-O*

Out-of-band emissions in FR2-NTN are limited by OTA out-of-band emission limits. Unless otherwise stated, the out-of-band emission limits in FR2-NTN are defined from channel edge up to frequencies separated from the channel edge by 200% of the necessary bandwidth. The requirements shall apply whatever the type of transmitter considered and for all transmission modes foreseen by the manufacturer's specification. For a RIB operating in multi-carrier, the requirements apply to SAN channel bandwidths of the outermost carrier for the frequency ranges defined in clause 6.6.4.1.

The OTA out-of-band emissions requirement for SAN type 2-O shall not exceed each applicable limit in clause 6.6.4.2.

### 9.7.5 OTA transmitter spurious emissions

#### 9.7.5.1 General

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

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

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

##### 9.7.5.2.1 General

The OTA transmitter spurious emission limits for FR1-NTN shall apply from 30 MHz to the 5th harmonic of the upper frequency edge of the DL operating band, excluding the *SAN transponder bandwidth* BWSAN and the frequency range where the out-of-band emissions apply.

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

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

The *basic limits* of table 9.7.5.2.2-1 shall apply. The application of those limits shall be the same as for operating band unwanted emissions in clause 6.6.4.

Table 9.7.5.2.2-1: General SAN transmitter spurious emission limits in FR1-NTN

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

##### 9.7.5.2.3 Protection of the SAN receiver

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

##### 9.7.5.2.4 Additional spurious emissions requirements

The additional spurious emissions requirement is not applicable for SAN.

9.7.5.3 Minimum requirement for *SAN type 2-O*

9.7.5.3.1 General

The OTA transmitter spurious emission limits for FR2-NTN shall apply from 30 MHz to the 2nd harmonic of the upper frequency edge of the DL operating band, excluding the *SAN transponder bandwidth* BWSAN and the frequency range where the out-of-band emissions apply.

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

9.7.5.3.2 General OTA transmitter spurious emissions requirements

The *basic limits* of table 9.7.5.3.2-1 shall apply. The application of those limits shall be the same as for operating band unwanted emissions in clause 9.7.4.3.

**Table 9.7.5.3.2-1: General radiated SAN transmitter spurious emission limits in FR2-NTN**

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

9.7.5.3.3 Protection of the SAN receiver

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

9.7.5.3.4 Additional spurious emissions requirements

The additional spurious emissions requirement is not applicable for SAN.

*<End of the change>*

*<Start of the change>*

# 10 Radiated receiver characteristics

## 10.1 General

Radiated receiver characteristics are specified at RIB for *SAN type 1-H or* *SAN type 1-O or SAN type 2-O*, with full complement of transceivers for the configuration in normal operating condition.

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

- Requirements shall be met for any transmitter setting.

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

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

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

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

- Each requirement shall be met over the RoAoA specified.

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

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

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

and

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

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

ΔminSENS = PREFSENS – EISminSENS (dB)

For FR2-NTN requirements which are to be met over the *OTA REFSENS RoAoA* absolute requirement values are offset by the following term:

ΔFR2\_REFSENS = -3 dB for the reference direction

and

ΔFR2\_REFSENS = 0 dB for all other directions

*<End of the change>*

*<Start of the change>*

### 10.3.3 Minimum requirement for *SAN type 2-O*

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

EISREFSENS levels are derived from a single declared basis level EISREFSENS\_50M, which is based on a reference measurement channel with 50 MHz *SAN channel bandwidth*. EISREFSENS\_50M itself is not a requirement and although it is based on a reference measurement channel with 50 MHz *SAN channel bandwidth* it does not imply that SAN has to support 50 MHz *SAN channel bandwidth*.

For GEO class SAN, EISREFSENS\_50M is an integer value in the range [-140] to [-149] dBm. The specific value is declared by the vendor.

For LEO class SAN, EISREFSENS\_50M is an integer value in the range [-120] to [-129] dBm. The specific value is declared by the vendor.

