**3GPP TSG-RAN WG4 Meeting #111 R4-2408940**

**Fukuoka, Japan, May 20 – 24, 2024**

**Agenda item:** 10.8.4

**Source:** Moderator (CMCC)

**Title:** Topic summary for [111][129] NR\_ATG\_enh

**Document for:** Information

# Introduction

*RAN#103 meeting approved RP-240839 New WID on Enhancements for Air-to-ground network for NR in Rel-19. This is the first meeting for R19.*

*This thread focuses on UE RF requirement parts for Rel-18 ATG maintenance and Rel-19 ATG enhancement and corresponds to agenda 5.2.6.1, 10.8.1 and 10.8.2.*

*Previous approved WF are listed as below:*

* *R4-2406594, WF on Rel-19 ATG UE requirements, CMCC, RAN4#110 bis*

# Topic #1: R18 UE RF requirements maintenance

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2407273**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2407273.zip)Formal CR | Apple | The following symbols are introduced for better description of the requirements.Pmax,c,ACMaximum carrier output power measured per antenna connectorPmax,c,TABC The maximum carrier output power per TAB connectorPrated,c,AC The rated carrier output power per antenna connectorPrated,c,TABC The rated carrier output power per TAB connectorDescription is updated for the following requirements,UE maximum output power for ATGConfigured transmitted power for ATGUpdated sub-clause includes: 3.2, 6.1J, 6.2J, 7.1J, 7.3J |
| [**R4-2407274**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2407274.zip)Formal CR | Apple | Description for REFESENS requirements need clarification with regard to different ATG UE antenna type. |
| [**R4-2407288**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2407288.zip)LS | Apple | LS on signalling *maxOutputPowerATG-r18*During 111 meeting, RAN4 had some discussion on the signaling name maxOutputPowerATG-r18. It is found that the current signalling name may cause some confusion as the UE declared is rated output power without tolerance. While maximum output power is rated output power with tolerance added. RAN4 propose to change the signaling name to *ratedOutputpowerATG-r18*. |
| [**R4-2407601**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2407601.zip)Formal CR | China Mobile Com. Corporation | In RAN4 #110bis meeting, the formal CR R4-2403864 for 38.101-1 of ATG has been approved. But after further check, only part of update in R4-2403864 has been captured in latest TS 38.101-1. This CR capture the remaining part of R4-2403864 which are not captured into latest TS 38.101-1 i50. Updated sub-clause includes: 3.1, 3.2, 6.1J, 6.2J, 6.4J and 7.5J |
| [**R4-2407979**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2407979.zip)Formal CR of 38.101-1 | LG Electronics, Huawei | For ATG UE, the measured configured maximum output power PUMAX,f,c is missed. It needs to be specified. It is a re-submission of the endorsed draft CR (R4-2406593).Updated sub-clause is 6.2J.2 |
| [**R4-2409320**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2409320.zip)discussion | Huawei, HiSilicon | **Proposal 1: RAN4 can discuss whether the following definitions of Tx requirements for ATG in table 2 are applicable or not.**

|  |  |
| --- | --- |
| **Tx requirements for ATG UE** | **The definition for Tx requirements** (Defined as the **sum of all antenna connectors** or **at each antenna connector)** |
| **6.2J Transmitter power for ATG** |  |
| 6.2J.1 UE maximum output power for ATG | **Defined as the sum of all antenna connectors** |
| 6.2J.2 Configured transmitted power for ATG | **Defined as the sum of all antenna connectors** |
| **6.3J Output power dynamics for ATG** |  |
| 6.3J.1 Minimum output power for ATG | **Defined as the sum of all antenna connectors** |
| 6.3J.2 Transmit OFF power for ATG | Defined at each antenna connector |
| 6.3J.3 Transmit ON/OFF time mask for ATG | Defined at each antenna connector |
| 6.3J.4 Power control for ATG | **Defined as the sum of all antenna connectors** |
| **6.4J Transmit signal quality for ATG** |  |
| 6.4J.1 Frequency error for ATG | Defined at each antenna connector |
| 6.4J.2 Transmit modulation quality for ATG | TBD |
| **6.5J Output RF spectrum emissions for ATG** |  |
| 6.5J.1 Occupied bandwidth for ATG | **Defined as the sum of all antenna connectors** |
| 6.5J.2 Out of band emission for ATG | **Defined as the sum of all antenna connectors** |
| 6.5J.3 Spurious emissions for ATG | **Defined as the sum of all antenna connectors** |

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| [**R4-2409321**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2409321.zip)Formal CR of 38.876 | Huawei, HiSilicon | For ATG UE, the measured configured maximum output power PUMAX,f,c is missed. Referring to the endorsed draft CR R4-2406593, the technical parts are introduced with some highlighted notes. |
| [**R4-2409322**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2409322.zip)Formal CR | Huawei, HiSilicon | Since ATG UE can support a larger range of the maximum output power compared to the handheld UE, RAN4 can consider to set the transmitter to Pcmax instead of 4 dB below.There is an editorial error in NOTE 1 of table 7.5J-4.Updated sub-clause includes: 7.5J |
| [**R4-2409498**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2409498.zip)Formal CR | ZTE Corporation, Sanechips | The Definitions of ATG UE are inaccurate and need to be updated.Update the Definitions of ATG UE in clause 3.1.Updated sub-clause includes: 7.5J |

## Open issues summary

This corresponds to item 5.2.6.1.

### Sub-topic 1-1 power related signaling

**Issue 1-1: whether to update the signaling *maxOutputPowerATG-r18* by new *ratedOutputpowerATG-r18*, the *maxOutputPowerATG-r18* is adding tolerance on top of *ratedOutputpowerATG-r18***

* Proposals
	+ Option 1: update the signaling name and send the LS to RAN2 for update
		- R4-2407288(APPLE) could be the baseline
	+ Option 2: no need to update the singling name but only updating in RAN4 spec, e.g. using different symbols in RAN4 to emphasize when rated power applies and when max output power applies
* Recommended WF:
	+ Option 2

ZTE: we are fine the recommend WF.

Qualcomm: In RAN4 we use the similar statement. If we change wording, it will impact RAN5.

Apple: Besides this change others are OK.

Agreement:

* no need to update the singling name in RAN2
* FFS on whether to update the wording in RAN4 spec.

### Sub-topic 1-2 Tx requirements applicability

In last meeting, APPLE propose one CR to differentiate reference point for two kinds of UE types. There is no agreements in last meeting and the CR is resubmitted in this meeting. Before approve this CR, at first RAN4 needs to find out which RF requirements needs to explicitly describe the reference point in spec, e.g. the RF requirement is defined at sum of antenna connectors or TAB connectors

**Issue 1-2: the reference point of all ATG Tx requirements for two types of antenna**

* Proposals
	+ Option 1: only maximum output power and configured output power
	+ Option 2: (Huawei)

Table 2 Tx requirements definition for two types of ATG UE antenna

|  |  |
| --- | --- |
| **Tx requirements for ATG UE** | **The definition for Tx requirements** (Defined as the **sum of all antenna connectors/TAB connectors** or **at each antenna connector/TAB connector)** |
| **6.2J Transmitter power for ATG** |  |
| 6.2J.1 UE maximum output power for ATG | **Defined as the sum of all antenna connectors/TAB connectors** |
| 6.2J.2 Configured transmitted power for ATG | **Defined as the sum of all antenna connectors/TAB connectors** |
| **6.3J Output power dynamics for ATG** |  |
| 6.3J.1 Minimum output power for ATG | **Defined as the sum of all antenna connectors/TAB connectors** |
| 6.3J.2 Transmit OFF power for ATG | Defined at each antenna connector/TAB connector |
| 6.3J.3 Transmit ON/OFF time mask for ATG | Defined at each antenna connector/TAB connector |
| 6.3J.4 Power control for ATG | **Defined as the sum of all antenna connectors/TAB connectors** |
| **6.4J Transmit signal quality for ATG** |  |
| 6.4J.1 Frequency error for ATG | Defined at each antenna connector/TAB connector |
| 6.4J.2 Transmit modulation quality for ATG | TBD |
| **6.5J Output RF spectrum emissions for ATG** |  |
| 6.5J.1 Occupied bandwidth for ATG | **Defined as the sum of all antenna connectors/TAB connectors** |
| 6.5J.2 Out of band emission for ATG | **Defined as the sum of all antenna connectors/TAB connectors** |
| 6.5J.3 Spurious emissions for ATG | **Defined as the sum of all antenna connectors/TAB connectors** |

* + Option 2: TBA
* Recommended WF:
	+ TBD

Huawei: the issues were identified last meeting. After further checking with Apple, some requirements can be defined at antenna connector. If we remove general, we need add some specific clarifications.

ZTE: for ATG with omini-antenna, … for ATG with array, there are multiple connectors. We can reuse the way for UL-MIMO definitions.

Apple: As Huawei mentioned, this is triggered by Apple paper. Huawei proposal gives the comprehensive lists.

Moderator: Leave it FFS in this meeting.

### Sub-topic 1-3 transmitter power for ACS testing

**Issue 1-3: transmitter power for ACS testing case 1 and 2**

* Proposals
	+ Option 1: maintain the same as in current spec, i.e.
		- for case 1, note 1: the transmitter shall be set to 4 dB below PCMAX\_L,f,c at the minimum UL configuration specified in Table 7.3.2-3 with PCMAX\_L,f,c defined in clause 6.2J.2
		- For case 2, note 1: NOTE 1: The transmitter shall be set to 24 dB below PCMAX\_L,f,c at the minimum UL configuration specified in Table 7.3.2-3 with PCMAX\_L,f,c defined in clause 6.2J.3
	+ Option 2: To clarify that the transmitter shall be set to Pcmax when testing ACS, i.e. in CR R4-2409322(Huawei)
		- for case 1, note 1: the transmitter shall be set to PCMAX,f,c at the minimum UL configuration specified in Table 7.3.2-3 with PCMAX,f,c defined in clause 6.2J.2
		- For case 2, note 1: NOTE 1: The transmitter shall be set to PCMAX,f,c at the minimum UL configuration specified in Table 7.3.2-3 with PCMAX,f,c defined in clause 6.2J.2
* Recommended WF:
	+ maintain current spec unchanged.
	+ It’s noted if option 2 is approved, this update also applies for other receiver RF requirements besides ACS.

