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| 3GPP TS 38.115-2 V0.1.0 (2022-08) |
| Technical Specification |

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| 3rd Generation Partnership Project;Technical Specification Group Radio Access Network;NR;Repeater conformance testing  Part 2: Radiated conformance testing (Release 17) |

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# Foreword

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

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

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where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

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

**shall** indicates a mandatory requirement to do something

**shall not** indicates an interdiction (prohibition) to do something

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

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

**should** indicates a recommendation to do something

**should not** indicates a recommendation not to do something

**may** indicates permission to do something

**need not** indicates permission not to do something

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

**can** indicates that something is possible

**cannot** indicates that something is impossible

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

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

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

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

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

In addition:

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

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

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

# 1 Scope

The present document establishes the minimum RF characteristics of NR Repeater.

# 2 References

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

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

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

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

**Beam:** beam (of the antenna) is the main lobe of the radiation pattern of an *antenna array*

**Beam centre direction:** direction equal to the geometric centre of the half-power contour of the beam

**Beam direction pair:** data set consisting of the *beam centre direction* and the related *beam peak direction*

**Beam peak direction:** direction where the maximum EIRP is found

**Beamwidth:** beam which has a half-power contour that is essentially elliptical, the half-power beamwidths in the two pattern cuts that respectively contain the major and minor axis of the ellipse

**directional requirement:** requirement which is applied in a specific direction within the *OTA coverage range*.**Equivalent isotropic radiated power:** equivalent power radiated from an isotropic directivity device producing the same field intensity at a point of observation as the field intensity radiated in the direction of the same point of observation by the discussed device

**Fractional bandwidth:** *fractional bandwidth* FBW is defined as $\frac{\_{}\_{}}{\_{}\_{}}$

**gap between passbands:** frequency gap between two consecutive passbands that belong to the same *operating band*, where the RF requirements in the gap are based on co-existence for un-coordinated operation

**Inter-passband gap**: The frequency gap between two supported consecutive *passbands* that belong to different operating bands.

**Maximum passband TRP output power:** mean power level measured perpassband during the *transmitter ON state* in a specified reference condition and corresponding to the declared *rated passband TRP output* power (Prated,p,,TRP)

**Measurement bandwidth**: RF bandwidth in which an emission level is specified

**Non-contiguous spectrum**: spectrum consisting of two or more *passbands* separated by *inter-passband gap*(s).

**Operating band:** frequency range in which NR operates (paired or unpaired), that is defined with a specific set of technical requirements

**OTA coverage range**: a common range of directions within which OTA requirements that are neither specified in the *OTA peak directions sets* nor as *TRP requirement* are intended to be met

**OTA peak directions set:** set(s) of *beam peak directions* within which certain OTA requirements are intended to be met, where all *OTA peak directions set(s)* are subsets of the *OTA coverage range***Passband:** The frequency range in which the repeater operates in with operational configuration, this frequency range can correspond to one or several consecutive nominal channels, if they are not consecutive each subset of channels shall be considered as an individual *passband*, a repeater can have one or several *passbands*, all channels within the *passband(s)* shall belong to a single operator or collaborating operators.

**passband edge***:* Frequency at the edge of the passband

**Radiated interface boundary**: *operating band* specific radiated requirements reference where the radiated requirements apply

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

**Rated passband TRP output power**: mean power level declared by the manufacturer per passband, that the manufacturer has declared to be available at the RIB during the *transmitter ON state*

**Rated total TRP output power**: mean power level associated with a particular *operating band*, that the manufacturer has declared to be available at the RIB during the *transmitter ON state* in a specified reference condition**Reference beam direction pair:** Beam direction pair in the reference direction declared by the manufacturer.

**Repeater type 2-O:** Repeater operating at FR2 with a requirement set consisting only of OTA requirements defined at the RIB

**Requirement set**: one of the NR requirements set as defined for *NR repeater*

**Sub-band**: A *sub-band* of an operating band contains a part of the uplink and downlink frequency range of the operating band.

**sub-block:** one contiguous allocated block of spectrum for transmission and reception by the repeater.

**Superseding-band**: A *superseding-band* of an operating band includes the whole of the uplink and downlink frequency range of the operating band.

**Total radiated power:** is the total power radiated by the antenna

NOTE: The *total radiated power* is the power radiating in all direction for two orthogonal polarizations. *Total radiated power* is defined in both the near-field region and the far-field region

**Transmitter OFF state:** Time period during which the repeater downlink or uplink is not allowed to transmit in the corresponding direction.

## 3.2 Symbols

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

BWPassband *Passband* bandwidth

Δf Separation between the *passband edge* frequency and the nominal -3 dB point of the measuring filter closest to the carrier frequency

Δfmax f\_offsetmax minus half of the bandwidth of the measuring filter

ΔfOBUE Maximum offset of the *operating band* unwanted emissions mask from the *operating band* edgeFDL,low The lowest frequency of the downlink *operating band*

FDL,high The highest frequency of the downlink *operating band*

FFBWhigh Highest supported frequency within supportedoperating band, for which *fractional bandwidth* support was declared

FFBWlow Lowest supported frequency within supported operating band, for which *fractional bandwidth* support was declared

Ffilter Filter centre frequency

Foffset,high Frequency offset from FC,high to the upper *passband edge*

Foffset,low Frequency offset from FC,low to the lower *passband edge*

f\_offset Separation between the *passband edge* frequency and the centre of the measuring

f\_offsetmax The offset to the frequency ΔfOBUE outside the *operating band*

Fstep,X Frequency steps for the OTA transmitter spurious emissions (Category B)

FUL,low The lowest frequency of the uplink *operating band*

FUL,high The highest frequency of the uplink *operating band*

PEM,n50/n75,ind Declared emission level for Band n50/n75; ind = a, b

Prated,p,EIRP Rated passband EIRP output power

Prated,p,TRP Rated passband TRP output power declared per RIB

Prated,t,TRP Rated total TRP output power declared per RIB

Pin,p,EIRP Input power intended to produce the maximum rated output power (Prated,p,TRP) at the RIB

Prated,out,FBWhigh The rated output EIRPfor the higher supported frequency range within supported *operating band,* for which *fractional bandwidth* support was declared

Prated,out,FBWlow The rated output EIRP for the lower supported frequency range within supported *operating band,* for which *fractional bandwidth* support was declared

Pmax,p,EIRP *Maximum passband EIRP output power* when repeater is configured at the rated passband TRP output power (Prated,p,TRP)

Pmax,p,TRP *Maximum passband TRP output power* measuredper RIB

Wgap *Inter passband Bandwidth gap* size

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

ACLR Adjacent Channel Leakage Ratio

AoA Angle of Arrival

BW Bandwidth

CACLR Cumulative ACLR

CP-OFDM Cyclic Prefix-OFDM

DFT-s-OFDM Discrete Fourier Transform-spread-OFDM

DL Downlink

EIRP Effective Isotropic Radiated Power

EVM Error Vector Magnitude

FBW Fractional Bandwidth

FR Frequency Range

ITU‑R Radiocommunication Sector of the International Telecommunication Union

LA Local Area

MR Medium Range

NR New Radio

OBUE Operating Band Unwanted Emissions

OOB Out-of-band

OTA Over-The-Air

QAM Quadrature Amplitude Modulation

RF Radio Frequency

RIB Radiated Interface Boundary

RX Receiver

SCS Sub-Carrier Spacing

TX Transmitter

TRP Total Radiated Power

UL Uplink

WA Wide Area

# 4 General radiated test conditions and declarations

## 4.1 Measurement uncertainties and test requirements

<Text will be added.>

## 4.2 Radiated requirement reference points

For *repeater 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 4.2-1: Radiated reference points for *repeater type 2-O*

## 4.3 Repeater classes

4.3.1 Repeater class for downlink

The requirements in this specification apply to downlink Wide Area repeaters, downlink Medium Range repeaters and downlink Local Area repeaters unless otherwise stated. The associated deployment scenarios for each class are exactly the same for repeater with and without connectors.

For *repeater type 2-O*, repeater downlink classes are defined as indicated below:

- Wide Area repeaters are characterised by requirements derived from Macro Cell scenarios with a repeater to UE minimum distance along the ground equal to 35 m.

- Medium Range repeaters are characterised by requirements derived from Micro Cell scenarios with a repeater to UE minimum distance along the ground equal to 5 m.

- Local Area repeaters are characterised by requirements derived from Pico Cell scenarios with a repeater to UE minimum distance along the ground equal to 2 m.

4.3.2 Repeater class for uplink

The requirements in this specification apply to uplink Wide Area repeaters and uplink Local Area repeaters unless otherwise stated. The associated deployment scenarios for each class are exactly the same for repeater with and without connectors.

For *repeater type 1-C* and *type 2-O*, repeater uplink classes are defined as indicated below:

- Wide Area repeaters are characterised by requirements derived from Macro Cell and/or Micro Cell scenarios.

- Local Area repeaters are characterised by requirements derived from Pico Cell and/or Micro Cell scenarios.

## 4.4 Regional requirements

Some requirements in the present document may only apply in certain regions either as optional requirements, or as mandatory requirements set by local and regional regulation. It is normally not stated in the 3GPP specifications under what exact circumstances the regional requirements apply, since this is defined by local or regional regulation.

Table 4.4-1 lists all requirements in the present specification that may be applied differently in different regions.

Table 4.4-1: List of regional requirements

| Clause number | Requirement | Comments |
| --- | --- | --- |
| 5.2 | *Operating bands* | Some NR *operating bands* may be applied regionally. |
| 7.3.4 | OTA repeater output power:Additional requirements | These requirements may be applied regionally as additional repeater output power requirements. |
| 7.5.3.2 | OTA operating band unwanted emissions | Category A or Category B operating band unwanted emissions limits may be applied regionally. |
| 7.5.4.2 | OTA Tx spurious emissions | Category A or Category B spurious emission limits, as defined in ITU-R Recommendation SM.329 [5], may apply regionally. |
| 7.5.4.2.3 | OTA Tx spurious emissions: additional requirements | These requirements may be applied for the protection of system operating in frequency ranges other than the repeater *operating band*. |

## 4.5 Repeater configurations

### 4.5.1 Downlink configurations

Unless otherwise stated, the radiated downlink characteristics in clause 6 are specified at RIB, with a full complement of transceiver units for the configuration in normal operating conditions.



Figure 4.5.1-1: Test interface for downlink

### 4.5.2 Uplink configurations

Unless otherwise stated, the radiated downlink characteristics in clause 6 are specified at RIB, with a full complement of transceiver units for the configuration in normal operating conditions.



Figure 4.5.2-1: Test interface for uplink

### 4.5.3 Power supply options

If the repeater is supplied with a number of different power supply configurations, it may not be necessary to test RF parameters for each of the power supply options, provided that it can be demonstrated that the range of conditions over which the equipment is tested is at least as great as the range of conditions due to any of the power supply configurations.

### 4.5.4 [Repeater with integrated Iuant repeater modem]

<Text will be added.>

## 4.6 Manufacturer's declarations

The following repeater manufacturer's declarations listed in table 4.6-1, when applicable to the BS under test, are required to be provided by the manufacturer for radiated requirements testing for *repeater type 2-O*. Declarations can be made independently for UL and DL.