Table 10.3.3-1: FR2-NTN OTA reference sensitivity requirement

|  |  |  |  |
| --- | --- | --- | --- |
| SAN channel Bandwidth  (MHz) | Sub-carrier spacing (kHz) | Reference measurement channel | OTA reference sensitivity level, EISREFSENS (dBm) |
| 50, 100, 200 | 60 | G-FR2-A1-1 | EISREFSENS\_50M + ΔFR2\_REFSENS |
| 50 | 120 | G-FR2-A1-2 | EISREFSENS\_50M + ΔFR2\_REFSENS |
| 100, 200, 400 | 120 | G-FR2-A1-3 | EISREFSENS\_50M + 3+ ΔFR2\_REFSENS |
| NOTE 1: EISREFSENS is the power level of a single instance of the reference measurement channel. This requirement shall be met for each consecutive application of a single instance of the reference measurement channel mapped to disjoint frequency ranges with a width corresponding to the number of resource blocks of the reference measurement channel each, except for one instance that might overlap one other instance to cover the full *SAN channel bandwidth*.  NOTE 2: The declared EISREFSENS\_50M shall be within the range specified above. | | | |

*<End of the change>*

*<Start of the change>*

#### 10.5.1.3 Minimum requirement for *SAN type 2-O*

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

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

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

For FR2-NTN, the OTA wanted and the interfering signal are specified in table 10.5.1.3-1 and table 10.5.1.3-2 for OTA ACS. The reference measurement channel for the OTA wanted signal is further specified in annex A.1. The characteristics of the interfering signal is further specified in annex D.

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

For RIBs supporting operation in *non-contiguous spectrum* within any *operating band*, the OTA ACS requirement shall apply in addition inside any *sub-block gap*, in case the *sub-block gap* size is at least as wide as the NR interfering signal in table 10.5.1.3-2. The OTA interfering signal offset is defined relative to the *sub-block* edges inside the *sub-block gap*.

Table 10.5.1.3-1: OTA ACS requirement for SAN *type 2-O*

|  |  |  |
| --- | --- | --- |
| *SAN channel bandwidth* of the *lowest/highest carrier* received (MHz) | Wanted signal mean power (dBm) | Interfering signal mean power (dBm) |
| 50, 100, 200, 400 | EISREFSENS + 6 dB (Note 3) | SAN LEO class,EISREFSENS\_50M + 27.7+ ΔFR2\_REFSENS  SAN GEO class,EISREFSENS\_50M + 21.7 + ΔFR2\_REFSENS |
| NOTE 3: EISREFSENS is given in clause 10.3.3 | | |

Table 10.5.1.3-2: OTA ACS interferer frequency offset for SAN *type 2-O*

|  |  |  |
| --- | --- | --- |
| *SAN channel bandwidth* of the *lowest/highest carrier* received (MHz) | Interfering signal centre frequency offset from the lower/upper *SAN RF Bandwidth* *edge* or sub*-block edge* inside a *sub-block gap* (MHz) | Type of interfering signal |
| 50 | ±24.29 |  |
| 100 | ±24.31 | 50 MHz DFT-s-OFDM NR |
| 200 | ±24.29 | signal,60 kHz SCS, 64 RBs |
| 400 | ±24.31 |  |

*<End of the change>*

*<Start of the change>*

*<End of the change>*

*<Start of the change>*

# Annex A (normative): Reference measurement channels

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

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

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

FR2-NTN parameters for the reference measurement channels are specified in table A.1-2.