Huawei: we use different approach to define ATG UE. Current transmitter condition is copied from normal handheld UE. For ATG transmitter we can use the simple approach.

ZTE: Tend to agree with moderator to keep the current spec and check the proposal further.

Chair: Check it until the next meeting.

### Sub-topic 1-4 recommendation for the formal CR provided in this meeting

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** | **Comments from moderator** | **recommendation** |
| [**R4-2407273**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2407273.zip)Formal CR | Apple | Updated sub-clause includes: 3.2, 6.1J, 6.2J, 7.1J, 7.3J | The sub-clause 6.2J repeating two times | Revised and merge 7601, 9498Detailed updates based on conclusion of sub-topic 1-2 |
| [**R4-2407274**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2407274.zip)Formal CR | Apple | Updated sub-clause includes: 3.2, 6.1J, 6.2J, 7.1J, 7.3J,  | the sub-set of 7273 | noted |
| [**R4-2407601**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2407601.zip)Formal CR | China Mobile Com. Corporation | In RAN4 #110bis meeting, the formal CR R4-2403864 for 38.101-1 of ATG has been approved. But after further check, only part of update in R4-2403864 has been captured in latest TS 38.101-1. This CR capture the remaining part of R4-2403864 which are not captured into latest TS 38.101-1 i50. Updated sub-clause includes: 3.1, 3.2, 6.1J, 6.2J, 6.4J and 7.5J |  | Merged |
| [**R4-2407979**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2407979.zip)Formal CR of 38.101-1 | LG Electronics, Huawei | For ATG UE, the measured configured maximum output power PUMAX,f,c is missed. It needs to be specified. It is a re-submission of the endorsed draft CR (R4-2406593).Updated sub-clause is 6.2J.2 |  | agreed |
| [**R4-2409321**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2409321.zip)Formal CR of 38.876 | Huawei, HiSilicon | For ATG UE, the measured configured maximum output power PUMAX,f,c is missed. Referring to the endorsed draft CR R4-2406593, the technical parts are introduced with some highlighted notes. |  | agreed |
| [**R4-2409322**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2409322.zip)Formal CR | Huawei, HiSilicon | Since ATG UE can support a larger range of the maximum output power compared to the handheld UE, RAN4 can consider to set the transmitter to Pcmax instead of 4 dB below.There is an editorial error in NOTE 1 of table 7.5J-4.Updated sub-clause includes: 7.5J |  | Based on conclusion of sub-topic 1-3 |
| [**R4-2409498**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2409498.zip)Formal CR | ZTE Corporation, Sanechips | The Definitions of ATG UE are inaccurate and need to be updated.Update the Definitions of ATG UE in clause 3.1.Updated sub-clause includes: 7.5J |  | Merged |

# Topic #2: R19 UE RF for intra-band contiguous CA

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2407279**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2407279.zip) | Apple | ***Proposal 1: it is proposed to adopt option 2 for ATG intra-band CA operation in Band n79.*** ***Proposal 2: it is proposed to use the analysis in Table 2.2-1 as the baseline for ATG UE Rx RF requirements development.*** |
| [**R4-2407951**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2407951.zip) | CMCC | **Proposal 1: Use the following BCS for CA\_n79C.****Table 1: BCS for CA\_n79C**

|  |
| --- |
| **NR CA configuration / Bandwidth combination set** |
| **NR CA configuration** | **Uplink CA configurations or single uplink carrier5** | **Channel bandwidths for carrier (MHz)** | **Channel bandwidths for carrier (MHz)** | **Channel bandwidths for carrier (MHz)** | **Channel bandwidths for carrier (MHz)** | **Channel bandwidths for carrier (MHz)** | **Maximum aggregated bandwidth (MHz)** | **Bandwidth combination set** |
| CA\_n79C | CA\_n79C | 50 | 60, 80, 100 |  |  |  | 200 | 0 |
|  |  | 60 | 60, 80, 100 |  |  |  |  |  |
|  |  | 80 | 80, 100 |  |  |  |  |  |
|  |  | 100 | 100 |  |  |  |  |  |
|  |  | See n79 channel bandwidths in Table 5.3.5-1 for each carrier2 |  |  |  | 200 | 4 and 5 |

**Proposal 2: Requirements of TDD contiguous intra-band CA in TS 38.101-1 sub-clause 7.3A.2.1 could be reused for ATG UE with intra-band CA.****Proposal 3: The max input level requirements for ATG UE with intra-band CA could be specified in table 3, and the principle in TS 38.101-1 sub-clause 7.4A.1 could be reused.****Proposal 4: The ACS principle and requirements for in clause 7.5A.1 for intra-band contiguous CA could be reused expect for the test parameters case 2, and case 2 could be defined as Table 6.****Proposal 5: The requirements specified in clause 7.6A.2.1 could be reused for ATG UE with intra-band contiguous CA.****Proposal 6: The requirements specified in clause 7.6A.3.1 could be reused for ATG UE with intra-band contiguous CA.****Proposal 7: There is no narrow band blocking requirement for ATG UE.****Proposal 8: The requirements specified in clause 7.7A.1 could be reused for ATG UE with intra-band contiguous CA.****Proposal 9: The intermodulation requirements specified in clause 7.8A.2.1 could be reused for ATG UE with intra-band contiguous CA.** |
| [**R4-2409333**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2409333.zip) | Huawei, HiSilicon | **Proposal 1: To reuse the existing configuration table for ATG UE supporting DL CA\_n79C.****Proposal 2: The information that only DL CA is supported in Rel-19 for ATG can be reflected in the clause of operating band for ATG.****Proposal 3: the requirements specified in clause 7.2J can be reused for DL CA\_n79C for Diversity characteristics.****Proposal 4: the following requirements for DL contiguous CA with one UL carrier specified in clause 7.3A.2.1 could be considered. Further discuss whether to include FDD REFSENS table 7.3.2-1a.**

|  |
| --- |
| 7.3A.2.1 Reference sensitivity power level for Intra-band contiguous CAFor intra-band contiguous carrier aggregation, the throughput of each component carrier shall be ≥ 95 % of the maximum throughput of the reference measurement channels as specified in Annexes A.2.2.2, A.3.2, and A.3.3 (with one sided dynamic OCNG Pattern OP.1 FDD/TDD for the DL-signal as described in Annex A.5.1.1/A.5.2.1) with parameters specified in Table 7.3.2-1a, Table 7.3.2-1b, Table 7.3.2-2, and Table 7.3.2-3.For UE(s) supporting one uplink carrier, the uplink configuration of the PCC shall be in accordance with Table 7.3.2-3 and the downlink PCC carrier center frequency shall be configured closer to uplink operating band than any of the downlink SCC center frequency. |

**Proposal 5: To introduce the following table for ATG CA maximum input level requirements.**

|  |  |  |  |
| --- | --- | --- | --- |
| Rx Parameter | Units | ATG UE Types | Reference measurement channel |
| Omni-directional antenna: receiver characteristics specified at the antenna connector(s) | Antenna array: receiver characteristics specified at transceiver array boundary (TAB) connectors |
| Power in Transmission Bandwidth Configuration | dBm | -42 | -30 | A.3.2.3 or A.3.3.3 for 64 QAM |
|  |  | -44 | -32 | A.3.2.4 or A.3.3.4 for 256 QAM |
| Power in each other CC | dBm | Plargest BW +10\*log{(NRB,c\*SCSc)/(NRB,largest BW\*SCSlargest BW)} |
| The applicable NR CA Bandwidth Class | MHz | **C** |
| NOTE 1: The transmitter shall be set to 4 dB below PCMAX\_L,f,c at the minimum uplink configuration specified in Table 7.3.2-3 with PCMAX\_L,f,c as defined in clause 6.2J.2. |

 |
| [**R4-2409601**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2409601.zip) | ZTE Corporation, Sanechips | **Proposal 1**: use BCS0 for band combination n79C if there are no practical market demand for 10/20/30/70MHz channel bandwidth.**Proposal 2**: for RF requirements for inter-band DL CA, refer to the proposals in table 2.  |
| [**R4-2409661**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2409661.zip) | Ericsson | [Proposal 1 BCS 0, 4, and 5 should be considered for CA\_n79C](#_Toc166054394)[Proposal 2 For intra-band contiguous CA, Power in largest transmission bandwidth configuration CC, Plargest BW should be updated as -42 dBm for omni antenna and -30 dBm for array antenna.](#_Toc166054395)[Proposal 4 For reference sensitivity, blocking characteristic, spurious response, and intermodulation characteristics, the existing requirements defined in clause 7 could be reused.](#_Toc166054396) |

## Open issues summary

This corresponds to agenda 10.8.2.1

### Sub-topic 2-1 system parameters

**Issue 2-1-1: BCS for DL CA\_n79C**

* Proposals
	+ Option 1: BCS0 if there are no practical market demand for 10/20/30/70MHz channel bandwidth (ZTE, APPLE)

Table 2.2-1 BCS for CA\_n79C

|  |
| --- |
| NR CA configuration / Bandwidth combination set |
| NR CA config | Uplink CA config  | Channel bandwidths for carrier (MHz) | Channel bandwidths for carrier (MHz) | Channel bandwidths for carrier (MHz) | Channel bandwidths for carrier (MHz) | Channel bandwidths for carrier (MHz) | Maximum aggregated bandwidth (MHz) | BCS |
| CA\_n79C | - | 50 | 60, 80, 100 |  |  |  | 200 | 0 |
| 60 | 60, 80, 100 |  |  |  |  |  |
| 80 | 80, 100 |  |  |  |  |  |
| 100 | 100 |  |  |  |  |  |

* + Option 2: BCS0, BCS4 and 5, the same as what have been specified for TN (CMCC, Huawei, Ericsson)

**Table 1: BCS for CA\_n79C**

|  |
| --- |
| **NR CA configuration / Bandwidth combination set** |
| **NR CA configuration** | **Uplink CA configurations or single uplink carrier5** | **Channel bandwidths for carrier (MHz)** | **Channel bandwidths for carrier (MHz)** | **Channel bandwidths for carrier (MHz)** | **Channel bandwidths for carrier (MHz)** | **Channel bandwidths for carrier (MHz)** | **Maximum aggregated bandwidth (MHz)** | **Bandwidth combination set** |
| CA\_n79C | CA\_n79C | 50 | 60, 80, 100 |  |  |  | 200 | 0 |
|  |  | 60 | 60, 80, 100 |  |  |  |  |  |
|  |  | 80 | 80, 100 |  |  |  |  |  |
|  |  | 100 | 100 |  |  |  |  |  |
|  |  | See n79 channel bandwidths in Table 5.3.5-1 for each carrier2 |  |  |  | 200 | 4 and 5 |

* Recommended WF
	+ Option 2.