Table 4.6-1: Manufacturers declarations for *repeater type 2-O* radiated test requirements

| **Declaration identifier** | **Declaration** | **Description** |
| --- | --- | --- |
| D.1 | Coordinate system reference point | Location of coordinated system reference point in reference to an identifiable physical feature of the repeater enclosure. |
| D.2 | Coordinate system orientation | Orientation of the coordinate system in reference to an identifiable physical feature of the repeater enclosure. |
| D.3 | Beam identifier | A unique title to identify a beam, e.g. a, b, c or 1, 2, 3. The vendor may declare any number of beams with unique identifiers. The minimum set to declare for conformance, corresponds to the beams at the reference beam direction with the highest intended EIRP, and covering the properties listed below:1) A beam with the narrowest intended BeWθ and narrowest intended BeWϕ possible when narrowest intended BeWθ is used.2) A beam with the narrowest intended BeWϕ and narrowest intended BeWθ possible when narrowest intended BeWϕ is used.3) A beam with the widest intended BeWθ and widest intended BeWϕ possible when widest intended BeWθ is used.4) A beam with the widest intended BeWϕ and widest intended BeWθ possible when widest intended BeWϕ is used.5) A beam which provides the highest intended EIRP of all possible beams.When selecting the above five beam widths for declaration, all beams that the repeater is intended to produce shall be considered, including beams that during operation may be identified by any kind of cell or UE specific reference signals, with the exception of any type of beam that is created from a group of transmitters that are not all phase synchronised.(Note 1) |
| D.4 | *Operating bands* and passband frequency ranges | List of NR *operating band(s)* supported by the repeater and passband frequency range(s) within the *operating band(s)* that the repeater can operate in. Supported bands declared for every beam (D.3). (Note 2) |
| D.5 | Repeater class | Declared as Wide Area repeater, Medium Range repeater, or Local Area repeater. |
| D.6 | *OTA peak directions set* reference beam direction pair | The beam direction pair, describing the reference beam peak direction and the reference beam centre direction. Declared for every beam (D.3). |
| D.7 | OTA peak directions set | The OTA peak directions set for each beam. Declared for every beam (D.3). |
| D.8 | *OTA peak directions set* maximum steering direction(s) | The *beam direction pair(s)* corresponding to the following points:1) The beam peak direction corresponding to the maximum steering from the reference beam centre direction in the positive Φ direction, while the θ value being the closest possible to the reference beam centre direction.2) The beam peak direction corresponding to the maximum steering from the reference beam centre direction in the negative *Φ* direction, while the *θ value being the closest possible to the* reference beam centre direction*.*3) The beam peak direction corresponding to the maximum steering from the reference beam centre direction in the positive *θ* direction, while the *Φ value being the closest possible to the* reference beam centre direction.4) The beam peak direction corresponding to the maximum steering from the reference beam centre direction in the negative *θ* direction, while the *Φ value being the closest possible to the* reference beam centre direction*.*The maximum steering direction(s) may coincide with *the reference beam centre direction*.Declared for every beam (D.3). |
| D.9 | Rated beam EIRP | The rated EIRP level per passband (Prated,p,EIRP) at the *beam peak direction* associated with a particular *beam direction pair* for each of the declared maximum steering directions (D.8), as well as the reference *beam direction pair* (D.8). Declared for every beam (D.3).(Note 5, 6, 7) |
| D.10 | Beamwidth | The *beamwidth* for the reference *beam direction pair* and the four maximum steering directions. Declared for every beam (D.3). |
| D.11 | Equivalent beams | List of beams which are declared to be equivalent.Equivalent beams imply that the beams are expected to have identical *OTA peak directions sets* and intended to have identical spatial properties at all steering directions within the *OTA peak directions set* when presented with identical signals. All declarations (D.4 – D.10) made for the beams are identical and the transmitter unit*,* RDN and antenna array responsible for generating the beam are of identical design. |
| D.12 | Parallel beams | List of beams which have been declared equivalent (D.11) and can be generated in parallel using independent RF power resources.Independent power resources mean that the beams are transmitted from mutually exclusive transmitter units. |
| D.13 | OTA coverage range | Declared as a single range of directions within which selected TX OTA requirements are intended to be met.(Note 3) |
| D.14 | *OTA coverage range* reference direction | The direction describing the reference direction of the *OTA coverage range* (D.13).(Note 4) |
| D.15 | OTA coverage range maximum directions | The directions corresponding to the following points:1) The direction determined by the maximum φ value achievable inside the *OTA coverage range*, while θ value being the closest possible to the *OTA coverage range* reference direction.2) The direction determined by the minimum φ value achievable inside the *OTA coverage range*, while θ value being the closest possible to the *OTA coverage range* reference direction.3) The direction determined by the maximum θ value achievable inside the *OTA coverage range*, while φ value being the closest possible to the *OTA coverage range* reference direction.4) The direction determined by the minimum θ value achievable inside the OTA coverage range, while φ value being the closest possible to the OTA coverage range reference direction. |
| D.16 | The rated passband OTA repeater power, Prated,p,TRP | Prated,p,TRP is declared as TRP OTA power per passband, declared per supported operating band.(Note 5, 7) |
| D.17 | Rated transmitter TRP, Prated,t,TRP | Rated total radiated output power*.*Declared per supported *operating band*.(Note 5, 7) |
| D.18 | Spurious emission category | Declare the repeater spurious emission category as either category A or B with respect to the limits for spurious emissions, as defined in Recommendation ITU-R SM.329 [5]. |
| D.19 | Additional operating band unwanted emissions | The manufacturer shall declare whether the repeater under test is intended to operate in geographic areas where the additional operating band unwanted emission limits defined in clause 6.7.4 apply. |
| D.20 | Co-existence with other systems | The manufacturer shall declare whether the repeater under test is intended to operate in geographic areas where one or more of the systems GSM850, GSM900, DCS1800, PCS1900, UTRA FDD, UTRA TDD, E-UTRA and/or PHS operating in another operating band are deployed. |
| [D.21 | Supported frequency range of the NR *operating band* | List of supported frequency ranges representing *fractional bandwidths* (FBW) of *operating bands* with FBW larger than 6%. |
| D.22 | Rated beam EIRP at lower end of the *fractional bandwidth* (Prated,out,FBWlow) | The rated EIRP level per passband at lower frequency range of the *fractional bandwidth* (Prated,out,FBWlow), at the *beam peak direction* associated with a particular *beam direction pair* for each of the declared maximum steering directions (D.10), as well as the reference *beam direction pair* (D.6).Declared per beam for all supported frequency ranges (D.21).(Note 5, 6, 7) |
| D.23 | Rated beam EIRP at higher frequency range of the *fractional bandwidth* (Prated,out,FBWhigh) | The rated EIRP level per passband at higher frequency range of the *fractional bandwidth* (Prated,out,FBWhigh), at the *beam peak direction* associated with a particular *beam direction pair* for each of the declared maximum steering directions (D.10), as well as the reference *beam direction pair* (D.6).Declared per beam for all supported frequency ranges in (D.21).(Note 5, 6, 7)] |
| D.24 | Long delay repeater | Declared only if the repeater internal delay between the input and output for this repeater does not fit within the TDD transient time. The repeater is intended for situations in which it will not cause interference to other nodes. This is achieved by RF isolation or by reservation of longer guard periods, which degrades frame utilization. The length of repeaters internal delay is declared using this declaration. |
| D.25 | Input signal EIRP for maximum output power | Declaration of input signal EIRP required to reach maximum output power. Declared per passband. |
| D.26 | Repeater radiating direction | Declaration on whether the repeater is intended to radiate in DL, UL or both. Testing shall be performed only for the direction(s) in which the repeater radiates. |
| NOTE 1: Depending on the capability of the system some of these beams may be the same. For those same beams, testing is not repeated.NOTE 2: These *operating bands* are related to their respective single‑band RIBs.NOTE 3: *OTA coverage range* is used for conformance testing of such TX OTA requirements as frequency error or EVM.NOTE 4: The *OTA coverage range* reference direction may be the same as the Reference beam direction pair (D.8) but does not have to be.NOTE 5: If a *Repeater type 2-O* is capable of 64QAM operation but not capable of 256QAM operation, then up to two rated output power declarations may be made. One declaration is applicable when configured for 64QAM operation and the other declaration is applicable when not configured for 64QAM operation.NOTE 6: If D.22 and D.23 are declared for certain frequency range (D.21), there shall be no "Rated beam EIRP" declaration (D.9) for the *operating band* containing that particular frequency range.NOTE 7: If a BS type 2-O is capable of 256QAM operation, then up to three rated output power declarations may be made. One declaration is applicable when configured for 256QAM operation, a different declaration is applicable when configured for 64QAM operation and the other declaration is applicable when not configured neither for 256QAM nor 64QAM operation. |

## 4.7 Test configurations

<Text will be added.>

## 4.8 Applicability of requirements

<Text will be added.>

## 4.9 RF channels and test models

<Text will be added.>

## 4.10 Requirements for contiguous and non-contiguous spectrum

A spectrum allocation where a repeater operates can either be contiguous or non-contiguous. Unless otherwise stated, the requirements in the present specification apply for repeater configured for both contiguous spectrum operation and non-contiguous spectrum operation.

For repeater operation in non-contiguous spectrum, some requirements apply both at the repeater *passband* edges and inside the sub-block gaps. For each such requirement, it is stated how the limits apply relative to the repeater *passband* edges and the sub-block edges respectively.

## 4.11 Format and interpretation of tests

Each test has a standard format:

X Title

All tests are applicable to all equipment within the scope of the present document, unless otherwise stated.

X.1 Definition and applicability

This clause gives the general definition of the parameter under consideration and specifies whether the test is applicable to all equipment or only to a certain subset. Required manufacturer declarations may be included here.

X.2 Minimum requirement

This clause contains the reference to the clause to the 3GPP reference (or core) specification which defines the minimum requirement.

X.3 Test purpose

This clause defines the purpose of the test.

X.4 Method of test

X.4.1 General

In some cases there are alternative test procedures or initial conditions. In such cases, guidance for which initial conditions and test procedures can be applied are stated here. In the case only one test procedure is applicable, that is stated here.

X.4.2y First test method

X.4.2y.1 Initial conditions

This clause defines the initial conditions for each test, including the test environment, the RF channels to be tested and the basic measurement set-up. The OTA Test System is assumed to be correctly calibrated as part of the initial conditions. Calibration is not explicitly mentioned.

X.4.2y.2 Procedure

This clause describes the steps necessary to perform the test and provides further details of the test definition like domain (e.g. frequency-span), range, weighting (e.g. bandwidth), and algorithms (e.g. averaging). The procedure may comprise data processing of the measurement result before comparison with the test requirement (e.g. average result from several measurement positions).

X.4.3y Alternative test method (if any)

If there are alternative test methods, each is described with its initial conditions and procedures.

X.5 Test requirement

This clause defines the pass/fail criteria for the equipment under test, see clause 4.1.3 (Interpretation of measurement results). Test requirements for every minimum requirement referred in clause X.2 are listed here. Cases where minimum requirements do not apply need not be mentioned.

## 4.12 Reference coordinate system

Radiated requirements are stated in terms of electromagnetic characteristics (e.g. EIRP) at certain angles with respect to the repeater. To be able to declare radiated characteristics part of radiated requirements a reference coordinate system is required. The reference coordinate system should be associated to an identifiable physical feature on the repeater enclosure. The location of the origin and the orientation of the reference coordinate system are for the repeater manufacturer to declare.

The reference coordinate system is created of a Cartesian coordinate system with rectangular axis (x***,*** y***,*** z) and spherical angles () as showed in figure 4.12-1.



Figure 4.12-1: Reference coordinate system

******is the angle in the x/y plane, between the x-axis and the projection of the radiating vector onto the x/y plane and is defined between -180° and +180°, inclusive. ****** is the angle between the projection of the vector in the x***/***y plane and the radiating vector and is defined between -90° and +90°, inclusive. Note that  is defined as positive along the down-tilt angle.

# 5 Operating bands and channel arrangement

For the NR operation in NR operating bands specification, their channel bandwidth configurations, channel spacing and raster, as well as synchronization raster specification, refer to TS 38.106 [x], clause 5 and its relevant clauses.