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

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Reference channel | G-FR1-A1-1 | G-FR1-A1-2 | G-FR1-A1-3 | G-FR1-A1-4 | G-FR1-A1-5 | G-FR1-A1-6 | G-FR1-A1-7 | G-FR1-A1-8 | G-FR1-A1-9 |
| Subcarrier spacing (kHz) | 15 | 30 | 60 | 15 | 30 | 60 | 15 | 30 | 60 |
| Allocated resource blocks | 25 | 11 | 11 | 106 | 51 | 24 | 15 | 6 | 6 |
| CP-OFDM Symbols per slot (Note 1) | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| Modulation | QPSK | QPSK | QPSK | QPSK | QPSK | QPSK | QPSK | QPSK | QPSK |
| Code rate (Note 2) | 1/3 | 1/3 | 1/3 | 1/3 | 1/3 | 1/3 | 1/3 | 1/3 | 1/3 |
| Payload size (bits) | 2152 | 984 | 984 | 9224 | 4352 | 2088 | 1320 | 528 | 528 |
| Transport block CRC (bits) | 16 | 16 | 16 | 24 | 24 | 16 | 16 | 16 | 16 |
| Code block CRC size (bits) | - | - | - | 24 | - | - | - | - | - |
| Number of code blocks - C | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 |
| Code block size including CRC (bits) (Note 3) | 2168 | 1000 | 1000 | 4648 | 4376 | 2104 | 1336 | 544 | 544 |
| Total number of bits per slot | 7200 | 3168 | 3168 | 30528 | 14688 | 6912 | 4320 | 1728 | 1728 |
| Total symbols per slot | 3600 | 1584 | 1584 | 15264 | 7344 | 3456 | 2160 | 864 | 864 |
| NOTE 1: *UL-DMRS-config-type* = 1 with *UL-DMRS-max-len* = 1, *UL-DMRS-add-pos* = 1 with *l0*= 2, *l* = 11 as per table 6.4.1.1.3-3 of TS 38.211 [5].  NOTE 2: MCS index 4 and target coding rate = 308/1024 are adopted to calculate payload size for receiver sensitivity and in-channel selectivity.  NOTE 3: Code block size including CRC (bits) equals to *K'* in clause 5.2.2 of TS 38.212 [10]. | | | | | | | | | |

Table A.1-2: Fixed Reference Channels for SAN Rx requirements, FR2-NTN

|  |  |  |  |
| --- | --- | --- | --- |
| **Reference channel** | **G-FR2-A1-1** | **G-FR2-A1-2** | **G-FR2-A1-3** |
| Subcarrier spacing (kHz) | 60 | 120 | 120 |
| Allocated resource blocks | 66 | 32 | 66 |
| CP-OFDM Symbols per slot (Note 1) | 12 | 12 | 12 |
| Modulation | QPSK | QPSK | QPSK |
| Code rate (Note 2) | 1/3 | 1/3 | 1/3 |
| Payload size (bits) | 5632 | 2792 | 5632 |
| Transport block CRC (bits) | 24 | 16 | 24 |
| Code block CRC size (bits) | - | - | - |
| Number of code blocks - C | 1 | 1 | 1 |
| Code block size including CRC (bits) (Note 3) | 5656 | 2808 | 5656 |
| Total number of bits per slot | 19008 | 9216 | 19008 |
| Total symbols per slot | 9504 | 4608 | 9504 |
| NOTE 1: DM-RS configuration type = 1 with DM-RS duration = single-symbol DM-RS, additional DM-RS position = pos1 with *l0* = 2, *l* = 11 as per table 6.4.1.1.3-3 of TS 38.211 [x].  NOTE 2: MCS index 4 and target coding rate = 308/1024 are adopted to calculate payload size.  NOTE 3: Code block size including CRC (bits) equals to *K'* in clause 5.2.2 of TS 38.212 [x]. | | | |