Huawei: generally we are fine with Option 2. One issue for option 1 is whether we will specify the separate conditions of CA for ATG. If not we would like to follow existing CA configuration. We do not need to create the separate ones. Operator can request the new configuration via basket.

ZTE: Option 2 is not allowed by the current basket. To support BCS#4 and #5 is not needed.

Huawei: We can clarify the uplink capability in the other clause. The reason to use the existing CA configuration is that RAN2 only has one IE to indicate the BCS. All the BCS are optional.

ZTE: We are fine to have dedicated Table.

Moderator: Huawei comment is not to create new table. CMCC prefers to keep the existing table. We can say uplink CA is not supported elsewhere.

Nokia: Agree with Huawei. We should not create the new table for ATG.

Agreement:

* Reuse the existing BCS table for ATG
* Clarify that uplink CA is not supported for ATG UE elsewhere for Rel-19
* FFS on whether BCS#4 and #5 are not supported for ATG UE for Rel-19

**Issue 2-1-2: whether/how to reflect operation band information in spec**

* Proposals
	+ Option 1: The information that only DL CA is supported in Rel-19 for ATG can be reflected in the clause of operating band for ATG (Huawei)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 5.2J Operating band for ATGNR operating bands n1, n3, n34, n39, n41, n78, n79, which are defined in Table 5.2-1, can be applied for ATG operation.NR intra-band carrier aggregation is designed to operate for ATG in the operating bands defined in Table 5.2J-1, where all operating bands are within FR1.Table 5.2J-1: Intra-band contiguous CA operating bands for ATG in FR1

|  |  |
| --- | --- |
| NR CA DL Band | NR CA UL Band |
| CA\_n79 | - |
| NOTE 1: “-” means that only single carrier is supported for ATG UL deployment. |

 |

* Recommended WF:
	+ Option 1.

Qualcomm: We should use the existing table. Do not need to create the new table.

Huawei: for BCS we have agreement because of RAN2 IE issue. For band combination, we need some place to clarify the downlink band combinations.

CMCC: we need clarify the capability. Do not need to agree on the CR framework.

Agreement:

* The information that only DL CA is supported in Rel-19 for ATG can be reflected in the clause of operating band for ATG

### Sub-topic 2-2 Rx requirement

**Issue 2-2: ATG Rx requirements applicability**

* Proposals

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sub-clause** | **Requirement** | **APPLE** | **CMCC** | **ZTE** | **Huawei** | **Ericsson** |
| **7** | Receiver characteristic |  |  |  |  |  |
| **7.1** | General | No impact due to introducation of CA. |  |  |  |  |
| **7.2** | Diversity characteristics | For TN UE, two Rx, four Rx and eight Rx requirements are specifed both for single carrier and for CA. For ATG UE, only two Rx and four Rx are considered. The CA requriement should also be based on two Rx and four Rx (optional) requirements.  |  |  | In current clause 7.2J, it seems that the clarification is clear enough, so the requirements specified in clause 7.2J can be reused for DL CA\_n79C |  |
| **7.3** | Reference sensitivity | TN UE REFSENS reqruiment is resued for ATG UE single carrier oepration.For CA, the same logic is applicable. E.g. the requriement specified in 7.4A.1 for intra-band contiguous CA and 7.4A.3 for inter-band CA with one UL carrier can be resued for ATG UE. | Requirements of TDD contiguous intra-band CA in TS 38.101-1 sub-clause 7.3A.2.1 could be reused for ATG UE with intra-band CA. | **Reference sensitivity power level for Intra-band contiguous CA**For intra-band contiguous carrier aggregation, the throughput of each component carrier shall be ≥ 95 % of the maximum throughput of the reference measurement channels as specified in Annexes A.2.2.2, A.3.2, and A.3.3 (with one sided dynamic OCNG Pattern OP.1 FDD/TDD for the DL-signal as described in Annex A.5.1.1/A.5.2.1) with parameters specified in Table 7.3.2-1a, Table 7.3.2-1b, Table 7.3.2-2, and Table 7.3.2-3.For UE(s) supporting one uplink carrier, the uplink configuration of the PCC shall be in accordance with Table 7.3.2-3 and the downlink PCC carrier center frequency shall be configured closer to uplink operating band than any of the downlink SCC center frequency. | Proposal 4: the following requirements for DL contiguous CA with one UL carrier specified in clause 7.3A.2.1 could be considered. Further discuss whether to include FDD REFSENS table 7.3.2-1a. | Proposal 4For reference sensitivity, blocking characteristic, spurious response, and intermodulation characteristics, the existing requirements defined in clause 7 could be reused. |
| **7.4** | Maximum input level | Specific requirement on maximum input level is specified based on ATG scenario link budget calculation. For intra-band contiguous CA, the Power in largest transmission bandwidth configuration CC and other CCs need to be scaled for ATG UE CA based on the single carrier level. Specific CA requirement need to be specified for ATG UE. | The max input level requirements for ATG UE with intra-band CA could be specified in table 3, and the principle in TS 38.101-1 sub-clause 7.4A.1 could be reused | 1715678125350 | Proposal 5: To introduce the following table for ATG CA maximum input level requirements. | For intra-band contiguous CA, Power in largest transmission bandwidth configuration CC, Plargest BW should be updated as -42 dBm for omni antenna and -30 dBm for array antenna. |
| **7.5** | Adjacent channel selectivity | TN UE Case 1 ACS is completely reused for ATG UE for single carrier operation. ATG Case 2 ACS is specified based on TN case 2 ACS but scaled the interference power level based on ATG maximum input level.For CA, specific case 2 ACS requirement need to be defined for ATG UE. | The ACS principle and requirements for in clause 7.5A.1 for intra-band contiguous CA could be reused expect for the test parameters case 2, and case 2 could be defined as Table 6 | To following the existing requirement defined in clause 7.5A.1 with the following power to be updated for ATG UE.* Pw in Transmission Bandwidth Configuration, per CC

PInterferer  |  | Proposal 3ACS test parameters for case 1 need to be specified, it could reuse the tables in 7.5A.1, ACS case 2 needs to be updated. Particularly Power in transmission bandwidth configuration, per CC needs to be scaled according to the ATG UE maximum input level. |
| **7.6** | Blocking characteristic | In-band blocking requirement and out-of-band blocking requirement are reused from TN UE single carrier requirement for ATG UEFor CA, the requirement specified in 7.6A.2/3 for intra-band contiguous CA and inter-band CA with one uplink carrier can be applied for ATG UE. | The requirements specified in clause 7.6A.2.1 could be reused for ATG UE with intra-band contiguous CA.Proposal 6: The requirements specified in clause 7.6A.3.1 could be reused for ATG UE with intra-band contiguous CA.Proposal 7: There is no narrow band blocking requirement for ATG UE. | To following the existing requirements defined in Clause 7.6A.2.1.To following the existing requirements defined in Clause 7.6A.3.1.Narrow band blocking: N/A |  | Proposal 4For reference sensitivity, blocking characteristic, spurious response, and intermodulation characteristics, the existing requirements defined in clause 7 could be reused. |
| **7.7** | Spurious response | Spurious response requriement is reused from TN UE single carrier requirements for ATG UE. For CA, the requriement sepcified in 7.7A.2/3 for intra-band contiguous CA and inter-band CA with one uplink carrier can be applided for ATG UE. | Proposal 8: The requirements specified in clause 7.7A.1 could be reused for ATG UE with intra-band contiguous CA. | To following the existing requirements defined in Clause 7.7A.1. |  |  |
| **7.8** | Intermodulation characteristics | Intermodulation requriement is reused from TN UE single carrier requirements for ATG UE. For CA, the requriement sepcified in 7.8A.2/3 for intra-band contiguous CA and inter-band CA with one uplink carrier can be applided for ATG UE. | Proposal 9: The intermodulation requirements specified in clause 7.8A.2.1 could be reused for ATG UE with intra-band contiguous CA. | To following the existing requirements defined in Clause 7.8A.2.1. |  | Proposal 4For reference sensitivity, blocking characteristic, spurious response, and intermodulation characteristics, the existing requirements defined in clause 7 could be reused. |
| **7.9** | Spurious emission | Spurious emission requirement is reused from TN UE single carrier requirements for ATG UE. For CA, the requriement sepcified in 7.9A.3 for inter-band CA with one uplink carrier can be applided for ATG UE. No requirement is needed for intra-band contiguous CA folliwng the TN UE methdology. |  |  |  | Proposal 4For reference sensitivity, blocking characteristic, spurious response, and intermodulation characteristics, the existing requirements defined in clause 7 could be reused. |