For the radiated testing purposes in this specification, only FR2-1 operating bands are considered.

# 6 Radiated characteristics

## 6.1 General

<Text will be added.>

## 6.2 OTA output power

<Text will be added.>

## 6.3 OTA frequency stability

### 6.3.1 Definition and applicability

Frequency stability is the ability to maintain the same frequency on the output signal with respect to the input signal.

### 6.3.2 Minimum Requirement

The minimum requirement is in TS 38.106 [x], clause 7.3.2.

### 6.3.3 Test purpose

The test purpose is to verify that frequency stability is within the limit specified by the minimum requirement.

### 6.3.4 Method of test

Requirement is tested together with modulation quality test, as described in clause 7.6.

### 6.3.5 Test Requirements

The frequency deviation of the output signal with respect to the input signal shall be accurate to within ±(0.01 ppm + 12 Hz) observed over 1 ms.

## 6.4 OTA out of band gain

### 6.4.1 Definition and applicability

Out of band gain refers to the gain of the repeater outside the *passband*.

### 6.4.2 Minimum Requirement

The minimum requirement is in TS 38.106 [x], clause 7.4.2.

### 6.4.3 Test purpose

The test purpose is to verify that out of band gain is within the limit specified by the minimum requirement.

### 6.4.4 Method of test

#### 6.4.4.1 Initial conditions

Test environment:

- Normal, see annex B.2,

#### 6.4.4.2 Procedure

For normal test environment conditions in OTA domain, the test procedure is as follows:

1) Place the repeater at the positioner.

2) Align the manufacturer declared coordinate system orientation (D.2) of the repeater with the test system.

3) Orient the positioner (and repeater and test signal generator) in order that the direction to be tested aligns with the test antenna and the correct angle of arrival for the input signal is achieved..

4) Set the CW generator power at the RIB as shown in annex D.1.1 with a power equivalent to Pin,p,EIRP, in the correct direction in respect to the repeater.

5) Orient the positioner (and repeater and test signal source) in order that the direction to be tested aligns with the test antenna such that measurements to determine TRP can be performed (see annex I) whilst maintaining the correct direction of arrival for the test signal.

6) Measure the radiated power for any two orthogonal polarizations (denoted p1 and p2) and calculate total radiated transmit power for particular beam direction pair as EIRP = EIRPp1 + EIRPp2.

7) Repeat step 6-7 for all directions in the appropriated TRP measurement grid needed for full TRP estimation (see annex I), whilst maintaining the input signal in the correct direction with respect to the repeater.

8) Calculate TRP using the EIRP measurements. The out of band gain at the frequency under test is given by the difference in dB between the measured output TRP and the EIRP of the input signal.

9) Repeat steps 2-8, shifting the offset frequency of the CW from the edge of the *passband* from 200kHz to 10MHz in steps of 200kHz for each *passband* and, for the case of multi-band connectors each operating band

### 6.4.5 Test Requirements

The gain outside the *passband* shall not exceed the maximum level specified in table 6.4.5-1, where:

- f\_offset\_CW is the offset between the outer channel edge frequency of the outer channel in the *passband* and a CW signal.

Table 6.4.5-1: Out of band gain limits

|  |  |
| --- | --- |
| Frequency offset, f\_offset\_CW | Maximum gain |
| 0.1\*Minimum {400MHz, *passband* BW}  f\_offset\_CW < 150 MHz  | 68 dB |
| 150 MHz  f\_offset\_CW < 400 MHz | 55 dB |
| 400 MHz  f\_offset\_CW < f\_offset\_max | 35 dB |

## 6.5 OTA unwanted emissions

6.5.1 General

Unwanted emissions consist of so-called out-of-band emissions and spurious emissions according to ITU definitions ITU-R SM.329 [5]. In ITU terminology, out of band emissions are unwanted emissions immediately outside the *passband* 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 *repeater type 2-O* transmitter is specified both in terms of Adjacent Channel Leakage power Ratio (ACLR) and operating band unwanted emissions (OBUE). OTA Unwanted emissions outside of this frequency range are limited by an OTA spurious emissions requirement.

The maximum offset of the operating band unwanted emissions mask from the *operating band* edge is ΔfOBUE. The value of ΔfOBUE is defined in table 6.5.1-1 for *repeater type 2-O* for NR *operating bands*.

**Table 6.5.1-1: Maximum offset ΔfOBUE outside the downlink *operating band* for *repeater type 2-O***

|  |  |  |
| --- | --- | --- |
| **Repeater type** | ***Operating band* characteristics** | **ΔfOBUE (MHz)** |
| *Repeater type 2-O* | FDL,high – FDL,low ≤ 4000 MHz | 1500 |

The unwanted emission requirements are applied per cell for all the configurations. Requirements for OTA unwanted emissions are captured using TRP, *directional requirements* or co-location requirements as described per requirement.

6.5.2 OTA Adjacent Channel Leakage Power Ratio (ACLR)

#### 6.5.2.1 Definition and applicability

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 during the *transmitter ON state*.

#### 6.5.2.2 Minimum requirement

The minimum requirement in TS 38.106 [x], clause 7.5.2.2.

#### 6.5.2.3 Test purpose

To verify that the adjacent channel leakage power ratio requirement shall be met as specified by the minimum requirement.

#### 6.5.2.4 Method of test

##### 6.5.2.4.1 Initial conditions

Test environment: Normal; see annex B.2.

RF channels to be tested for single carrier: B, M and T; see clause 4.9.1.

##### 6.5.2.4.2 Procedure

The following procedure for measuring TRP is based on the directional power measurements as described in annexI.

1) Place the repeater at the positioner.

2) Align the manufacturer declared coordinate system orientation (D.2) of the repeater with the test system.

3) The measurement devices characteristics shall be:

 - measurement filter bandwidth: defined in clause 6.7.3.5.

 - detection mode: true RMS voltage or true power averaging.

4a) Set the input signal at the RIB according to the applicable test configuration and direction in clause 4.8 using the corresponding test models NR-FR1‑TM 1.1 in clause 4.9.2 at the input power intended to produce the maximum rated output power, Pin,p,EIRP + 10dB.

4b) Verify measurement impact from feeding test signal by generating a signal for repeater input with repeater to be turned off. Verify measured result is enough below requirement limit.

5) Orient the positioner (and repeater and test signal source) in order that the direction to be tested aligns with the test antenna such that measurements to determine TRP can be performed (see annex I) whilst maintaining the correct direction of arrival for the test signal.

6) Measure the absolute power of the assigned channel frequency and the (adjacent channel frequency).

7) Repeat step 5-6 for all directions in the appropriated TRP measurement grid needed for TRPEstimate (see annex I).

8) Calculate TRPEstimate for the absolute total radiated power of the wanted channel and the adjacent channel using the measurements made in Step 7.

9) Calculate relative ACLR estimate.

NOTE 1: ACLR is calculated by the ratio of the absolute TRP of the assigned channel frequency and the absolute TRP of the adjacent frequency channel.

10) Measure OTA ACLR for the frequency offsets both side of channel frequency as specified in table 6.5.2.5-1. In multiple carrier case only offset frequencies below the lowest and above the highest carrier frequency used shall be measured.

11) For the OTA ACLR requirement applied inside sub-block gap for non-contiguous spectrum operation or inside *Inter RF Bandwidth gap* for multi-band operation:

a) Measure OTA ACLR inside sub-block gap or *Inter RF Bandwidth gap*, if applicable.

b) Measure OTA CACLR inside sub-block gap or *Inter RF Bandwidth gap*, if applicable.

#### 6.5.2.5 Test requirements

The OTA ACLR limit is specified in table 6.5.2.5-1 for DL and UL for Wide Area class and DL for Local Area class.

The OTA ACLR limit is specified in table 6.5.2.5-1a for UL for Local Area class.

The OTA ACLR absolute limit is specified in table 6.5.2.5-2.

The OTA ACLR (CACLR) absolute limit in table 6.5.2.5-2 or 6.5.2.5-5 or the ACLR (CACLR) limit in table 6.5.2.5-1, 6.5.2.5-3 or 6.5.2.5-4, whichever is less stringent, shall apply.

For a RIB operating in *non-contiguous spectrum*, the OTA ACLR requirement in table 6.5.2.5-3 shall apply in *gaps between passbands* for the frequency ranges defined in the table, while the OTA CACLR requirement in table 6.5.2.5-4 shall apply in *gaps between passbands* for the frequency ranges defined in the table.

The CACLR in a *gap between passbands* is the ratio of:

a) the sum of the filtered mean power centred on the assigned channel frequencies for the two carriers adjacent to each side of the *gap between passbands*, and

b) the filtered mean power centred on a frequency channel adjacent to one of the respective *sub-block* edges.

The assumed filter for the adjacent channel frequency is defined in table 6.5.2.5-4 and the filters on the assigned channels are defined in table 6.5.2.5-6.

For operation in *non-contiguous spectrum*, the CACLR for NR carriers located on either side of the *gap between passbands* shall be higher than the value specified in table 6.5.2.5-4.

For *repeater type 2-O* *nominal repeater channel bandwidth* is calculated as min(400MHz, BW*passband*).

**Table 6.5.2.5-1: *Repeater type 2-O* ACLR limit for DL and UL for WA class and DL for LA class**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***Repeater nominal channel bandwidth* of *lowest/highest carrier* transmitted****BWChannel (MHz)** | ***Repeater* 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)** |
|  min(400MHz, BW*passband*) | BWChannel | NR of same BW (Note 2) | Square (BWConfig) | 25.7 (Note 3)23.4 (Note 4)23.2 (Note 5) |
| NOTE 1: BWChannel and BWConfig are the nominal *repeater bandwidth configuration* of the *lowest/highest carrier* transmitted on the assigned channel frequency.NOTE 2: With SCS that provides nominal *bandwidth configuration* (BWConfig).NOTE 3: Applicable to bands defined within the frequency spectrum range of 24.25 – 33.4 GHzNOTE 4: Applicable to bands defined within the frequency spectrum range of 37 – 43.5 GHzNOTE 5: Applicable to bands defined within the frequency spectrum range of 43.5 – 48.2 GHz |

**Table 6.5.2.5-1a: *Repeater type 2-O* ACLR limit for UL LA class**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***Repeater nominal channel bandwidth* of *lowest/highest carrier* transmitted****BWChannel (MHz)** | ***Repeater* 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)** |
|  min(400MHz, BW*passband*) | BWChannel | NR of same BW (Note 2) | Square (BWConfig) | 14.7 (Note 3)13.4 (Note 4)13.2 (Note 5) |
| NOTE 1: BWChannel and BWConfig are the nominal *repeater bandwidth configuration* of the *lowest/highest carrier* transmitted on the assigned channel frequency.NOTE 2: With SCS that provides nominal *bandwidth configuration* (BWConfig).NOTE 3: Applicable to bands defined within the frequency spectrum range of 24.25 – 33.4 GHzNOTE 4: Applicable to bands defined within the frequency spectrum range of 37 – 43.5 GHzNOTE 5: Applicable to bands defined within the frequency spectrum range of 43.5 – 48.2 GHz |

**Table 6.5.2.5-2: *Repeater type 2-O* ACLR absolute limit**

|  |  |  |
| --- | --- | --- |
| Repeater class | ACLR absolute limit (Note 1) | ACLR absolute limit (Note 2) |
| Wide-area DL and UL | -10.3 dBm/MHz | -10.1 dBm/MHz |
| Medium-range DL | -17.3 dBm/MHz | -17.1 dBm/MHz |
| Local-area DL | -17.3 dBm/MHz | -17.1 dBm/MHz |
| NOTE 1: Applicable to bands defined within the frequency spectrum range of 24.25 – 43.5 GHzNOTE 2: Applicable to bands defined within the frequency spectrum range of 43.5 – 48.2 GHz |