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

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

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

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Reference channel | G-FR1-A2-1 | G-FR1-A2-2 | G-FR1-A2-3 | G-FR1-A2-4 | G-FR1-A2-5 | G-FR1-A2-6 |
| Subcarrier spacing (kHz) | 15 | 30 | 60 | 15 | 30 | 60 |
| Allocated resource blocks | 25 | 11 | 11 | 106 | 51 | 24 |
| CP-OFDM Symbols per slot (Note 1) | 12 | 12 | 12 | 12 | 12 | 12 |
| Modulation | 16QAM | 16QAM | 16QAM | 16QAM | 16QAM | 16QAM |
| Code rate (Note 2) | 2/3 | 2/3 | 2/3 | 2/3 | 2/3 | 2/3 |
| Payload size (bits) | 9224 | 4032 | 4032 | 38936 | 18960 | 8968 |
| Transport block CRC (bits) | 24 | 24 | 24 | 24 | 24 | 24 |
| Code block CRC size (bits) | 24 | - | - | 24 | 24 | 24 |
| Number of code blocks – C | 2 | 1 | 1 | 5 | 3 | 2 |
| Code block size including CRC (bits) (Note 3) | 4648 | 4056 | 4056 | 7816 | 6352 | 4520 |
| Total number of bits per slot | 14400 | 6336 | 6336 | 61056 | 29376 | 13824 |
| Total symbols per slot | 3600 | 1584 | 1584 | 15264 | 7344 | 3456 |
| NOTE 1: DM-RS configuration type = 1 with DM-RS duration = single-symbol DM-RS, additional DM-RS position = pos1 with *l0*= 2, *l* = 11 as per table 6.4.1.1.3-3 of TS 38.211 [5].  NOTE 2: MCS index 16 and target coding rate = 658/1024 are adopted to calculate payload size.  NOTE 3: Code block size including CRC (bits) equals to *K'* in clause 5.2.2 of TS 38.212 [10]. | | | | | | |

# A.3 Fixed Reference Channels for performance requirements (QPSK, R=308/1024)

The parameters for the reference measurement channel are specified in table A.3-1 for FR1-NTN PUSCH performance requirements:

- FRC parameters are specified in table A.3-1 for FR1-NTN PUSCH with transform precoding disabled, additional DM-RS position = pos0 and 1 transmission layer.

- FRC parameters are specified in table A.3-2 for FR1-NTN PUSCH with transform precoding enabled, additional DM-RS position = pos0 and 1 transmission layer.

Table A.3-1: FRC parameters for FR1-NTN PUSCH performance requirements, transform precoding disabled, additional DM-RS position = pos1 and 1 transmission layer (QPSK, R=308/1024)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Reference channel | G-FR1-A3-1 | G-FR1-A3-2 | G-FR1-A3-3 | G-FR1-A3-4 |
| Subcarrier spacing (kHz) | 15 | 15 | 30 | 30 |
| Allocated resource blocks | 25 | 12 | 24 | 12 |
| Data bearing CP-OFDM Symbols per slot (Note 1) | 12 | 12 | 12 | 12 |
| Modulation | QPSK | QPSK | QPSK | QPSK |
| Code rate (Note 2) | 308/1024 | 308/1024 | 308/1024 | 308/1024 |
| Payload size (bits) | 2152 | 1032 | 2024 | 1032 |
| Transport block CRC (bits) | 16 | 16 | 16 | 16 |
| Code block CRC size (bits) | - | - | - | - |
| Number of code blocks - C | 1 | 1 | 1 | 1 |
| Code block size including CRC (bits) (Note 2) | 2168 | 1048 | 2040 | 1048 |
| Total number of bits per slot | 7200 | 3456 | 6912 | 3456 |
| Total resource elements per slot | 3600 | 1728 | 3456 | 1728 |
| NOTE 1: DM-RS configuration type = 1 with DM-RS duration = single-symbol DM-RS and the number of DM-RS CDM groups without data is 2, additional DM-RS position = pos1, *l0*= 2 and *l* =11 for PUSCH mapping type A, *l0*= 0 and *l* =10 for PUSCH mapping type B as per table 6.4.1.1.3-3 of TS 38.211 [5].  NOTE 2: Code block size including CRC (bits) equals to *K'* in clause 5.2.2 of TS 38.212 [10]. | | | | |