* Recommended WF
	+ Following requirements needs to be updated for ATG CA compared with TN CA.
		- Max input level
		- ACS testing case 2
	+ Following requirements can reuse legacy TN CA requirements
		- Blocking including in-band and out of band blocking, narrow-band blocking
		- REFSENSE
		- Spurious response
		- Intermodulation
	+ Following requirement is not applicable for ATG CA
		- No CA Rx Spurious emission
		- No CA narrow-band blocking
	+ Following single carrier requirement of ATG is enough and no need to define ATG CA specific requirements
		- diversity characteristics requirement

Agreement:

* + Following requirements needs to be updated for ATG CA compared with TN CA.
		- Max input level
		- ACS testing case 2
	+ Following requirements can reuse legacy TN CA requirements
		- Blocking including in-band and out of band blocking, narrow-band blocking
		- REFSENSE
		- Spurious response
		- Intermodulation
	+ Following requirement is not applicable for ATG CA
		- No CA Rx Spurious emission
		- No CA narrow-band blocking
	+ Following single carrier requirement of ATG is enough and no need to define ATG CA specific requirements
		- diversity characteristics requirement

### Sub-topic 2-3 max input level

**Issue 2-3: max input level**

* Proposals
	+ Option 1: (CMCC, Huawei, ZTE, Ericsson)

Table 3: Maximum input level for ATG with CA\_n79C

|  |  |  |
| --- | --- | --- |
| Rx Parameter | Units  | ATG UE Types |
|  |  | Omni-directional antenna | Antenna array |
| Power in largest transmission bandwidth configuration CC, Plargest BW | dBm | -422 | -302 |
|  |  | -443 | -323 |
| Power in each other CC | dBm | Plargest BW +10\*log{(NRB,c\*SCSc)/(NRB,largest BW\*SCSlargest BW)} |
| The applicable NR CA Bandwidth Class | MHz | **C** |
| NOTE 1: The transmitter shall be set to 4 dB below PCMAX\_L,f,c at the minimum uplink configuration specified in Table 7.3.2-3 and 7.3F.2-3 for shared spectrum channel access operation with PCMAX\_L,f,c as defined in clause 6.2.4.NOTE 2: Reference measurement channel is A.3.2.3 or A.3.3.3 for 64 QAM.NOTE 3: Reference measurement channel is A.3.2.4 or A.3.3.4 for 256 QAM. |

* Recommended WF:
	+ Option 1.

Agreement:

* max input level

Table 3: Maximum input level for ATG with CA\_n79C

|  |  |  |
| --- | --- | --- |
| Rx Parameter | Units  | ATG UE Types |
|  |  | Omni-directional antenna | Antenna array |
| Power in largest transmission bandwidth configuration CC, Plargest BW | dBm | -422 | -302 |
|  |  | -443 | -323 |
| Power in each other CC | dBm | Plargest BW +10\*log{(NRB,c\*SCSc)/(NRB,largest BW\*SCSlargest BW)} |
| The applicable NR CA Bandwidth Class | MHz | **C** |
| NOTE 1: The transmitter shall be set to 4 dB below PCMAX\_L,f,c at the minimum uplink configuration specified in Table 7.3.2-3 and 7.3F.2-3 for shared spectrum channel access operation with PCMAX\_L,f,c as defined in clause 6.2.4.NOTE 2: Reference measurement channel is A.3.2.3 or A.3.3.3 for 64 QAM.NOTE 3: Reference measurement channel is A.3.2.4 or A.3.3.4 for 256 QAM. |

### Sub-topic 2-4 ACS testing parameters for case 2

**Issue 2-4: ACS testing parameters for case 2**

* Proposals
	+ Option 1: the principle of TN contiguous CA could be reused (CMCC)

Table 6: Test parameters for intra-band contiguous CA with FDL\_low ≥ 3300 MHz and FUL\_low ≥ 3300 MHz, case 2

|  |  |  |
| --- | --- | --- |
| Rx Parameter | Units  | NR CA bandwidth class |
|  |  | C |
| Pw in Transmission Bandwidth Configuration, per CC | dBm | -73.54-61.55 |
| PInterferer | dBm | -424-305 |
| BWInterferer | MHz | BWchannel CA |
| FInterferer (offset) | MHz | BWchannel CA/-BWchannel CA |
| NOTE 1: The transmitter shall be set to 24 dB below PCMAX\_L,f,c at the minimum UL configuration specified in Table 7.3.2-3 with PCMAX\_L,f,c defined in clause 6.2.4.NOTE 2: The absolute value of the interferer offset Finterferer (offset) shall be further adjusted to MHz with SCS the sub-carrier spacing of the carrier closest to the interferer in MHz. The interferer is an NR signal with an SCS equal to that of the closest carrier.NOTE 3: The interferer consists of the RMC specified in Annexes A.3.2.2 and A.3.3.2 with one sided dynamic OCNG Pattern OP.1 FDD/TDD for the DL-signal as described in Annex A.5.1.1/A.5.2.1. NOTE 4: Pinterferer shall be set to -42dBm for omni-directional antenna.NOTE 5: Pinterferer shall be set to -30dBm for antenna array. |

* Recommended WF:
	+ Option 1.

ZTE: we would like to have time to check especial on Pw transmission power.

Ericsson: Share the similar view as ZTE. We also need consider the power transmission. It can be scaled.

Agreement:

* the principle of TN contiguous CA could be reused

# Topic #3: R19 UE RF for inter-band CA

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2407280**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2407280.zip) | Apple | ***Proposal 1: Both following options should be allowed for ATG UE supporting inter-band CA.**** Option 1: Only one antenna type could be used for one CA inter-band combination.
* Option 2: Both antenna types could be used for one CA inter-band combination.

***Proposal 2: It is proposed RAN4 to discuss the following solutions for ATG UE supporting CA\_n3A-n39A assuming DL only in band n39 by default.******Option 1: PRX has normal n3 DPX and DRX path has n3-n39 filter plus an n39 RF filter.******Option 2: separate DPX or RF filter is considered for each band for both primary path and diversity path.******Proposal 3: It is proposed to study whether there is a possibility to support normal TDD in band n39 with 5MHz guard band.******Proposal 4: It is proposed to consider the BCS in table 2.2-2 for CA\_n3-n39.******Proposal 5: it is proposed to use the requirement as specified in table 2.3 as baseline for further discussion.*** |
| [**R4-2407950**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2407950.zip) | CMCC | **Proposal 1: Table 1 as the starting point for BCS of CA\_n3A-n39A.****Table 1: BCS for CA\_n3A-n39A**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **NR CA configuration** | **Uplink CA configuration or single uplink carrier** | **NR Band** | **Channel bandwidth (MHz)** | **Bandwidth combination set** |
| CA\_n3A-n39A | - | n3 | 5, 10, 15, 20, 25, 30 | 0 |
|  |  | n39 | 5, 10, 15, 20, 25, 30, 35, 40 |  |

**Proposal 2: CA\_n3-n39 with DL n39 should not be preclude.****Proposal 3: supporting two ATG UE antenna types should be set as the starting point.****Proposal 4: For delta RIB, MSD requirements, companies needs detailed analysis.****Proposal 5: Except for delta RIB, MSD requirements, per band requirements i.e the requirements in suffix J could be reused for ATG CA inter-band combination.** |
| [**R4-2409334**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2409334.zip) | Huawei, HiSilicon | **Proposal 1: omni-antenna type can be assumed for both band n3 and n39 in DL CA\_n3-n39 to simplify the discussion.****Observation 1: if WG is targeted to introduce UL configuration in band n39 for DL CA\_n3-n39, the frequency gap between DL band n3 and band n39 should be assumed and considered in the real implementation as the transition guard band for the filter to protect each other.****Proposal 2: RAN4 can further consider the exemplary RF architecture for DL CA\_n3-n39 with the partial frequency range filter(s) in DL band n3 or band n39 or both DL band n3 and n39 as shown in figure 2.** |
| [**R4-2409602**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2409602.zip) | ZTE Corporation, Sanechips | Proposal 1. The BCS for inter-band DL CA\_n3A-n39A is proposed in table 1.Table 1. Supported bandwidths per CA band combination of band n3+n39

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| NR CA configuration | Uplink CA configuration or single uplink carrier | NR Band | Channel bandwidth (MHz) | Bandwidth combination set |
| CA\_n3A-n39AX | - | n3 | 5, 10, 15, 20, 25, 30, 35, 40, 45, 50 | 0 |
|  |  | n39 | 5, 10, 15, 20, 25, 30, 35, 40 |  |
| NOTE X: Uplink is only in n3 for CA\_n3-n39 |

**Proposal 2**: for RF requirements for inter-band DL CA, refer to the proposals in table 2.  |
| [**R4-2409662**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2409662.zip) | Ericsson | [Proposal 1 Both antenna types could be used for the CA inter-band combination](#_Toc165966800)[Proposal 2 BCS 0, 4, and 5 should be supported for DL CA\_n3-n39](#_Toc165966801)[Proposal 3 For the existing inter-band CA combinations, ΔRIB,c for ATG UE inter-band CA could be reused. For the newly introduced band combination, ΔRIB,c needs to be studied.](#_Toc165966802) |
| [**R4-2409664**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2409664.zip) | Ericsson | 1. FDD band n3 serves as PCell and TDD band n39 could serve as SCell while n39 is configured as DL to avoid interference with the n3 DL.
 |

## Open issues summary

This corresponds to agenda 10.8.2.2.