**Table 6.5.2.5-3: *Repeater type 2-O* ACLR limit in non-contiguous spectrum**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***Repeater nominal channel bandwidth* of *lowest/highest carrier* transmitted (MHz)** | ***Gap between passbands* size (Wgap) where the limit applies (MHz)** | ***Repeater* adjacent channel centre frequency offset below or above the *sub-block* edge (inside the gap)** | **Assumed adjacent channel carrier** | **Filter on the adjacent channel frequency and corresponding filter bandwidth** | **ACLR limit** |
|  min(400MHz, BW*passband*) | Wgap≥ 100 (Note 6)Wgap≥ 250 (Note 7) | 25 MHz | 50 MHz NR (Note 2) | Square (BWConfig) | 25.7 (Note 3)23.4 (Note 4)23.2 (Note 5) |
|  min(400MHz, BW*passband*) | Wgap≥ 400 (Note 7)Wgap≥ 250 (Note 6) | 100 MHz | 200 MHz NR (Note 2) | Square (BWConfig) | 25.7 (Note 3)23.4 (Note 4)23.2 (Note 5) |
| NOTE 1: BWConfig is the nominal *bandwidth configuration* of the assumed adjacent channel carrier.NOTE 2: With SCS that provides nominal *bandwidth configuration* (BWConfig).NOTE 3: Applicable to bands defined within the frequency spectrum range of 24.25 – 33.4 GHz.NOTE 4: Applicable to bands defined within the frequency spectrum range of 37 – 43.5 GHz.NOTE 5: Applicable to bands defined within the frequency spectrum range of 43.5 – 52.6 GHz.NOTE 6: Applicable in case the *repeater passband* at the other edge of the gap is ≤ 100 MHz.NOTE 7: Applicable in case the *repeater passband* at the other edge of the gap is > 100 MHz. |

**Table 6.5.2.5-4: *Repeater type 2-O* CACLR limit in non-contiguous spectrum**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***Repeater channel bandwidth* of *lowest/highest carrier* transmitted (MHz)**  | ***Gap between passbands* size (Wgap) where the limit applies (MHz)** | ***Repeater* adjacent channel centre frequency offset below or above the *sub-block* edge (inside the gap)** | **Assumed adjacent channel carrier** | **Filter on the adjacent channel frequency and corresponding filter bandwidth** | **CACLR limit** |
|  min(400MHz, BW*passband*) | 50 ≤Wgap< 100 (Note 6)50 ≤Wgap< 250 (Note 7) | 25 MHz | 50 MHz NR (Note 2) | Square (BWConfig) | 25.7 (Note 3)23.4 (Note 4)23.2 (Note 5) |
|  min(400MHz, BW*passband*) | 200 ≤Wgap< 400 (Note 7)200 ≤Wgap< 250 (Note 6) | 100 MHz | 200 MHz NR (Note 2) | Square (BWConfig) | 25.7 (Note 3)23.4 (Note 4)23.2 (Note 5) |
| NOTE 1: BWConfig is the nominal bandwidth configuration of the assumed adjacent channel carrier.NOTE 2: With SCS that provides nominal bandwidth configuration (BWConfig).NOTE 3: Applicable to bands defined within the frequency spectrum range of 24.25 – 33.4 GHz.NOTE 4: Applicable to bands defined within the frequency spectrum range of 37 – 43.5 GHz.NOTE 5: Applicable to bands defined within the frequency spectrum range of 43.5 – 52.6 GHz.NOTE 6: Applicable in case the *repeater passband* at the other edge of the gap is ≤ 100 MHz.NOTE 7: Applicable in case the *repeater passband* at the other edge of the gap is > 100 MHz. |

**Table 6.5.2.5-5: *Repeater type 2-O* CACLR absolute limit**

|  |  |  |
| --- | --- | --- |
| Repeater class | ACLR absolute limit (Note 1) | ACLR absolute limit (Note 2) |
| Wide-area DL and UL | -10.3 dBm/MHz | -10.1 dBm/MHz |
| Medium-range DL | -17.3 dBm/MHz | -17.1 dBm/MHz |
| Local-area DL | -17.3 dBm/MHz | -17.1 dBm/MHz |
| NOTE 1: Applicable to bands defined within the frequency spectrum range of 24.25 – 43.5 GHzNOTE 2: Applicable to bands defined within the frequency spectrum range of 43.5 – 48.2 GHz |

**Table 6.5.2.5-6: Filter parameters for the assigned channel**

|  |  |
| --- | --- |
| **RAT of the carrier adjacent to the *gap between passbands***  | **Filter on the assigned channel frequency and corresponding filter bandwidth** |
| NR | NR of same BW with SCS that provides largest *nominal bandwidth configuration* |

6.5.3 OTA operating band unwanted emissions

#### 6.5.3.1 Definition and applicability

The requirements of either clause 6.5.4.5.2 (Category A limits) or clause 6.5.4.5.3 (Category B limits) shall apply. The application of either Category A or Category B limits shall be the same as for General OTA transmitter spurious emissions requirements (*repeater type 2-O*) in clause 7.5.3.3.2. In addition, the limits in clause 7.5.3.2.4 may also apply.

Out-of-band emissions in FR2 are limited by OTA operating band unwanted emission limits.

For *repeater type 2-O*, unless otherwise stated, the OTA operating band unwanted emission limits in FR2 are defined from ΔfOBUE below the lowest frequency of each supported downlink *operating band* up to ΔfOBUE above the highest frequency of each supported downlink *operating band*.

The values of ΔfOBUE are defined in table 6.5.1-1 for the NR *operating bands*.

The requirements shall apply whatever the type of transmitter considered and for all transmission modes foreseen by the manufacturer's specification. For a *RIB* operating in contiguous CA, the requirements apply to the frequencies (ΔfOBUE) starting from the edge of the *passband.* In addition, for a *RIB* operating in *non-contiguous spectrum*, the requirements apply inside any *gap between passbands*.

Emissions shall not exceed the maximum levels specified in the tables below, where:

- Δf is the separation between the *passband* edge frequency and the nominal -3dB point of the measuring filter closest to the *passband* edge.

- f\_offset is the separation between the *passband* edge frequency and the centre of the measuring filter.

- f\_offsetmax is the offset to the frequency ΔfOBUE outside thedownlink *operating band*, where ΔfOBUE is defined in table 7.5.1-1.

- Δfmax is equal to f\_offsetmax minus half of the bandwidth of the measuring filter.

In addition, inside any *gap between passbands* for a *RIB* operating in *non-contiguous spectrum*, emissions shall not exceed the cumulative sum of the limits specified for the adjacent *sub-blocks* on each side of the *gap between passbands*. The limit for each *sub-block* is specified in clauses 6.5.4.5.2 and 6.5.4.5.3 below, where in this case:

- Δf is the separation between the *sub-block* edge frequency and the nominal -3 dB point of the measuring filter closest to the *sub-block* edge.

- f\_offset is the separation between the *sub-block* edge frequency and the centre of the measuring filter.

- f\_offsetmax is equal to the *gap between passbands* bandwidth minus half of the bandwidth of the measuring filter.

- Δfmax is equal to f\_offsetmax minus half of the bandwidth of the measuring filter.

#### 6.5.3.2 Minimum requirement

The minimum requirement is defined in TS 38.106 [x], clause 7.5.3.2

#### 6.5.3.3 Test purpose

This test measures the emissions close to the assigned channel bandwidth of the wanted signal, while the transmitter is in operation.

#### 6.5.3.4 Method of test

##### 6.5.3.4.1 Initial conditions

Test environment: Normal; see annex B.2.

RF channels to be tested for single carrier: B, M and T; see clause 4.9.1.

##### 6.5.3.4.2 Procedure

The following procedure for measuring TRP is based on the directional power measurements as described in annex I.

1) Place the repeater at the positioner.

2) Align the manufacturer declared coordinate system orientation (D.2) of the repeater with the test system.

3) The measurement devices characteristics shall be:

 - detection mode: true RMS.

As a general rule, the resolution bandwidth of the measuring equipment should be equal to the measurement bandwidth. However, to improve measurement accuracy, sensitivity, efficiency and avoiding e.g. carrier leakage, the resolution bandwidth may be smaller than the measurement bandwidth. When the resolution bandwidth is smaller than the measurement bandwidth, the result should be integrated over the measurement bandwidth in order to obtain the equivalent noise bandwidth of the measurement bandwidth.

4a) Set the input signal at the RIB according to the applicable test configuration and direction in clause 4.8 using the corresponding test models NR-FR1‑TM 1.1 in clause 4.9.2 at the input power intended to produce the maximum rated output power, Pin,p,EIRP + 10dB.

4b) Verify measurement impact from feeding test signal by generating a signal for repeater input with repeater to be turned off. Verify measured result is enough below requirement limit.

5) Orient the positioner (and repeater and test signal source) in order that the direction to be tested aligns with the test antenna such that measurements to determine TRP can be performed (see annex I) whilst maintaining the correct direction of arrival for the test signal.

6) Step the centre frequency of the measurement filter in contiguous steps and measure the emission within the specified frequency ranges with the specified measurement bandwidth. For connector under test declared to operate in non-contiguous spectrum, the emission within the *sub-block gap* shall be measured using the specified measurement bandwidth from the closest sub block edge.

7) Repeat step 5-6 for all directions in the appropriated TRP measurement grid needed for TRPEstimate (see annex I).

8) Calculate TRPEstimate using the measurements made in Step 7.

#### 6.5.3.4 Test requirements

6.5.3.4.1 OTA operating band unwanted emission limits (Category A)

*Repeater type 2-O* unwanted emissions shall not exceed the maximum levels specified in table 6.5.3.4.1‑1 or 6.5.3.4.1-2 or 6.5.3.4.1-3.

**Table 6.5.3.4.1-1: OBUE limits applicable in the frequency range 24.25 – 33.4 GHz**

|  |  |  |  |
| --- | --- | --- | --- |
| **Frequency offset of measurement filter -3B point, Δf**  | **Frequency offset of measurement filter centre frequency, f\_offset** | **Limit** | ***Measurement bandwidth*** |
| 0 MHz ≤ Δf < 0.1\*BWcontiguous | 0.5 MHz ≤ f\_offset < 0.1\* BWcontiguous +0.5 MHz | Min(-2.3 dBm, Max(Prated,t,TRP – 32.3 dB, -9.3 dBm)) | 1 MHz |
| 0.1\*BWcontiguous ≤ Δf < Δfmax | 0.1\* BWcontiguous +0.5 MHz ≤ f\_offset < f\_ offsetmax | Min(-13 dBm, Max(Prated,t,TRP – 43 dB, -20 dBm)) | 1 MHz |
| NOTE 1: For *non-contiguous spectrum* operation within any *operating band* the limitwithin *gaps between passbands* is calculated as a cumulative sum of contributions from adjacent *sub-blocks* on each side of the *gap between passbands*.  |

**Table 6.5.3.4.1-2: OBUE limits applicable in the frequency range 37 – 43.5 GHz**

|  |  |  |  |
| --- | --- | --- | --- |
| **Frequency offset of measurement filter -3B point, Δf**  | **Frequency offset of measurement filter centre frequency, f\_offset** | **Limit** | ***Measurement bandwidth*** |
| 0 MHz ≤ Δf < 0.1\*BWcontiguous | 0.5 MHz ≤ f\_offset < 0.1\* BWcontiguous +0.5 MHz | Min(-2.3 dBm, Max(Prated,t,TRP – 30.3 dB, -9.3 dBm)) | 1 MHz |
| 0.1\*BWcontiguous ≤ Δf < Δfmax | 0.1\* BWcontiguous +0.5 MHz ≤ f\_offset < f\_ offsetmax | Min(-13 dBm, Max(Prated,t,TRP – 41 dB, -20 dBm)) | 1 MHz |
| NOTE 1: For *non-contiguous spectrum* operation within any *operating band* the limitwithin *gaps between passbands* is calculated as a cumulative sum of contributions from adjacent *sub-blocks* on each side of the *gap between passbands*. |

**Table 6.5.3.4.1-3: OBUE limits applicable in the frequency range 43.5 – 48.2 GHz**

|  |  |  |  |
| --- | --- | --- | --- |
| **Frequency offset of measurement filter -3B point, Δf**  | **Frequency offset of measurement filter centre frequency, f\_offset** | **Limit** | ***Measurement bandwidth*** |
| 0 MHz ≤ Δf < 0.1\*BWcontiguous | 0.5 MHz ≤ f\_offset < 0.1\* BWcontiguous +0.5 MHz | Min(-2.1 dBm, Max(Prated,t,TRP – 30.1 dB, -9.1 dBm)) | 1 MHz |
| 0.1\*BWcontiguous ≤ Δf < Δfmax | 0.1\* BWcontiguous +0.5 MHz ≤ f\_offset < f\_ offsetmax | Min(-13 dBm, Max(Prated,t,TRP – 41 dB, -20 dBm)) | 1 MHz |
| NOTE 1: For *non-contiguous spectrum* operation within any *operating band* the limitwithin *gaps between passbands* is calculated as a cumulative sum of contributions from adjacent *sub-blocks* on each side of the *gap between passbands*. |

6.5.3.4.2 OTA operating band unwanted emission limits (Category B)

*Repeater type 2-O* unwanted emissions shall not exceed the maximum levels specified in table 6.5.3.4.2‑1 or 6.5.3.4.2-2 or 6.5.3.4.2-3.