Table A.3-2: FRC parameters for FR1-NTN PUSCH performance requirements, transform precoding enabled, additional DM-RS position = pos1 and 1 transmission layer (QPSK, R=308/1024)

|  |  |  |
| --- | --- | --- |
| Reference channel | G-FR1-A3-5 | G-FR1-A3-6 |
| Subcarrier spacing (kHz) | 15 | 30 |
| Allocated resource blocks | 25 | 24 |
| Data bearing CP-OFDM Symbols per slot (Note 1) | 12 | 12 |
| Modulation | QPSK | QPSK |
| Code rate (Note 2) | 308/1024 | 308/1024 |
| Payload size (bits) | 2152 | 2088 |
| Transport block CRC (bits) | 16 | 16 |
| Code block CRC size (bits) | - | - |
| Number of code blocks - C | 1 | 1 |
| Code block size including CRC (bits) (Note 2) | 2168 | 2104 |
| Total number of bits per slot | 7200 | 6912 |
| Total resource elements per slot | 3600 | 3456 |
| NOTE 1: DM-RS configuration type = 1 with DM-RS duration = single-symbol DM-RS and the number of DM-RS CDM groups without data is 2, additional DM-RS position = pos1, *l0*= 2 and *l* =11 for PUSCH mapping type A, *l0*= 0 and *l* =10 for PUSCH mapping type B as per table 6.4.1.1.3-3 of TS 38.211 [5].  NOTE 2: Code block size including CRC (bits) equals to *K'* in clause 5.2.2 of TS 38.212 [10]. | | |

# A.3A Fixed Reference Channels for performance requirements (QPSK, R=99/1024)

The parameters for the reference measurement channel are specified in table A.3A-1 for FR1-NTN PUSCH performance requirements:

- FRC parameters are specified in table A.3A-1 for FR1-NTN PUSCH with transform precoding disabled, additional DM-RS position = pos1 and 1 transmission layer.

Table A.3A-1: FRC parameters for FR1-NTN PUSCH performance requirements, transform precoding disabled, additional DM-RS position = pos1 and 1 transmission layer (QPSK, R=99/1024)

|  |  |  |
| --- | --- | --- |
| Reference channel | G-FR1-A3A-1 | G-FR1-A3A-2 |
| Subcarrier spacing (kHz) | 15 | 30 |
| Allocated resource blocks | 25 | 24 |
| Data bearing CP-OFDM Symbols per slot (Note 1) | 12 | 12 |
| Modulation | QPSK | QPSK |
| Code rate (Note 2) | 99/1024 | 99/1024 |
| Payload size (bits) | 704 | 672 |
| Transport block CRC (bits) | 16 | 16 |
| Code block CRC size (bits) | - | - |
| Number of code blocks - C | 1 | 1 |
| Code block size including CRC (bits) (Note 2) | 720 | 688 |
| Total number of bits per slot | 7200 | 6912 |
| Total resource elements per slot | 3600 | 3456 |
| NOTE 1: DM-RS configuration type = 1 with DM-RS duration = single-symbol DM-RS and the number of DM-RS CDM groups without data is 2, additional DM-RS position = pos1, *l0* = 2 and *l* = 11 for PUSCH mapping type A, *l0* = 0 and *l* = 10 for PUSCH mapping type B as per table 6.4.1.1.3-3 of TS 38.211 [5].  NOTE 2: Code block size including CRC (bits) equals to *K'* in clause 5.2.2 of TS 38.212 [10]. | | |

# A.4 PRACH test preambles

Table A.4-1 Test preambles in FR1-NTN

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Burst format | SCS (kHz) | Ncs | Logical sequence index | v |
| 0 | 1.25 | 13 | 22 | 32 |
| 2 | 1.25 | 13 | 22 | 32 |
| B4, C2 | 15 | 23 | 0 | 0 |
| 30 | 46 | 0 | 0 |

*<End of the change>*

*<Start of the change>*

# Annex E (normative): Error Vector Magnitude (FR2-NTN)

# E.1 Reference point for measurement

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



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

# E.2 Basic unit of measurement

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



where

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

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

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

 is the modified signal under test defined in E.3.