RAN4 core part of the work item are listed as below:

The core part of the work item includes:

* Specify the RF and RRM core requirements for intra-band co-located and inter-band co-located DL CA [RAN4]:
	+ FR1 intra-band contiguous CA
		- Example band combination: n79
	+ FR1+FR1 inter-band CA
		- Example band combination: n3+n39
* Specify the RF requirements for support of UL MIMO with 2TX for single CC for UE. [RAN4]

### Sub-topic 3-1 antenna type for inter-band CA

**Issue 3-1: clarify the antenna type for each band for inter-band CA**

* Proposals
	+ Option 1: both following options are allowed (CMCC, APPLE, Ericsson)
		- Option 1: Only one antenna type could be used for one CA inter-band combination.
		- Option 2: Both antenna types could be used for one CA inter-band combination.
	+ Option 2: omni-antenna type can be assumed for both band n3 and n39 in DL CA\_n3-n39 to simplify the discussion. (Huawei)
* Recommended WF
	+ TBA.

Qualcomm: UE does the DL CA with different type of capabilities?

ZTE: whether to have single type or different types depends on the frequency ranges and size of device on aircraft. It is better to leave two options open.

Moderator: we do not need have any limitation of types on CA. To Qualcomm, no. We do not need new capabilities.

Qualcomm:

**Agreement:**

* No limitation on antenna types for ATG CA
* FFS on whether to assume omni-antenna type can be assumed for both band n3 and n39 in DL CA\_n3-n39
* FFS on whether new capability is needed for ATG CA

### Sub-topic 3-2 RF implementation for inter-band CA\_n3A-n39A

**Issue 3-2-1: whether to allow n39 UL for CA\_n3A-n39A**

* Proposals
	+ Option 1: It is proposed to study whether there is a possibility to support normal TDD in band n39 with transition guard band assumption. (CMCC, APPLE, Huawei)
		- 5MHz as starting point
	+ Option 2: FDD band n3 serves as PCell and TDD band n39 could serve as SCell while n39 is configured as DL to avoid interference with the n3 DL.(Ericsson)
* Recommended WF
	+ study whether there is a possibility to support normal TDD in band n39 with 5MHz transition guard band assumption
		- 5MHz guard band assumption between n39 and n3 DL for future discussion

Qualcomm: We prefer Option 2. We need understand the benefit to enable both.

ZTE: This band combinations have no conclusion for smartphone. We prefer to postpone discussions.

Huawei: For smartphone, we have conclusion that only band n3 can support uplink. For ATG we can discuss it separately.

Moderator: we can keep it open. CMCC can have 5MHz guard band already.

Apple: Option 2 is also option. It is feasible.

**Issue 3-2-2: candidate solutions for ATG UE supporting CA\_n3A-n39A.**

* Proposals
	+ Option 1 (assuming DL only in band n39): PRX has normal n3 DPX and DRX path has n3-n39 filter plus an n39 RF filter.
	+ Option 2 (assuming DL only in band n39): separate DPX or RF filter is considered for each band for both primary path and diversity path.
	+ Option 3 (allowing UL in band n39): RAN4 can further consider the exemplary RF architecture for DL CA\_n3-n39 with the partial frequency range filter(s) in DL band n3 or band n39 or both DL band n3 and n39 as shown in figure 2. (Huawei)
* 
* Recommended WF
	+ At first consider the feasibility of option 3, i.e. the feasibility of allowing n39 UL
	+ If n39 UL is not feasible, analyze option 1 and option 2 assuming DL only in band n39.

### Sub-topic 3-3 BCS for inter-band CA\_n3A-n39A

**Issue 3-3: BCS for DL CA\_n3\_n39**

* Proposals
	+ Option 1: (Apple)

Table 2.2-2 BCS for CA\_n3-n39

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **NR CA config** | **Uplink CA configuration or single uplink carrier10** | **NR Band** | **Channel bandwidth (MHz)**  | **BCS** |
| CA\_n3A-n39A | - | n3 | 10, 15, 20, 25, 30, 35, 40, 45, 50 | 0 |
|  |  | n39 | 10, 15, 20, 25, 30, 35, 40 |  |

* + Option 2: (CMCC)

**Table 1: BCS for CA\_n3A-n39A**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **NR CA configuration** | **Uplink CA configuration or single uplink carrier** | **NR Band** | **Channel bandwidth (MHz)** | **Bandwidth combination set** |
| CA\_n3A-n39A | - | n3 | 5, 10, 15, 20, 25, 30 | 0 |
|  |  | n39 | 5, 10, 15, 20, 25, 30, 35, 40 |  |

* + Option 3: (ZTE)

Table 1. Supported bandwidths per CA band combination of band n3+n39

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| NR CA configuration | Uplink CA configuration or single uplink carrier | NR Band | Channel bandwidth (MHz) | Bandwidth combination set |
| CA\_n3A-n39AX | - | n3 | 5, 10, 15, 20, 25, 30, 35, 40, 45, 50 | 0 |
|  |  | n39 | 5, 10, 15, 20, 25, 30, 35, 40 |  |
| NOTE X: Uplink is only in n3 for CA\_n3-n39 |

* Recommended WF
	+ Option 3 since Option 3 includes option 1 and 2

Huawei: there is no existing table in the current spec. There are some misalignment from smartphone. If we want to enable uplink for n39, we should be careful of larger bandwidth.

ZTE: it is fine to postpone discussions.

### Sub-topic 3-4 Rx requirement applicability for inter-band CA\_n3A-n39A

**Issue 3-4-1: ATG Rx requirements applicability**

* Proposals

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sub-clause** | **Requirement** | **APPLE** | **ZTE** | **CMCC** | **Ericsson** |
| **7** | Receiver characteristic |  |  |  |
| **7.1** | General | No impact due to introducation of CA. |  | Proposal 4: For delta RIB, MSD requirements, companies needs detailed analysis.Proposal 5: Except for delta RIB, MSD requirements, per band requirements i.e the requirements in suffix J could be reused for ATG CA inter-band combination. | Proposal 3: For the existing inter-band CA combinations, ΔRIB,c for ATG UE inter-band CA could be reused. For the newly introduced band combination, ΔRIB,c needs to be studied. |
| **7.2** | Diversity characteristics | For TN UE, two Rx, four Rx and eight Rx requirements are specifed both for single carrier and for CA. For ATG UE, only two Rx and four Rx are considered. The CA requriement should also be based on two Rx and four Rx (optional) requirements.  |  |
| **7.3** | Reference sensitivity | TN UE REFSENS reqruiment is resued for ATG UE single carrier oepration.For inter-band CA, the same logic is applicable. E.g. the requriement specified in 7.4A.3 with one UL carrier can be resued for ATG UE. | **Reference sensitivity power level for Inter-band CA**For inter-band carrier aggregation with one component carrier per operating band and the uplink assigned to one NR band the throughput shall be ≥ 95 % of the maximum throughput of the reference measurement channels as specified in Annexes A.2.2.2, A.2.3.2, A.3.2, and A.3.3 (with one sided dynamic OCNG Pattern OP.1 FDD/TDD for the DL-signal as described in Annex A.5.1.1/A.5.2.1 with parameters specified in Table 7.3.2-1, Table 7.3.2-2 and Table 7.3.2-3 modified in accordance with clause 7.3A.3.2. The reference sensitivity is defined to be met with all downlink component carriers active and one of the uplink carriers active. Exceptions to reference sensitivity are allowed in accordance with clause 7.3A.4.**ΔRIB,c for Inter-band CA**This needs further discussions for it. |
| **7.4** | Maximum input level | Specific requirement on maximum input level is specified based on ATG scenario link budget calculation. For inter-band CA, a similar requirement as for 7.4A.3 should be defined for ATG UE but with each component carrier shall meet the ATG specific maximum input level for single CC. | **Maximum input level for Inter-band CA**For inter-band carrier aggregation with one component carrier per operating band and the uplink assigned to one NR band, the maximum input level is defined with the uplink active on the band(s) other than the band whose downlink is being tested. For NR CA configurations including an operating band without uplink band or an operating band with an unpaired DL part (as noted in Table 5.2-1), the requirements for all downlinks shall be met with the single uplink carrier active in each band capable of UL operation. The UE shall meet the requirements specified in clause 7.4J for each component carrier while all downlink carriers are active.The throughput shall be ≥ 95 % of the maximum throughput of the reference measurement channels as specified in Annexs A.3.2 and A.3.3 (with one sided dynamic OCNG Pattern OP.1 FDD/TDD as described in Annex A.5.1.1/A.5.2.1) for each component carrier. |
| **7.5** | Adjacent channel selectivity | TN UE Case 1 ACS is completely reused for ATG UE for single carrier operation. ATG Case 2 ACS is specified based on TN case 2 ACS but scaled the interference power level based on ATG maximum input level.For inter-band CA, a similar requirement as in 7.5A.3 needs to be defined for ATG UE while each component CC shall meet the ATG UE ACS requirement for single CC. | **Adjacent channel selectivity Inter-band CA**For inter-band carrier aggregation with one component carrier per operating band and the uplink assigned to one NR band, the adjacent channel requirements are defined with the uplink active on the band(s) other than the band whose downlink is being tested. For NR CA configurations including an operating band without uplink operation or an operating band with an unpaired DL part (as noted in Table 5.2-1), the requirements for all downlinks shall be met with the single uplink carrier active in each band capable of UL operation. The ATG UE shall meet the requirements specified in clause 7.5J, for each component carrier while all downlink carriers are active.The throughput of each carrier shall be ≥ 95 % of the maximum throughput of the reference measurement channels as specified in Annexes A.2.2, A.3.2, and A.3.3 (with one sided dynamic OCNG Pattern OP.1 FDD/TDD for the DL-signal as described in Annex A.5.1.1/A.5.2.1). |
| **7.6** | Blocking characteristic | In-band blocking requirement and out-of-band blocking requirement are reused from TN UE single carrier requirement for ATG UEFor inter-band CA, the requirements specified in 7.6A.2.3 and 7.6A.3.3 are applicable for ATG UE. | IBB: To following the existing requirements defined in Clause 7.6A.2.3.OBB: To following the existing requirements defined in Clause 7.6A.3.3. And no OOB exception for CA\_n3-n39NBB: N/A |
| **7.7** | Spurious response | Spurious response requriement is reused from TN UE single carrier requirements for ATG UE. For inter-band CA, the requriement sepcified in 7.7A.3 for inter-band CA with one uplink carrier can be applided for ATG UE.  | To following the existing requirements defined in Clause 7.7A.3. |
| **7.8** | Intermodulation characteristics | Intermodulation requriement is reused from TN UE single carrier requirements for ATG UE. For CA, the requriement sepcified in 7.8A.3 for inter-band CA with one uplink carrier can be applided for ATG UE. | To following the existing requirements defined in Clause 7.8A.2.3. |
| **7.9** | Spurious emission | Spurious emission requirement is reused from TN UE single carrier requirements for ATG UE. For CA, the requriement sepcified in 7.9A.3 for inter-band CA with one uplink carrier can be applided for ATG UE.  | To following the existing requirements defined in Clause 7.9A.3 |