**Table 6.5.3.4.2-1: OBUE limits applicable in the frequency range 24.25 – 33.4 GHz**

|  |  |  |  |
| --- | --- | --- | --- |
| **Frequency offset of measurement filter -3 dB point, Δf**  | **Frequency offset of measurement filter centre frequency, f\_offset** | **Limit** | ***Measurement bandwidth*** |
| 0 MHz ≤ Δf < 0.1\*BWcontiguous | 0.5 MHz ≤ f\_offset < 0.1\* BWcontiguous +0.5 MHz | Min(-2.3 dBm, Max(Prated,t,TRP – 32.3 dB, -9.3 dBm)) | 1 MHz |
| 0.1\*BWcontiguous ≤ Δf < ΔfB | 0.1\* BWcontiguous +0.5 MHz ≤ f\_offset < ΔfB +0.5 MHz | Min(-13 dBm, Max(Prated,t,TRP – 43 dB, -20 dBm)) | 1 MHz |
| ΔfB ≤ Δf < Δfmax | ΔfB +5 MHz ≤ f\_offset < f\_ offsetmax | Min(-5 dBm, Max(Prated,t,TRP – 33 dB, -10 dBm)) | 10 MHz |
| NOTE 1: For non-contiguous spectrum operation within any *operating band* the limitwithin gaps between *passbands* is calculated as a cumulative sum of contributions from adjacent sub-blocks on each side of the gap between *passbands*. NOTE 2: ΔfB = 2\*BWcontiguous when BWcontiguous ≤ 500 MHz, otherwise ΔfB = BWcontiguous + 500 MHz. |

**Table 6.5.3.4.2-2: OBUE limits applicable in the frequency range 37 – 43.5 GHz**

|  |  |  |  |
| --- | --- | --- | --- |
| **Frequency offset of measurement filter -3 dB point, Δf** | **Frequency offset of measurement filter centre frequency, f\_offset** | **Limit** | ***Measurement bandwidth*** |
| 0 MHz ≤ Δf < 0.1\*BWcontiguous | 0.5 MHz ≤ f\_offset < 0.1\* BWcontiguous +0.5 MHz | Min(-2.3 dBm, Max(Prated,t,TRP – 30.3 dB, -9.3 dBm)) | 1 MHz |
| 0.1\*BWcontiguous ≤ Δf < ΔfB | 0.1\* BWcontiguous +0.5 MHz ≤ f\_offset < ΔfB +0.5 MHz | Min(-13 dBm, Max(Prated,t,TRP – 41 dB, -20 dBm)) | 1 MHz |
| ΔfB ≤ Δf < Δfmax | ΔfB +5 MHz ≤ f\_offset < f\_ offsetmax | Min(-5 dBm, Max(Prated,t,TRP – 31 dB, -10 dBm)) | 10 MHz |
| NOTE 1: For non-contiguous spectrum operation within any *operating band* the limitwithin gaps between *passbands* is calculated as a cumulative sum of contributions from adjacent sub-blocks on each side of the gap between *passbands*. NOTE 2: ΔfB = 2\*BWcontiguous when BWcontiguous ≤ 500 MHz, otherwise ΔfB = BWcontiguous + 500 MHz. |

**Table 6.5.3.4.2-2: OBUE limits applicable in the frequency range 43.5 - 48.2 GHz**

|  |  |  |  |
| --- | --- | --- | --- |
| **Frequency offset of measurement filter -3 dB point, Δf** | **Frequency offset of measurement filter centre frequency, f\_offset** | **Limit** | ***Measurement bandwidth*** |
| 0 MHz ≤ Δf < 0.1\*BWcontiguous | 0.5 MHz ≤ f\_offset < 0.1\* BWcontiguous +0.5 MHz | Min(-2.3 dBm, Max(Prated,t,TRP – 30.3 dB, -9.3 dBm)) | 1 MHz |
| 0.1\*BWcontiguous ≤ Δf < ΔfB | 0.1\* BWcontiguous +0.5 MHz ≤ f\_offset < ΔfB +0.5 MHz | Min(-13 dBm, Max(Prated,t,TRP – 41 dB, -20 dBm)) | 1 MHz |
| ΔfB ≤ Δf < Δfmax | ΔfB +5 MHz ≤ f\_offset < f\_ offsetmax | Min(-5 dBm, Max(Prated,t,TRP – 31 dB, -10 dBm)) | 10 MHz |
| NOTE 1: For non-contiguous spectrum operation within any *operating band* the limitwithin gaps between *passbands* is calculated as a cumulative sum of contributions from adjacent sub-blocks on each side of the gap between *passbands*. NOTE 2: ΔfB = 2\*BWcontiguous when BWcontiguous ≤ 500 MHz, otherwise ΔfB = BWcontiguous + 500 MHz. |

6.5.3.4.3 Additional OTA operating band unwanted emission requirements

6.5.3.4.3.1 Protection of Earth Exploration Satellite Service

For repeater operating in the frequency range 24.25 – 27.5 GHz, the power of unwanted emission shall not exceed the limits in table 6.5.3.4.3.1-1 for DL and in table 6.5.3.4.3.1-2 for UL.

**Table 6.5.3.4.3.1-1: OBUE limits for protection of Earth Exploration Satellite Service for DL**

|  |  |  |
| --- | --- | --- |
| **Frequency range**  | **Limit** | ***Measurement Bandwidth*** |
| 23.6 – 24 GHz | -3 dBm (Note 1) | 200 MHz |
| 23.6 – 24 GHz | -9 dBm (Note 2) | 200 MHz |
| NOTE 1: This limit applies to repeater brought into use on or before 1 September 2027.NOTE 2: This limit applies to repeater brought into use after 1 September 2027. |

**Table 6.5.3.4.3.1-2: OBUE limits for protection of Earth Exploration Satellite Service for UL**

|  |  |  |
| --- | --- | --- |
| **Frequency range**  | **Limit** | ***Measurement Bandwidth*** |
| 23.6 – 24 GHz | 1 dBm | 200 MHz |

6.5.4 OTA transmitter spurious emissions

#### 6.5.4.1 Definition and applicability

For *repeater type 2-O*, the OTA transmitter spurious emission limits apply from 30 MHz to 2nd harmonic of the upper frequency edge of the downlink *operating band*, excluding the frequency range from ΔfOBUE below the lowest frequency of the downlink *operating band*, up to ΔfOBUE above the highest frequency of the downlink *operating band*, where the ΔfOBUE is defined in table 6.5.1-1.

#### 6.5.4.2 Minimum requirement

The minimum requirement is defined in TS 38.106 [x], clause 7.5.4.2.2.

#### 6.5.4.3 Test purpose

This test measures conducted spurious emissions while the transmitter is in operation.

#### 6.5.4.4 Method of test

##### 6.5.4.4.1 Initial conditions

Test environment: Normal; see annex B.2.

RF channels to be tested for single carrier:

- B when testing the spurious emissions below FDL\_low - ΔfOBUE,

- T when testing the spurious emissions above FDL\_high + ΔfOBUE; see clause 4.9.1.

##### 6.5.4.4.2 Procedure

The following procedure for measuring TRP is based on the directional power measurements as described in annex.

1) Place the repeater at the positioner.

2) Align the manufacturer declared coordinate system orientation (D.2) of the repeater with the test system.

3) The measurement devices characteristics shall be:

 - detection mode: true RMS.

4a) Set the input signal at the RIB according to the applicable test configuration and direction in clause 4.8 using the corresponding test models NR-FR1‑TM 1.1 in clause 4.9.2 at the input power intended to produce the maximum rated output power, Pin,p,EIRP + 10dB.

4b) Verify measurement impact from feeding test signal by generating a signal for repeater input with repeater to be turned off. Verify measured result is enough below requirement limit.

5) Orient the positioner (and repeater and test signal source) in order that the direction to be tested aligns with the test antenna such that measurements to determine TRP can be performed with the specified measurement bandwidth (see annex I) whilst maintaining the correct direction of arrival for the test signal.

7) Repeat step 5-6 for all directions in the appropriated TRP measurement grid needed for TRPEstimate (see annex I).

8) Calculate TRPEstimate using the measurements made in Step 7.

#### 6.5.4.5 Test requirements

##### 6.5.4.5.1 General

The requirements of either clause 6.5.4.5.2 (Category A limits) or clause 6.5.4.5.3 (Category B limits) shall apply. The application of either Category A or Category B limits shall be the same as for Operating band unwanted emissions in clause 6.5.3.

##### 6.5.4.5.2 OTA transmitter spurious emissions (Category A)

The power of any spurious emission shall not exceed the limits in table 6.5.4.5.2-1

**Table 6.5.4.5.2-1: Repeater radiated Tx spurious emission limits in FR2**

|  |  |  |  |
| --- | --- | --- | --- |
| **Frequency range** | **Limit** | ***Measurement Bandwidth*** | **Note** |
| 30 MHz – 1 GHz | -13 dBm | 100 kHz | Note 1 |
| 1 GHz – 2nd harmonic of the upper frequency edge of the *passband* |  | 1 MHz | Note 1, Note 2 |
| NOTE 1: Bandwidth as in ITU-R SM.329 [5], s4.1NOTE 2: Upper frequency as in ITU-R SM.329 [5], s2.5 table 1. |

##### 6.5.4.5.3 OTA transmitter spurious emissions (Category B)

The power of any spurious emission shall not exceed the limits in table 6.5.4.5.3-1.