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

# E.3 Modified signal under test

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



where

 is the time domain samples of the signal under test.

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

 is the RF frequency offset.

 is the phase response of the TX chain.

 is the amplitude response of the TX chain.

# E.4 Estimation of frequency offset

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

# E.5 Estimation of time offset

## E.5.1 General

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

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

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

Two values for  are determined:

 and

 where  if  is odd and  if is even.

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

## E.5.2 Window length

Table E.5.2-1 and table E.5.2-2 specify the EVM window length (*W*) for normal CP for FR2-NTN.

Table E.5.2-1: EVM window length for normal CP, FR2-NTN, 60 kHz SCS

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Channel bandwidth (MHz) | FFT size | CP length in FFT samples | EVM window length W | Ratio of *W* to total CP length (Note) (%) |
| 50 | 1024 | 72 | 36 | 50 |
| 100 | 2048 | 144 | 72 | 50 |
| 200 | 4096 | 288 | 144 | 50 |
| NOTE: These percentages are informative and apply to all OFDM symbols within subframe except for symbol 0 of slot 0 and slot 2. Symbol 0 of slot 0 and slot 2 may have a longer CP and therefore a lower percentage. | | | | |

Table E.5.2-2: EVM window length for normal CP, FR2-NTN, 120 kHz SCS

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Channel bandwidth (MHz) | FFT size | CP length in FFT samples | EVM window length W | Ratio of *W* to total CP length (Note) (%) |
| 50 | 512 | 36 | 18 | 50 |
| 100 | 1024 | 72 | 36 | 50 |
| 200 | 2048 | 144 | 72 | 50 |
| 400 | 4096 | 288 | 144 | 50 |
| NOTE: These percentages are informative and apply to all OFDM symbols within subframe except for symbol 0 of slot 0 and slot 4. Symbol 0 of slot 0 and slot 4 may have a longer CP and therefore a lower percentage. | | | | |

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

The equalizer coefficients and  are determined as follows:

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



Where the post-FFT ideal signal  is constructed by the measuring equipment according to the relevant TX specifications, using the following parameters:

- nominal demodulation reference signals and nominal PT-RS if present (all other modulation symbols are set to 0 V),

- nominal carrier frequency,

- nominal amplitude and phase for each applicable subcarrier,

- nominal timing.

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

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

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

4. Perform linear interpolation from the equalizer coefficients  and  to compute coefficients ,  for each subcarrier. To account for the common phase error (CPE) experienced in millimetre wave frequencies, , in the estimated coefficients contain phase rotation due to the CPE, , in addition to the phase of the equalizer coefficient , that is

For OFDM symbols where PT-RS does not exist, can be estimated by performing linear interpolation from neighboring symbols where PT-RS is present.

In order to separate component of the CPE,, contained in, , estimation and compensation of the CPE needs to follow. is the common phase error (CPE), that rotates all the subcarriers of the OFDM symbol at time .

Estimate of the CPE, , at OFDM symbol time, , can then be obtained from using the PT-RS employing the expression

In the above equation, is the set of subcarriers where PT-RS are mapped, where is the set of OFDM symbols where PT-RS are mapped while and are is the post-FFT acquired signal and the ideal PT-RS signal respectively. That is, estimate of the CPE at a given OFDM symbol is obtained from frequency correlation of the complex ratios at the PT-RS positions with the conjugate of the estimated equalizer complex coefficients. The estimated CPE can be subtracted from to remove influence of the CPE, and obtain estimate of the complex coefficient's phase

(t)



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

# E.7 Averaged EVM

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

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



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

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

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

- Thus we get:

*<End of the change>*