* Recommended WF
	+ Following requirements needs further analysis:
		- delta RIB,
		- MSD,
		- Diversity requirements
			* FFS whether current ATG single carrier requirement is enough
	+ legacy inter-band CA requirements applies for following requirements while each CC shall meet the ATG UE requirement for single CC
		- REFSENSE
		- Max input level
		- ACS
		- in-band blocking
		- out of band blocking
			* FFS whether no OOB exception for CA\_n3A-n39A
		- spurious response
		- wide band intermodulation
		- spurious emissions
	+ Following requirements are not applicable
		- Narrow band blocking

Agreement:

* + Following requirements needs further analysis:
		- delta RIB,
		- MSD,
		- Diversity requirements
			* FFS whether current ATG single carrier requirement is enough
	+ legacy inter-band CA requirements applies for following requirements while each CC shall meet the ATG UE requirement for single CC
		- REFSENSE
		- Max input level
		- ACS
		- in-band blocking
		- out of band blocking
			* FFS whether no OOB exception for CA\_n3A-n39A
		- spurious response
		- wide band intermodulation
		- spurious emissions
	+ Following requirements are not applicable
		- Narrow band blocking

# Topic #4: R19 UE RF for UL-MIMO

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2407281**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2407281.zip) | Apple | ***Proposal 1: Reuse the rated output power declared by the ATG UE capability maxOutputPowerATG-r18, and consider the existing NR UL-MIMO requirement with some adaption in requirement description specific to ATG UE.******Proposal 2: Configured transmitted power for ATG UL MIMO is defined on per UE basis.***

|  |  |  |
| --- | --- | --- |
| PCMAX,*c*(dBm) | ToleranceTLOW(PCMAX\_L,*c*) (dB) | ToleranceTHIGH(PCMAX\_H,*c*) (dB) |
| 23 ≤ PCMAX,*c* ≤ 40 | 3.0 | 2.0 |
| 22 ≤ PCMAX,*c* < 23 | 5.0 | 2.0 |
| 21 ≤ PCMAX,*c* < 22 | 5.0 | 3.0 |
| 20 ≤ PCMAX,*c* < 21 | 5.0 | 4.0 |
| 16 ≤ PCMAX,*c* < 20 | 5.0 |
| 11 ≤ PCMAX,*c* < 16 | 6.0 |
| -40 ≤ PCMAX,*c* < 11 | 7.0 |

***Proposal 3: UL Output power dynamic requirements for MIMO as specified in 6.3D.1/6.3D.2/6.3D.3/6.3D.4 could be reused for ATG UE with omni-directional antenna and adapted for ATG UE with antenna array as following,*** * For minimum output power and power control, the power should be the sum of the mean power from all TAB connectors for ATG UE indicating capability antennaArrayType-r18;
* For transmit OFF power, transmit ON/OFF time mask, the requirement should be applicable at each TAB connector for ATG UE indicating capability antennaArrayType-r18

***Proposal 4: transmit signal quality requirement for UL MIMO as defined in 6.4D.0/1/2/3 could be reused for ATG UE with omni-directional antenna and adapted for ATG UE with antenna array indicating capability antennaArrayType-r18.*** * For Frequency error and transmit modulation quality requirements, the measurement is done at each antenna connector and requirement is applied per layer. It can be reused for ATG UE with antenna array indicating capability antennaArrayType-r18 with replacement of antenna connector with TAB connector in the description.
* For transmit alignment error, the requirement is by comparing the frame timing differences between transmissions on multiple transmit antenna connectors. For ATG UE, the comparison happens between TAB connectors.

***Proposal 5: UL MIMO requirement for ATG UE can be defined as following,*** * For ATG UE with omni-directional antenna connector, occupied channel bandwidth and spurious emission requirement can be reused directly from 6.5D.1. Similar requirement as 6.5D.2/3can be reused with replacement of ATG UE single carrier requirement for out of band emission.
* For ATG UE with antenna array, besides those adaptions for ATG UE with omni-directional antenna, the reference point should be changed to TAB connector.

***Proposal 6: for ATG Rx MIMO requirements, t is enough to add the following clarification for reference sensitivity, maximum input level, ACS, blocking, spurious response and receiver intermodulation requirements.**** For ATG UE with omni-directional antenna (or antenna array indicating capability antennaArrayType-r18) in closed-loop spatial multiplexing scheme, the minimum requirements specified in clause 7.xJ shall be met with the UL MIMO configurations described in clause 6.2J.y and clause 6.2J.z for shared spectrum access operation, and the reference measurement channels as specified in Annex A.2.2 for CP-OFDM waveforms shall apply. For UL MIMO, the parameter PUMAX is the total transmitter power over all transmit antenna connectors (or TAB connectors).
 |
| [**R4-2407952**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2407952.zip) | CMCC | **Proposal 1: support ULFPTx mode for ATG UL-MIMO.****Proposal 2: configured transmitted power tolerance could be specified as Table 1.****Proposal 3: not preclude the single antenna port related requirement.****Proposal 4: apply the coherent UL MIMO requirement for ATG UE.** |
| [**R4-2407985**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2407985.zip) | LG Electronics | **Proposal 1: Consider ULFPTx mode for ATG UL-MIMO.****Proposal 2: For configured transmitted power, reuse the existing ATG UE requirement with Table 2.1 PCMAX,c tolerance.**Table 2.1: ATG PCMAX,*c* tolerance in closed-loop spatial multiplexing scheme

|  |  |  |
| --- | --- | --- |
| PCMAX,*c*(dBm) | ToleranceTLOW(PCMAX\_L,*c*) (dB) | ToleranceTHIGH(PCMAX\_H,*c*) (dB) |
| 23 ≤ PCMAX,*c* ≤ 40 | 3.0 | 2.0 |
| 22 ≤ PCMAX,*c* < 23 | 5.0 | 2.0 |
| 21 ≤ PCMAX,*c* < 22 | 5.0 | 3.0 |
| 20 ≤ PCMAX,*c* < 21 | 5.0 | 4.0 |
| 16 ≤ PCMAX,*c* < 20 | 5.0 |
| 11 ≤ PCMAX,*c* < 16 | 6.0 |
| -19 ≤ PCMAX,*c* < 11 | 7.0 |