**Table 6.5.4.5.3-1: Repeater radiated Tx spurious emission limits in FR2 (Category B)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Frequency range (Note 4)** | **Limit** | ***Measurement Bandwidth*** | **Note** |
| 30 MHz ↔ 1 GHz | -36 dBm | 100 kHz | Note 1 |
| 1 GHz ↔ 18 GHz | -30 dBm | 1 MHz | Note 1 |
| 18 GHz ↔ Fstep,1 | -20 dBm | 10 MHz | Note 2 |
| Fstep,1  ↔ Fstep,2 | -15 dBm | 10 MHz | Note 2 |
| Fstep,2 ↔ Fstep,3  | -10 dBm | 10 MHz | Note 2 |
| Fstep,4  ↔ Fstep,5 | -10 dBm | 10 MHz | Note 2 |
| Fstep,5  ↔ Fstep,6 | -15 dBm | 10 MHz | Note 2 |
| Fstep,6 ↔ 2nd harmonic of the upper frequency edge of the *passband* | -20 dBm | 10 MHz | Note 2, Note 3 |
| NOTE 1: Bandwidth as in ITU-R SM.329 [5], s4.1NOTE 2: Limit and bandwidth as in ERC Recommendation 74-01 [9], Annex 2.NOTE 3: Upper frequency as in ITU-R SM.329 [5], s2.5 table 1.NOTE 4: The step frequencies Fstep,X are defined in Table 6.5.4.5.3-2. |

**Table 6.5.4.5.3-2: Step frequencies for defining the Repeater radiated Tx spurious emission limits in FR2 (Category B)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Operating band** | **Fstep,1(GHz)** | **Fstep,2(GHz)** | **Fstep,3(GHz) (Note 2)** | **Fstep,4(GHz) (Note 2)** | **Fstep,5(GHz)** | **Fstep,6(GHz)** |
| n258 | 18 | 21 | 22.75 | 29 | 30.75 | 40.5 |
| n259 | 23.5 | 35.5 | 38 | 45 | 47.5 | 59.5 |
| NOTE 1: Fstep,X are based on ERC Recommendation 74-01 [9], Annex 2.NOTE 2: Fstep,3 and Fstep,4 are aligned with the values for ΔfOBUE in Table 6.5.1-1 |

##### 6.5.4.5.4 Additional OTA transmitter spurious emissions requirements

These requirements may be applied for the protection of systems operating in frequency ranges other than the repeater-Node. The limits may apply as an optional protection of such systems that are deployed in the same geographical area as the repeater-Node, or they may be set by local or regional regulation as a mandatory requirement for an NR *operating band*. It is in some cases not stated in the present document whether a requirement is mandatory or under what exact circumstances that a limit applies, since this is set by local or regional regulation.

6.5.4.5.4.1 Limits for protection of Earth Exploration Satellite Service

For repeater operating in the frequency range 24.25 – 27.5 GHz, the power of any spurious emissions shall not exceed the limits in Table 6.5.4.5.4.1-1 and Table 6.5.4.5.4.1-2.

**Table 6.5.4.5.4.1-1: Limits for protection of Earth Exploration Satellite Service for DL**

|  |  |  |  |
| --- | --- | --- | --- |
| **Frequency range**  | **Limit** | ***Measurement Bandwidth*** | **Note** |
| 23.6 – 24 GHz | -3 dBm  | 200 MHz | Note 1 |
| 23.6 – 24 GHz | -9 dBm | 200 MHz | Note 2 |
| NOTE 1: This limit applies to Repeater brought into use on or before 1 September 2027.NOTE 2: This limit applies to Repeater brought into use after 1 September 2027. |

**Table 6.5.4.5.4.1-2: OBUE limits for protection of Earth Exploration Satellite Service for UL**

|  |  |  |
| --- | --- | --- |
| **Frequency range**  | **Limit** | ***Measurement Bandwidth*** |
| 23.6 – 24 GHz | 1 dBm | 200 MHz |

## 6.6 OTA Error Vector Magnitude

6.6.1 Downlink Error vector magnitude

#### 6.6.1.1 General

The Error Vector Magnitude (EVM) is a measure of the difference between the symbols provided at the input of the repeater and the measured signal symbols at the output of the repeater after the equalization by the measurement equipment. This difference is called the error vector. Details about how the EVM is determined are specified in TS 38.104 [x] Annex [C] for FR2. The EVM result is defined as the square root of the ratio of the mean error vector power to the mean reference power expressed in percent.

OTA modulation quality requirement is defined as a *directional requirement* at the RIB and shall be met within the *OTA coverage range* on the transmit side and the AoA of the incident wave of the received signal is in the reference direction at the receive side.

The EVM requirement is applicable when the repeater is operating with an input power level within the range from what is required to reach the rated beam EIRP output power (Prated,p,EIRP) to the minimum power levels in table 6.6.1.1-1.

Table 6.6.1.1-1: Minimum input power for EVM

|  |  |
| --- | --- |
| BS class | Minimum input power (dBm/MHz) |
| 24.25 – 33.4 GHz | 37 – 52.6 GHz |
| Up to 16 QAM | 64QAM 1 | 256QAM 2 | Up to 16 QAM | 64QAM 1 | 256QAM 2 |
| WA, MR, LA | [-77- GRX\_ANT] | [-73- GRX\_ANT] | [-66- GRX\_ANT] | [-75- GRX\_ANT] | [-71- GRX\_ANT] | [-64- GRX\_ANT] |
| Note 1: support of 64QAM is based on the declarationNote 2: support of 256QAM is based on the declaration |

Where GRX\_ANT is the gain of the receive side antennas and is based on EIRP and TRP declaration.

#### 6.6.1.2 Minimum requirements

The minimum requirement is in TS 38.106 [x] clause 7.6.1.2.

#### 6.6.1.3 Test purpose

To verify that the downlink EVM deterioration is within the limit specified by the minimum requirements after the signal passed through the Repeater.

#### 6.6.1.4 Method of test

##### 6.6.1.4.1 Initial conditions

Test environment: normal; see Annex [B.2]

RF channels to be tested for single carrier:

- B and T; see clause 4.9.1.

*Passband* positions to be tested for multi-carrier:

- BRFBW and TRFBW in single-band operation, see clause 4.9.1;

- BRFBW\_T'RFBW and B'RFBW\_TRFBW in multi-band operation, see clause 4.9.1.

Directions to be tested:

- The OTA coverage range reference direction [(D.35)].

- The OTA coverage range maximum directions [(D.36)].

Polarizations to be tested: For dual polarized systems the requirement shall be tested and met for both polarizations.

##### 6.6.1.4.2 Procedure

1a) Place the repeater at the positioner.

1b) Verify measurement impact from feeding test signal by generating a signal for repeater input with repeater to be turned off. Verify measured result is enough below requirement limit.

2) Align the manufacturer declared coordinate system orientation [(D.2)] of the repeater with the test system.

3) Orient the positioner (and repeater) in order that the direction to be tested aligns with the test antenna.

For *repeater type 2-O* declared to be capable of single carrier operation only, set the repeater to transmit a signal according to the applicable test signal configuration and corresponding power setting specified in clause 4.7.2 and 4.8 using the corresponding test models on all carriers configured:

- RDL-FR2-TM3.1a with 256QAM signal if 256QAM is supported by repeater without power back off, or

- RDL-FR2-TM3.1a at manufacturer's declared rated output power if 256QAM is supported by repeater with power back off, and RDL-FR2-TM3.1 with highest modulation order supported without power back off, or

- RDL-FR2-TM3.1 with 64QAM signal if 64QAM is supported by repeater without power back off, or

- RDL-FR2-TM3.1 with highest modulation order without power back off if 64QAM is not supported by repeater, or

- if 64 QAM is supported by repeater with power back off, RDL-FR2-TM 3.1 with 64QAM at manufacturer's declared rated output power (Prated,c,EIRP) and RDL-FR2-TM3.1 with highest modulation order supported at maximum power.

 For *repeater type 2-O* declared to be capable of multi-carrier, set the repeater to transmit according to:

- RDL-FR2-TM3.1a with 256QAM signal if 256QAM is supported by repeater without power back off, or

- RDL-FR2-TM3.1a at manufacturer's declared rated output power if 256QAM is supported by repeater with power back off, and RDL-FR2-TM3.1 at maximum power, or

- RDL-FR2-TM3.1 with 64QAM signal if 64QAM is supported by repeater without power back off, or

- RDL-FR2-TM3.1 with highest modulation order supported without power back off if 64QAM is not supported by repeater, or

- if 64QAM is supported by repeater with power back off, RDL-FR2-TM3.1 with 64QAM signal at manufacturer's declared rated output power (Prated,c,EIRP) and RDL-FR2-TM3.1 with highest supported modulation order at maximum power

 For RDL-FR1-TM 3.1a and RDL-FR2-TM 3.1, power back-off shall be applied if it is declared.

5) For each carrier, measure the EVM and frequency error as defined in annex L.

6) Repeat steps 5 and 6 for RDL-FR2-TM2 if 256QAM is not supported by *repeater type 2-O* or for RDL-FR2-TM2a if 256QAM is supported by *repeater type 2-O*. For RDL-FR2-TM2 the OFDM symbol power (in the conformance direction) shall be at the lower limit of the dynamic range according to the test procedure in clause 6.4.3.4.2 and test requirements in clause 6.4.3.5.2.

2) Adjust the input power to the Repeater to create the maximum nominal Repeater output power at maximum gain.

3) Measure the EVM and frequency error as defined in TS 38.141-2 [x] Annex [F].

4) Repeat the procedure with all the narrower bandwidths of NR-FR2-TM3.1

#### 6.6.1.5 Test requirement

The downlink of the Repeater EVM levels for different modulation schemes shall not exceed values in table 6.6.1.5-1.

Table 6.6.1.5-1: EVM test requirements

|  |  |
| --- | --- |
| **Parameter** | **Required EVM** |
| Up to 16QAM | [13.75%] |
| 64QAM | [9.25 %] 1 |
| 256QAM | [4.75 %]2 |
| Note 1: support of 64QAM is based on the declarationNote 2: support of 256QAM is based on the declaration. |

6.6.2 Uplink Error vector magnitude

#### 6.6.1.1 General

The Error Vector Magnitude (EVM) is a measure of the difference between the symbols provided at the input of the repeater and the measured signal symbols at the output of the repeater after the equalization by the measurement equipment. This difference is called the error vector. Details about how the EVM is determined are specified in TS 38.104 [x] Annex [C] for FR2. The EVM result is defined as the square root of the ratio of the mean error vector power to the mean reference power expressed in percent.

OTA modulation quality requirement is defined as a *directional requirement* at the RIB and shall be met within the *OTA coverage range* on the transmit side and the AoA of the incident wave of the received signal is in the reference direction at the receive side.

The EVM requirement is applicable when the repeater is operating with an input power level within the range from what is required to reach the rated beam EIRP output power (Prated,p,EIRP) to the minimum power levels in table 6.6.1.1-1.

Table 6.6.1.1-1: Minimum input power for EVM

|  |  |
| --- | --- |
| BS class | Minimum input power (dBm/MHz) |
| 24.25 – 33.4 GHz | 37 – 52.6 GHz |
| Up to 16 QAM | 64QAM 1 | 256QAM 2 | Up to 16 QAM | 64QAM 1 | 256QAM 2 |
| WA, MR, LA | [-77- GRX\_ANT] | [-73- GRX\_ANT] | [-66- GRX\_ANT] | [-75- GRX\_ANT] | [-71- GRX\_ANT] | [-64- GRX\_ANT] |
| Note 1: support of 64QAM is based on the declarationNote 2: support of 256QAM is based on the declaration |

Where GRX\_ANT is the gain of the receive side antennas and is based on EIRP and TRP declaration.

#### 6.6.1.2 Minimum requirements

The minimum requirement is in TS 38.106 [x] clause 7.6.1.2.

#### 6.6.1.3 Test purpose

To verify that the downlink EVM deterioration is within the limit specified by the minimum requirements after the signal passed through the Repeater.

#### 6.6.1.4 Method of test

##### 6.6.1.4.1 Initial conditions

Test environment: normal; see Annex [B.2]

RF channels to be tested for single carrier:

- B and T; see clause 4.9.1.