**Proposal 3/4/5: Define the following requirements for single layer UL MIMO operation and single antenna-port(*W*=1) without indicating *txDiversity*, and with indicating *txDiversity* with the capability *antennaArrayType-r18*.*** output power dynamics
* transmit signal quality
* output RF spectrum emissions
 |
| [**R4-2409335**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2409335.zip) | Huawei, HiSilicon | **Observation 1: Unless WG identify some benefits for ATG UE supporting ULFPTx mode, there is no need to extend ULFPTx mode to ATG UE.****Proposal 1: RAN4 can discuss whether only two Tx ports can be assumed for ATG UE considering polarization diversity or multiplex. If so, RAN4 can discuss the corresponding RF reference architecture.****Proposal 2: RAN4 can discuss whether coherent UL MIMO are applicable to ATG UE considering polarization diversity or multiplex.** |
| [**R4-2409603**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2409603.zip) | ZTE Corporation, Sanechips | **Proposal 1**: ULFPTx Mode is not relevant to this feature.**Proposal 2** : Configured transmitted power for UL MIMO is per carrier, and it is not needed to define MPR/A-MPR requirements for ATG UE supporting UL MIMO[since there will be power tolerance requirement defined.] **Proposal 3**: for the minimum output power, reuse the existing requirement in clause 6.3D.1 for two antenna ports for ATG UE with UL MIMO and preclude the single antenna port related requirement.**Proposal 4**: for transmit OFF power, to reuse the existing requirements in clause 6.3D.2 for two antenna connectors.**Proposal 5**: for transmit ON/OFF time mask for UL MIMO, to reuse the existing requirements in clause 6.3D.3 for two antenna connectors and preclude the single antenna port related requirement. **Proposal 6**: for transmit signal quality, the general principle as described in 6.4D.1 could be reused for ATG UE supporting the UL MIMO. **Proposal 7:**For ATG UE(s) supporting UL MIMO, the basic measurement interval of modulated carrier frequency is 1 UL slot. The mean value of basic measurements of UE modulated carrier frequency per layer shall be accurate to within ± 0.1 PPM observed over a period of 1 ms of cumulated measurement intervals observed over a period of 1 ms of cumulated measurement intervals compared to ideally pre-compensated reference uplink carrier frequency. NOTE 1: the ideally pre-compensated reference uplink carrier frequency consists of the UL carrier frequency signalled to the UE by ATG BS and UL precompensated doppler frequency shift.NOTE 2: UE shall rely on the ATG BS location broadcasted by the [ATG specific SIB] in 38.331. **Proposal 8**: for transmit modulation quality for UL MIMO, reuse the existing requirements in clause 6.4D.2 for two antenna connectors and preclude the single antenna port related requirement. **Proposal 9**: for TAE requirement for UL MIMO, reuse the existing requirement in clause 6.4D.3.**Proposal 10**: don’t apply the coherent UL MIMO requirement for ATG UE.**Proposal 11**: for OBW, reuse the existing requirement for two antenna ports in clause 6.5D.1 for ATG UE.**Proposal 12**: for out of band emission, to reuse the existing requirement in 6.5D.2 with the emission requirement referring to subclause 6.5J.2. **Proposal 13**: for transmitter spurious emission, to reuse the existing requirement in 6.5D.3 for two antenna connectors and preclude the single port related requirements.**Proposal 14**: for transmitter intermodulation requirements, to reuse the existing requirement in 6.5D.4 for two antenna connectors and preclude the single port related requirements.**Proposal 15**: for REFSENS requirements, reuse the same REFSENS requirement as specified 7.3J.**Proposal 16**: for maximum input power, reuse the same maximum input power requirement as specified 7.4J.**Proposal 17**: for ACS requirement, reuse the same ACS requirement as specified 7.5J.**Proposal 18**: for blocking requirement, reuse the same blocking requirement as specified 7.6J.**Proposal 19**:for receiver spurious response requirement, reuse the same spurious response requirement as specified 7.7J.**Proposal 20**: for receiver intermodulation requirement, reuse the same Intermodulation characteristics requirement as specified 7.8J.* **Proposal 21:** if the legacy requirement for UL MIMO is defined as sum of measurements of all UE transmit antenna connectors, then for ATG UE with capability antennaArrayType-r18, the requirement should be defined as sum of all TAB connector including both polarization. If the legacy requirement for UL MIMO is defined as per antenna port or per layer, then for ATG UE with capability antennaArrayType-r18, the requirement should be defined as sum of all TAB connector per polarization or per layer.
 |
| [**R4-2409663**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_111/Docs/R4-2409663.zip) | Ericsson | [Proposal 1 ULFPTx mode should be supported for ATG UL-MIMO](#_Toc166516220)[Proposal 2 For UE maximum output power, reuse the rated maximum output power declared by the ATG UE capability maxOutputPowerATG-r18.](#_Toc166516221)[Proposal 3 For configured transmitted power, reuse the existing ATG UE requirement with PCMAX,c tolerance of below Table](#_Toc166516222)[Proposal 4 Reuse the existing NR UL-MIMO requirement for output power dynamic, transmit signal quality, and output RF spectrum emissions, and do not exclude the single antenna port requirement.](#_Toc166516223)[Proposal 5 Reuse the requirements defined in ATG UE for the following requirements: Reference sensitivity for UL MIMO, Maximum input level for UL MIMO, Adjacent channel selectivity for UL MIMO, Blocking characteristics for UL MIMO, Spurious response for UL MIMO, Intermodulation characteristics for UL MIMO.](#_Toc166516224) |

## Open issues summary

This corresponds to agenda 10.8.2.3.

RAN4 core part of the work item are listed as below:

The core part of the work item includes:

* Specify the RF and RRM core requirements for intra-band co-located and inter-band co-located DL CA [RAN4]:
	+ FR1 intra-band contiguous CA
		- Example band combination: n79
	+ FR1+FR1 inter-band CA
		- Example band combination: n3+n39
* Specify the RF requirements for support of UL MIMO with 2TX for single CC for UE. [RAN4]

### Sub-topic 4-1 UL MIMO General requirements

**Issue 4-1-1: ULFPTx mode for UL-MIMO**

* Proposals
	+ Option 1: no need to extend ULFPTx mode to ATG UE (ZTE, Huawei)
		- Unless WG identify some benefits for ATG UE supporting ULFPTx mode
	+ Option 2: ULFPTx mode still applies for ATG UE for implementation diversity (CMCC, APPLE, LGE, Ericsson)
* Recommended WF
	+ TBD.

ZTE: Full power transmission is due to RAN1 PHY design issue. But for ATG, the power depends on declaration. Uplink full transmission mode 0 is for single layer…. Here we focus on two-layer transmission. From those aspects, we do not need the feature.

Qualcomm: Support ZTE view. No such limitation on transmission mode.

Huawei: Current output power is defined as sum of all the antenna connectors. It means different situation from handheld UE.

Ericsson: In this uplink full power transmission mode, even for 2-layer mode, UE can be configured as single layer mode. Otherwise it is uncompleted.

LGE: There is no limitation in RAN1 design. The fully power mode can be used for ATG.

ZTE: there is no limitation in RAN1 design. For uplink full transmission mode 2 scheme 1, do you think it can be used for ATG?

LGE: Scheme 2 can be used.

**Issue 4-1-2: whether preclude the single antenna port related requirement**

* Proposals
	+ Option 1: no (CMCC)
	+ Option 2: yes (ZTE)
* Recommended WF
	+ TBD.

|  |
| --- |
| In NR, ULFPTx mode is specified for PC2 and PC1.5 as follows. * Single layer for 2 Tx port & 4 Tx port
	+ PC2/PC1.5
* 2 layers for 4 Tx port
	+ PC1.5
 |

**Issue 4-1-3: assumed max Tx ports number for ULFPTx mode**

* Proposals
	+ Option 1: 2 considering polarization diversity or multiplex (Huawei)
	+ Option 2: yes
* Moderator note: for 2 layer, if support ULFPTx mode, it seems at least 4Tx ports are needed.
* Recommended WF
	+ Depends on agreements of issue 4-1-1.

### Sub-topic 4-2 UL MIMO Tx requirements

Summary of requirement applicable reference point/measurement reference point for NR UL MIMO.

|  |  |
| --- | --- |
| **Tx requirements for UL MIMO** | **The definition for Tx requirements** (Defined as the **sum of all antenna connectors** or **at each antenna connector)** |
| **6.2D Transmitter power for UL MIMO** |  |
| 6.2D.1 UE maximum output power for UL MIMO | ULFPTx for UL MIMO, **Defined as the sum of all antenna connectors**single antenna-port transmission **without indicating Tx diversity** with precoding matrix *W*=1, apply for at least one antenna connectorsingle antenna-port transmission **indicating Tx diversity** with precoding matrix *W*=1, **apply as the sum of all antenna connectors**single antenna-port transmission with dual Tx indicating the feature *ul-FullPwrMode-r16* or *ul-FullPwrMode2-TPMIGroup-r16* with precoding matrix *W=1*, defined for at least one antenna connector |
| 6.2D.2 UE maximum output power reduction for UL MIMO | **Defined as the sum of all antenna connectors** |
| 6.2D.4 Configured transmitted power for UL MIMO | For UE supporting UL MIMO, the transmitted power is configured per each UE. |
| **6.3D Output power dynamics for UL MIMO** |  |
| 6.3D.1 Minimum output power for UL MIMO | **Defined as the sum of all antenna connectors** for single antenna-port transmission **indicating Tx diversity** with precoding matrix *W*=1 |
| 6.3D.2 Transmit OFF power for UL MIMO | Defined at each antenna connector |
| 6.3D.3 Transmit ON/OFF time mask for UL MIMO | Defined at each antenna connector |
| 6.3D.4 Power control for UL MIMO | **Defined as the sum of all antenna connectors** |
| **6.4D Transmit signal quality for UL MIMO** |  |
| 6.4D.0 General | defined per layer or as the sum of emissions from both antennas to account for the UL MIMO scheme |
| 6.4D.1 Frequency error for UL MIMO | per layer |
| 6.4D.2 Transmit modulation quality for UL MIMO |  |
| 6.4D.2.0 General | For UE supporting UL MIMO, the transmit modulation quality requirements are specified based on measurements made at each transmit antenna connector. |
| 6.4D.2.1 Error Vector Magnitude | per layer |
| 6.4D.2.2 Carrier leakage | per layer |
| 6.4D.2.3 In-band emissions | apply at each transmit antenna connector |
| 6.4D.2.4 EVM equalizer spectrum flatness for UL MIMO | per layer |
| **6.5D Output RF spectrum emissions for UL MIMO** |  |
| 6.5D.1 Occupied bandwidth for UL MIMO | **Defined as the sum of all antenna connectors** |
| 6.5D.2 Out of band emission for UL MIMO | **Defined as the sum of all antenna connectors** |
| 6.5D.3 Spurious emission for UL MIMO | **Defined as the sum of all antenna connectors** |
| 6.5D.4 Transmit intermodulation for UL MIMO | **Defined as the sum of all antenna connectors** |

**Issue 4-2-1: how to modify the NR UL MIMO requirement with ATG capability antennaArrayType-r18**

* Proposals
	+ if the legacy requirement for UL MIMO is defined as sum of measurements of all UE transmit antenna connectors,
		- Option 1: then for ATG UE with capability antennaArrayType-r18, the requirement should be defined as sum of all TAB connector including both polarization.
	+ If the legacy requirement for UL MIMO is defined as per antenna port or per layer,
		- Option 2-1: then for ATG UE with capability antennaArrayType-r18, the same reference point as legacy NR UL MIMO but updating antenna connector by TAB connector, detailed reference point for each RF requirement is listed in above table.
		- Option 2-2: then for ATG UE with capability antennaArrayType-r18, the requirement should be defined as sum of all TAB connector per polarization or per layer. (ZTE)
* Recommended WF
	+ if the legacy requirement for UL MIMO is defined as sum of measurements of all UE transmit antenna connectors, then for ATG UE with capability antennaArrayType-r18, the requirement should be defined as sum of all TAB connector including both polarization.
	+ If the legacy requirement for UL MIMO is defined as per antenna port or per layer, FFS

Agreement:

* + if the legacy requirement for UL MIMO is defined as sum of measurements of all UE transmit antenna connectors, then for ATG UE with capability antennaArrayType-r18, the requirement should be defined as sum of all TAB connector including both polarization.
	+ If the legacy requirement for UL MIMO is defined as per antenna port or per layer, FFS

**Issue 4-2-2: maximum output power**

* Proposals
	+ Option 1: Reuse the rated output power declared by the ATG UE capability *maxOutputPowerATG-r18*, and consider the existing NR UL-MIMO requirement with some adaption in requirement description specific to ATG UE. (APPLE, Ericsson)
		- Detailed modification of NR UL MIMO requirement with ATG capability antennaArrayType is based on conclusion of issue 4-2-1
* Recommended WF
	+ Option 1.