*Passband* positions to be tested for multi-carrier:

- BRFBW and TRFBW in single-band operation, see clause 4.9.1;

- BRFBW\_T'RFBW and B'RFBW\_TRFBW in multi-band operation, see clause 4.9.1.

Directions to be tested:

- The OTA coverage range reference direction [(D.35)].

- The OTA coverage range maximum directions [(D.36)].

Polarizations to be tested: For dual polarized systems the requirement shall be tested and met for both polarizations.

##### 6.6.1.4.2 Procedure

1a) Place the repeater at the positioner.

1b) Verify measurement impact from feeding test signal by generating a signal for repeater input with repeater to be turned off. Verify measured result is enough below requirement limit.

2) Align the manufacturer declared coordinate system orientation [(D.2)] of the repeater with the test system.

3) Orient the positioner (and repeater) in order that the direction to be tested aligns with the test antenna.

For *repeater type 2-O* declared to be capable of single carrier operation only, set the repeater to transmit a signal according to the applicable test signal configuration and corresponding power setting specified in clause 4.7.2 and 4.8 using the corresponding test models on all carriers configured:

- RDL-FR2-TM3.1a with 256QAM signal if 256QAM is supported by repeater without power back off, or

- RDL-FR2-TM3.1a at manufacturer's declared rated output power if 256QAM is supported by repeater with power back off, and RDL-FR2-TM3.1 with highest modulation order supported without power back off, or

- RDL-FR2-TM3.1 with 64QAM signal if 64QAM is supported by repeater without power back off, or

- RDL-FR2-TM3.1 with highest modulation order without power back off if 64QAM is not supported by repeater, or

- if 64 QAM is supported by repeater with power back off, RDL-FR2-TM 3.1 with 64QAM at manufacturer's declared rated output power (Prated,c,EIRP) and RDL-FR2-TM3.1 with highest modulation order supported at maximum power.

 For *repeater type 2-O* declared to be capable of multi-carrier, set the repeater to transmit according to:

- RDL-FR2-TM3.1a with 256QAM signal if 256QAM is supported by repeater without power back off, or

- RDL-FR2-TM3.1a at manufacturer's declared rated output power if 256QAM is supported by repeater with power back off, and RDL-FR2-TM3.1 at maximum power, or

- RDL-FR2-TM3.1 with 64QAM signal if 64QAM is supported by repeater without power back off, or

- RDL-FR2-TM3.1 with highest modulation order supported without power back off if 64QAM is not supported by repeater, or

- if 64QAM is supported by repeater with power back off, RDL-FR2-TM3.1 with 64QAM signal at manufacturer's declared rated output power (Prated,c,EIRP) and RDL-FR2-TM3.1 with highest supported modulation order at maximum power

 For RDL-FR1-TM 3.1a and RDL-FR2-TM 3.1, power back-off shall be applied if it is declared.

5) For each carrier, measure the EVM and frequency error as defined in annex L.

6) Repeat steps 5 and 6 for RDL-FR2-TM2 if 256QAM is not supported by *repeater type 2-O* or for RDL-FR2-TM2a if 256QAM is supported by *repeater type 2-O*. For RDL-FR2-TM2 the OFDM symbol power (in the conformance direction) shall be at the lower limit of the dynamic range according to the test procedure in clause 6.4.3.4.2 and test requirements in clause 6.4.3.5.2.

2) Adjust the input power to the Repeater to create the maximum nominal Repeater output power at maximum gain.

3) Measure the EVM and frequency error as defined in TS 38.141-2 [x] Annex [F].

4) Repeat the procedure with all the narrower bandwidths of NR-FR2-TM3.1

#### 6.6.1.5 Test requirement

The downlink of the Repeater EVM levels for different modulation schemes shall not exceed values in table 6.6.1.5-1.

Table 6.6.1.5-1: EVM test requirements

|  |  |
| --- | --- |
| **Parameter** | **Required EVM** |
| Up to 16QAM | [13.75%] |
| 64QAM | [9.25 %] 1 |
| 256QAM | [4.75 %]2 |
| Note 1: support of 64QAM is based on the declarationNote 2: support of 256QAM is based on the declaration. |

## 6.7 OTA input intermodulation

### 6.7.1 Definition and applicability

#### 6.7.1.1 General

The input intermodulation is a measure of the capability of the repeater to inhibit the generation of interference in the passband, in the presence of interfering signals on frequencies other than the passband.

Third and higher order mixing of the two interfering RF signals can produce an interfering signal in the band of the desired channel. Intermodulation response rejection is a measure of the capability of the repeater to maintain the wanted frequency free of internally created interference.

The measurements shall apply to both uplink and downlink paths of the repeater, at maximum gain.

#### 6.7.1.2 Minimum requirements

The minimum requirement is in TS 38.106 [x] clause 7.7.2.

#### 6.7.1.3 Test purpose

The purpose of this test is to verify that the repeater meets the intermodulation characteristics requirements as specified by the minimum requirements.

#### 6.7.1.4 Method of test

##### 6.7.1.4.1 Initial conditions

Test environment: normal; see Annex B

A measurement system set-up is shown in Annex E.

##### 6.7.1.4.2 Procedure

1a) Verify measurement impact from feeding test signal by generating a signal for repeater input with repeater to be turned off. Verify measured result is enough below requirement limit.

1b) Set the repeater to maximum gain.

2) Place the repeater with its manufacturer declared coordinate system reference point in the same place as calibrated point in the test system, as shown in Annex E.

3) Align the test antennas and repeater both in input and output directions of the repeater.

4) Align the repeater and test antennas so that repeater antennas are polarization matched with the test antenna(s)

5) Configure the beam peak direction of the repeater according to declared reference beam direction pair for the appropriate beam identifier.

6) Adjust the frequency of the input signals, either below or above the passband, so that one carrier, f1, is 1 MHz outside the channel edge frequency of the first or last channel in the passband, and the lowest order intermodulation product from the two carriers is positioned in the centre of the passband.

7) Measure the increase in output power in the passband when the interferer is applied

8) Repeat the measurement for all supported polarizations and all specified measurement directions.

9) Repeat the measurement for the opposite path of the repeater.

#### 6.7.1.5 Test requirements

For the parameters specified in table 6.7.1.5-1, the power in the *passband* shall not increase with more than [10+TT] dB at the output of the repeater as measured with 1 MHz measurement bandwidth, compared to the level obtained without interfering signals applied.

Table 6.7.1.5-1 specifies the parameters for two interfering signals, where:

- f1 offset is the offset from the channel edge frequency of the first or last channel in the *passband* of the closer carrier.

- GRX\_ANT is the gain of the receive side antennas and is calculated from EIRP and TRP declaration.

Table 6.7.1.5-1: Input intermodulation requirement

|  |  |  |  |
| --- | --- | --- | --- |
| f1 offset | Interfering signal levels  | Type of signals | Measurement bandwidth |
| 1 MHz | -53dBm – G\_RX\_ANT | 2 CW carriers | 1 MHz |

## 6.8 OTA Adjacent Channel Rejection Ratio (ACRR)

### 6.8.1 Definitions and applicability

OTA Adjacent Channel Rejection Ratio (ACRR) is the ratio of the average gain over a carrier of the repeater in the *passband* to the average gain of the repeater over an adjacent channel outside the repeater *passband*. The requirement shall apply to the uplink and downlink of the Repeater. The bandwidth of the channel inside the *passband* and the adjacent channel are assumed to be minimum {400MHz, *passband* BW}.

The requirement is differentiated between downlink and uplink.

The requirement shall apply during the *transmitter ON state*.

The ACRR is a ratio of gain in the adjacent channel to gain in the wanted channel. The gain in each case is defined as the ratio of TRP output power to directional input power.

### 6.8.2 Co-existence with NR

This requirement shall be applied for the protection of NR signals in geographic areas in which NR Repeater and NR BS are deployed so that they serve adjacent channels. The reference carrier is a NR carrier.

#### 6.8.2.1 Minimum requirements

The minimum requirement is in TS 38.106 [2] sub-clause 7.8.1.1.

#### 6.8.2.2 Test purpose

To verify that the Repeater OTA ACRR requirement is met as specified in sub-clause 6.8.2.1.

#### 6.8.2.3 Method of test

##### 6.8.2.3.1 Initial conditions

Test environment: normal; see Annex A2.

RF channels to be tested for single carrier: B, M, T; see clause 4.9.1.

Beams to be tested:

As the requirement is TRP the beam pattern(s) may be set up to optimise the TRP measurement procedure (see annex I) as long as the required TRP level is achieved.

##### 6.8.2.3.2 Procedure

1a) Place the repeater with its manufacturer declared coordinate system reference point in the same place as calibrated point in the test system, as shown in annex E.2.7.

1b) Verify measurement impact from feeding test signal by generating a signal for repeater input with repeater to be turned off. Verify measured result is enough below requirement limit.

2) Align the manufacturer declared coordinate system orientation of the repeater with the test system.

3) Align the repeater with the test antenna in the declared direction to be tested.

4) Align the repeater to that the wanted signal and interferer signal is *polarization matched* with the test antenna(s).

5) Set the signal generator to transmit a signal modulated with test model XX for downlink and test model XX for uplink as defined in section 4.9 at the first or last channel with channel offset from frequency range of passband defined in section 6.8.2.3.3 within the pass band.

6) Adjust the input power to the Repeater to create the maximum nominal Repeater output power at maximum gain

7) Orient the positioner (and repeater) in order that the direction to be tested aligns with the test antenna such that measurements to determine TRP can be performed (see annex XX).

8) Measure the absolute power of the assigned channel frequency.

9) Repeat step 7-8 for all directions in the appropriated TRP measurement grid needed for TRPEstimate (see annex XX).

10) Calculate TRPEstimate for the absolute total radiated power of a carrier of the repeater in the *passband* and using the measurements made in Step 9.

11) Set the signal generator to transmit the same signal and the same input power at one of the channel offsets outside the repeater pass band according to Tables in section 6.8.2.3.3.

12) Repeat step 7) to 9) for the measurement of the input signal outside the repeater pass-band.;

13) Calculate TRPEstimate for the absolute total radiated power of a carrier over an adjacent channel outside the repeater *passband* and using the measurements made in Step 9.

14) Calculate relative ACRR estimate.

15) Repeat step 5) to 14) until all channel offsets in Tables in section 6.8.2.3.3 are measured.

##### 6.8.2.3.3 Test Requirements

The requirement shall apply at the RIB when the AoA of the incident wave of a received signal in the *passband* and a received signal on an adjacent channel outside repeater *passband* is from the same direction and are the same as the TX reference direction for the opposite DL/UL setting*.*

For a repeater operating at passband operating in FR2, the ACRR requirements in table 6.8.2.3.3-1 shall apply in downlink. In normal conditions the ACRR for downlink shall be higher than the value specified in the Table 6.8.2.3.3-1.

**Table 6.8.2.3.3-1: Repeater Downlink ACRR**

|  |  |  |  |
| --- | --- | --- | --- |
| Co-existence with other systems | Repeater Class | Channel offset from frequency edge of *passband* (MHz) | ACRR limit (dB) |
| NR | Wide Area repeater | minimum {400MHz, *passband* BW}/2 | [28] (Note 2)[26] (Note 3) |
| Medium Range repeater | minimum {400MHz, *passband* BW}/2 | [28] (Note 2)[26] (Note 3) |
| Local Area repeater | minimum {400MHz, *passband* BW}/2 | [28] (Note 1, 2)[26] (Note 1, 3) |
| NOTE 1: This requirement is not applicable if the *passband* occupies the entire *operating band*.NOTE 2: Applicable to bands defined within the frequency spectrum range of 24.25 – 33.4 GHz.NOTE 3: Applicable to bands defined within the frequency spectrum range of 37 – 52.6 GHz |

For a repeater operating at passband operating in FR2, the ACRR requirements in table 6.8.2.3.3-2 shall apply in uplink. In normal conditions the ACRR for uplink shall be higher than the value specified in the Table 6.8.2.3.3-2.