Agreement:

* In principle agree on Option 1 and need refine the wording.

**Issue 4-2-3: configured transmitted power**

* Proposals
	+ Option 3: Configured transmitted power for UL MIMO is per each UE with following tolerance (CMCC, APPLE, LGE, ZTE, Ericsson)

|  |  |  |
| --- | --- | --- |
| PCMAX,*c*(dBm) | ToleranceTLOW(PCMAX\_L,*c*) (dB) | ToleranceTHIGH(PCMAX\_H,*c*) (dB) |
| 23 ≤ PCMAX,*c* ≤ 40 | 3.0 | 2.0 |
| 22 ≤ PCMAX,*c* < 23 | 5.0 | 2.0 |
| 21 ≤ PCMAX,*c* < 22 | 5.0 | 3.0 |
| 20 ≤ PCMAX,*c* < 21 | 5.0 | 4.0 |
| 16 ≤ PCMAX,*c* < 20 | 5.0 |
| 11 ≤ PCMAX,*c* < 16 | 6.0 |
| -19 ≤ PCMAX,*c* < 11 | 7.0 |

* Moderator note: the minimum limit of Pcmax,c is -19dBm rather than -40dBm
* Recommended WF
	+ Configured transmitted power for UL MIMO is for each UE
	+ Reuse ATG single carrier tolerance requirement
	+ modify the NR UL MIMO requirement with ATG capability antennaArrayType-r18, detailed based on issue 4-2-1

Agreement

* + Configured transmitted power for UL MIMO is for each UE
	+ Reuse ATG single carrier tolerance requirement
	+ modify the NR UL MIMO requirement with ATG capability antennaArrayType-r18, detailed based on issue 4-2-1

**Issue 4-2-4: output power dynamic**

* Proposals
	+ Option 1: For output power dynamics, define the requirement for single layer UL MIMO operation and single antenna-port(W=1) without indicating txDiversity, and with indicating txDiversity with the capability antennaArrayType-r18.. (LGE)
	+ Option 2: (APPLE)
		- UL Output power dynamic requirements for MIMO as specified in 6.3D.1/6.3D.2/6.3D.3/6.3D.4 could be reused for ATG UE with omni-directional antenna and adapted for ATG UE with antenna array as following,
			* -For minimum output power and power control, the power should be the sum of the mean power from all TAB connectors for ATG UE indicating capability antennaArrayType-r18;
			* -For transmit OFF power, transmit ON/OFF time mask, the requirement should be applicable at each TAB connector for ATG UE indicating capability antennaArrayType-r18
	+ Option 3: (ZTE)
		- for the minimum output power, reuse the existing requirement in clause 6.3D.1 for two antenna ports for ATG UE with UL MIMO and preclude the single antenna port related requirement.
		- for transmit OFF power, to reuse the existing requirements in clause 6.3D.2 for two antenna connectors.
		- for transmit ON/OFF time mask for UL MIMO, to reuse the existing requirements in clause 6.3D.3 for two antenna connectors and preclude the single antenna port related requirement.
	+ Option 4: (Ericsson)
		- Reuse the existing NR UL-MIMO requirement for output power dynamic, transmit signal quality, and output RF spectrum emissions, and do not exclude the single antenna port requirement.
* Recommended WF
	+ - Legacy NR UL MIMO requirements is baseline
			* modify the NR UL MIMO requirement with ATG capability antennaArrayType-r18, detailed based on issue 4-2-1

Agreement:

* + - Legacy NR UL MIMO requirements is baseline
			* modify the NR UL MIMO requirement with ATG capability antennaArrayType-r18, detailed based on issue 4-2-1

**Issue 4-2-5: transmit signal quality**

* Proposals
	+ Option 1: For transmit signal quality, define the requirement for single layer UL MIMO operation and single antenna-port(W=1) without indicating txDiversity, and with indicating txDiversity with the capability antennaArrayType-r18.. (LGE)
	+ Option 2: (APPLE)
		- transmit signal quality requirement for UL MIMO as defined in 6.4D.0/1/2/3 could be reused for ATG UE with omni-directional antenna and adapted for ATG UE with antenna array indicating capability antennaArrayType-r18.
			* -For Frequency error and transmit modulation quality requirements, the measurement is done at each antenna connector and requirement is applied per layer. It can be reused for ATG UE with antenna array indicating capability antennaArrayType-r18 with replacement of antenna connector with TAB connector in the description.
			* -For transmit alignment error, the requirement is by comparing the frame timing differences between transmissions on multiple transmit antenna connectors. For ATG UE, the comparison happens between TAB connectors.
	+ Option 3: (ZTE)
		- for transmit signal quality, the general principle as described in 6.4D.1 could be reused for ATG UE supporting the UL MIMO.
		- For ATG UE(s) supporting UL MIMO, the basic measurement interval of modulated carrier frequency is 1 UL slot. The mean value of basic measurements of UE modulated carrier frequency per layer shall be accurate to within ± 0.1 PPM observed over a period of 1 ms of cumulated measurement intervals observed over a period of 1 ms of cumulated measurement intervals compared to ideally pre-compensated reference uplink carrier frequency.
		- for transmit modulation quality for UL MIMO, reuse the existing requirements in clause 6.4D.2 for two antenna connectors and preclude the single antenna port related requirement.
		- for TAE requirement for UL MIMO, reuse the existing requirement in clause 6.4D.3.
	+ Option 4: (Ericsson)
		- Reuse the existing NR UL-MIMO requirement for output power dynamic, transmit signal quality, and output RF spectrum emissions, and do not exclude the single antenna port requirement.
* Recommended WF
	+ - Legacy NR UL MIMO requirements is baseline
			* modify the NR UL MIMO requirement with ATG capability antennaArrayType-r18, detailed based on issue 4-2-1

Agreement:

* + - Legacy NR UL MIMO requirements is baseline
			* modify the NR UL MIMO requirement with ATG capability antennaArrayType-r18, detailed based on issue 4-2-1

**Issue 4-2-6: whether to apply coherent UL MIMO requirement for ATG UE**

* Proposals
	+ Option 1: yes (CMCC, Ericsson)
	+ Option 2: no (ZTE)
* Recommended WF
	+ TBD.

ZTE: In market, we have no coherent MIMO supported by UE in the field.

Ericsson: Prefer to keep option 1. We do not want to preclude any optional features.

**Issue 4-2-7: Output RF spectrum emissions**

* Proposals
	+ Option 1: For output RF spectrum emissions, define the requirement for single layer UL MIMO operation and single antenna-port(W=1) without indicating txDiversity, and with indicating txDiversity with the capability antennaArrayType-r18. (LGE)
	+ Option 3: UL MIMO requirement for ATG UE can be defined as following, (APPLE)
		- -For ATG UE with omni-directional antenna connector, occupied channel bandwidth and spurious emission requirement can be reused directly from 6.5D.1. Similar requirement as 6.5D.2/3can be reused with replacement of ATG UE single carrier requirement for out of band emission.
		- -For ATG UE with antenna array, besides those adaptions for ATG UE with omni-directional antenna, the reference point should be changed to TAB connector.
	+ Option 3: to reuse the existing requirement for NR UL-MIMO for two antenna connectors and preclude the single port related requirements.(ZTE)
	+ Option 4: (Ericsson)
		- Reuse the existing NR UL-MIMO requirement for output power dynamic, transmit signal quality, and output RF spectrum emissions, and do not exclude the single antenna port requirement.
* Recommended WF
	+ - Legacy NR UL MIMO requirements is baseline
			* modify the NR UL MIMO requirement with ATG capability antennaArrayType-r18, detailed based on issue 4-2-1

Agreement:

* + - Legacy NR UL MIMO requirements is baseline
			* modify the NR UL MIMO requirement with ATG capability antennaArrayType-r18, detailed based on issue 4-2-1

### Sub-topic 4-3 UL MIMO Rx requirements

**Issue 4-3: receiver requirements**

* Proposals
	+ Option 1: reuse ATG single carrier requirements for following Rx requirements (ZTE, Ericsson)
		- REFSENSE
		- Max input level
		- ACS
		- Blocking
		- Spurious emission
		- Intermodulation
	+ Option 2: for ATG Rx MIMO requirements, it is enough to add the following clarification for reference sensitivity, maximum input level, ACS, blocking, spurious response and receiver intermodulation requirements. (APPLE)
		- -For ATG UE with omni-directional antenna (or antenna array indicating capability antennaArrayType-r18) in closed-loop spatial multiplexing scheme, the minimum requirements specified in clause 7.xJ shall be met with the UL MIMO configurations described in clause 6.2J.y and clause 6.2J.z for shared spectrum access operation, and the reference measurement channels as specified in Annex A.2.2 for CP-OFDM waveforms shall apply. For UL MIMO, the parameter PUMAX is the total transmitter power over all transmit antenna connectors (or TAB connectors).
* Recommended WF
	+ - Option 1 and FFS for further clarification

Huawei: we are not sure if we need define the separate requirements for UL-MIMO for ATG. We can skip Rx requirements.

Apple: Our proposal in option 2 gives more detailed proposal which is not contradict with option 1.

LGE: Have same view as Huawei.

ZTE: Currently we do have Rx requirement for UL-MIMO, which is similar to non-UL-MIMO. Keeping the consistency, we need keep the structure for ATG. No harm

Moderator: Companies have different views how to capture.

Agreement:

* FFS on whether to have Rx requirements for UL-MIMO for ATG UE