**Table 6.8.2.3.3-2: Repeater Uplink ACRR**

|  |  |  |  |
| --- | --- | --- | --- |
| Co-existence with other systems | Repeater Class | Channel offset from frequency edge of *passband* (MHz) | ACRR limit (dB) |
|  NR | Wide Area repeater | minimum {400MHz, *passband* BW}/2 | [28] (Note 2)[26] (Note 3) |
| Local Area repeater | minimum {400MHz, *passband* BW}/2 | [17] (Note 1, 2)[16] (Note 1, 3) |
| NOTE 1: This requirement is not applicable if the *passband* occupies the entire *operating band*.NOTE 2: Applicable to bands defined within the frequency spectrum range of 24.25 – 33.4 GHz.NOTE 3: Applicable to bands defined within the frequency spectrum range of 37 – 52.6 GHz |

## 6.9 OTA transmit ON/OFF power

6.9.1 OTA transmitter OFF power

6.9.1.1 Definition and applicability

OTA transmitter OFF power is defined as the mean power measured over 70/N µs filtered with a square filter of bandwidth equal to the *passband bandwidth* of the repeater (BWpassband) centred on the assigned channel frequency during the *transmitter OFF state*. N = SCS/15, where SCS is Sub Carrier Spacing in kHz of the input signal. The OTA transmitter OFF power is defined as TRP.

6.9.1.2 Minimum requirement

The minimum requirement is in TS 38.106 [x], clause 7.9.2.2.

6.9.1.3 Test purpose

The purpose of this test is to verify the OTA transmitter OFF power is within the limits of the minimum requirements.

6.9.1.4 Method of test

Requirement is tested together with transmitter transient period, as described in clause 6.9.2.4.

6.9.1.5 Test requirements

The conformance testing of transmit OFF power is included in the conformance testing of transmitter transient period; therefore, see clause 6.9.2.5 for test requirements.

6.9.2 OTA transient period

6.9.2.1 Definition and applicability

The OTA *transmitter transient period* is the time period during which the transmitter is changing from the tra*nsmitter OFF state* to the *transmitter ON state* or vice versa. The *transmitter transient period* is illustrated in figure 6.9.2.1-1.



**Figure 6.9.2.1-1: Example of relations between transmitter *ON state*, transmitter *OFF state* and *transmitter transient period***

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

For a repeater that is not declared to be a long delay repeater (D.15), the beginning and end point of downlink and uplink bursts are referenced to the slot timing at the input.

For a repeater that is declared to be a long delay repeater (D.15), the beginning and end point of downlink and uplink bursts are referenced to the slot timing at the input plus the declared repeater delay.

6.9.2.2 Minimum requirement

The minimum requirement is in TS 38.106 [x], clause 7.9.3.2.

6.9.2.3 Test purpose

The purpose of this test is to verify the OTA transmitter transient periods are within the limits of the minimum requirements.

6.9.2.4 Method of test

6.9.2.4.1 Initial conditions

Test environment: Normal; see annex B.2.

RF channels to be tested: M; see clause 4.9.1.

Directions to be tested:

- The requirement is verified by an EIRP measurement at a direction corresponding to the OTA peak directions set reference beam direction pair (D.8) for the beam identifier (D.3) which provides the highest intended EIRP.

6.9.2.4.2 Procedure

1a) Place the repeater at the positioner.

1b) Verify measurement impact from feeding test signal by generating a signal for repeater input with repeater to be turned off. Verify measured result is enough below requirement limit.

2) Align the manufacturer declared coordinate system orientation (D.2) of the repeater with the test system.

4a) For trainsient period measurement, set the input signal at the RIB according to the applicable test configuration and direction in clause 4.8 using the corresponding test models NR-FR2‑TM 1.1 in clause 4.9.2 at the input power intended to produce the maximum rated output power, Prated,in, EIRP + 10dB.

4b)For OFF power measurement, set the signal generator RF output turned off for not to generate input signal.

5) Orient the positioner (and repeater and test signal source) in order that the direction to be tested aligns with the test antenna such that measurements to determine TRP can be performed (see annex I) whilst maintaining the correct direction of arrival for the test signal.

6) Measure the mean EIRP spectral density as the power sum over two orthogonal polarizations over 70/N μs filtered with a square filter of bandwidth equal to the *passband* bandwidth of the repeater centred on the central frequency of the *passband*. 70/N μs average window centre is set from 35/N μs after end of one transmitter ON period + 3 μs to 35/N μs before start of next transmitter ON period - 3 μs. N = SCS/15, where SCS is Sub Carrier Spacing in kHz.

NOTE: Make sure that the measurement receiver is not overloaded.

6.9.2.5 Test requirements

The OTA transmitter OFF TRP spectral density for *repeater type 2-O* shall be less than ‑33.1 dBm/MHz for the frequency range 24.25 – 29.5 GHz.

The OTA transmitter OFF TRP spectral density for *repeater type 2-O* shall be less than ‑32.7 dBm/MHz for the frequency range 37 - 43.5 GHz.

The OTA transmitter OFF TRP spectral density for *repeater type 2-O* shall be less than ‑32.4 dBm/MHz for the frequency range 43.5 – 48.2 GHz.

# Annex A (normative):

# Repeater stimulus signals

# A.1 Repeater stimulus signal 1

This repeater stimulus signal shall be used for tests on:

- Uplink maximum output power

- Uplink operating band unwanted emissions

- Uplink spurious emissions

Two uplink fixed reference channels for performance requirements (16QAM ¾) for FDD according to the TS38.141-2 [x], [A.4 table A.4-1, channel reference A4-3 of 50 MHz] bandwidth generated on separate centre frequencies with equal power and combined with a time difference of [266,7 us (4 OFDM symbols)].

The PUSCH data payload shall contain only zeroes (0000 0000)

Each reference channel shall be subjected to time windowing and filtering so that it fulfils the spectral purity requirements defined in A.3

# A.2 Repeater stimulus signal 2

This repeater stimulus signal shall be used for tests on:

- Downlink operating band unwanted emissions

- Downlink spurious emissions

Two NR-FR2-TM1.1 channels according to the TS38.141-2 [x] of 50 MHz bandwidth generated on separate centre frequencies with equal power and combined with a time difference of [1400 us (21 OFDM symbols)].

Each NR-FR2-TM1.1 channel shall be subjected to time windowing and filtering so that it fulfils the spectral purity requirements defined in A.3.

# A.3 Repeater stimulus signal spectral purity requirements

The reference channels or test models constituting the repeater stimulus signal shall fulfil the spectral purity requirements defined by table A.3-1, where;

- the reference spectral density shall be taken 200 kHz off the carrier centre frequency with an integration bandwidth of 30 kHz.

- Δf is the separation between the channel edge frequency and the nominal -3dB point of the measuring filter closest to the carrier frequency.

- f\_offset is the separation between the channel edge frequency and the centre of the measuring filter.

- f\_offsetmax is the offset to the frequency 10 MHz outside the downlink operating band.

- Δfmax is equal to f\_offsetmax minus half of the bandwidth of the measuring filter.

- the minimum spectral density suppression is related to the reference spectral density.

[Table A.3-1: Repeater stimulus signal spectral purity requirements]

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency offset of measurement filter ‑3dB point, Δf | Frequency offset of measurement filter centre frequency, f\_offset | Minimum requirement | Measure-ment bandwidth  |
| 0 MHz ≤ Δf < 0.15 MHz | 0.015 MHz ≤ f\_offset < 0.165 MHz | -40 + 20\*( f\_offset -0.015) dBc | 30 kHz |
| 0.15 MHz ≤ Δf < 0.2 MHz | 0.165 MHz ≤ f\_offset < 0.215 MHz | -37 dBc | 30 kHz |
| 0.2 MHz ≤ Δf < 1 MHz | 0.215 MHz ≤ f\_offset < 1.015 MHz |  | 30 kHz  |
|  | 1.015 MHz ≤ f\_offset < 1.5 MHz | -106 dBm | 30 kHz |
| 1 MHz ≤ Δf < 2.8 MHz | 1.5 MHz ≤ f\_offset < 2.85 MHz | -78 dBm | 1 MHz  |
| 2.8 MHz ≤ Δf ≤ Δfmax | 2.85 MHz ≤ f\_offset < f\_offsetmax  | -80 dBm | 1 MHz |
| NOTE: Frequencies and bandwidths are given in MHz |

# Annex B (normative):

# Environmental requirements for the Repeater equipment

<Text will be added.>

# Annex C (informative):

# Test tolerances and derivation of test requirements

<Text will be added.>

# Annex D (normative):

# Calibration

OTA test requirements specific and OTA measurement chamber specific calibration (and measurement) procedures were captured in [xxx] for the following requirements sets:

- TX directional requirements

- within passband and out-of-passband TRP requirements.

# Annex E (informative):

#  OTA measurement system set-up

**E.1 OTA output power EIRP, OTA Frequency stability, OTA Error Vector Magnitude and OTA Transmit ON/OFF power**



Figure E.1-1: Measuring system set-up for maximum EIRP testing

Note 1: The repeater is a bi-directional device. The signal generator may need protection.

Note 2: The OTA chamber shown in figure E.1-1 is intended to be generic and can be replaced with any suitable OTA chamber (Far field anechoic chamber, etc.)

Note 3: UL/DL timing can be provided to the repeater.

**E.2 Out of band gain**



Figure E.2-1: Measuring system set-up for out of band gain

Note 1: That repeater is a bi-directional device. The signal generator may need protection.

Note 2: The OTA chamber shown in figure E.2-1 is intended to be generic and can be replaced with any suitable OTA chamber (Far field anechoic chamber, etc.)

Note 3: It is possible to keep the repeater static but move the measurement probes or use multiple probe.

**E.3 Unwanted emission: Operating band unwanted emission and ACLR**



Figure E.3-1: Measuring system set-up for unwanted emission: ACLR, Operating band unwanted emission and spurious emission requirement

Note 1: That repeater is a bi-directional device. The signal generator may need protection.

Note 2: The OTA chamber shown in figure E.3-1 is intended to be generic and can be replaced with any suitable OTA chamber (Far field anechoic chamber, etc.)

Note 3: It is possible to keep the repeater static but move the measurement probes or use multiple probe.

Note 4: UL/DL timing can be provided to the repeater.

**E.4 Input intermodulation**



Figure E.4-1: Measuring system set-up for input intermodulation.

Note 1: That repeater is a bi-directional device. The signal generator may need protection.

Note 2: The OTA chamber shown in figure E.4-1 is intended to be generic and can be replaced with any suitable OTA chamber (Far field anechoic chamber, etc.)

Note 3: It is possible to keep the repeater static but move the measurement probes or use multiple probe.

**E.5 Adjacent Channel Rejection Ratio**



Figure E.5-1: Measuring system set-up for Adjacent Channel Rejection Ratio

Note 1: That repeater is a bi-directional device. The signal generator may need protection.

Note 2: The OTA chamber shown in figure E.5-1 is intended to be generic and can be replaced with any suitable OTA chamber (Far field anechoic chamber, etc.)

Note 3: It is possible to keep the repeater static but move the measurement probes or use multiple probe.

Note 4: UL/DL timing can be provided to the repeater.

# Annex F (normative):

# Characteristics of interfering signals

<Text will be added.>

# Annex G (normative):

#  In-channel TX tests

<Text will be added.>

# Annex H (informative):Change history

|  |
| --- |
| **Change history** |
| **Date** | **TSG #** | **TSG Doc.** | **CR** | **Rev** | **Subject/Comment** | **Old** | **New** |
|  |  |  |  |  |  |  |  |