**3GPP TSG-RAN WG4 Meeting # 97-e R4-200XXXX**

**Electronic Meeting, 2-13 Nov., 2020**

**Agenda item:** 10.18.1

**Source:** Moderator (China Telecom)

**Title:** Email discussion summary for [97e][121] NR\_SAR\_PC2\_interB\_SUL\_2BUL

**Document for:** Information

# Introduction

In the last RAN4#96e meeting, the SAR schemes for UE power class 2 NR inter-band CA and SUL configurations were discussed and a WF of R4-20011789 was approved with the following candidate options for SAR schemes:

* *Duty cycle based solutions*
	+ *Option 1: Report one total UL duty cycle capability*
	+ *Option 2: Report the duty cycle capabilities per band*
* *UE implementation based solution, i.e. P-MPR*
* *Other options are not precluded and will be continually discussed in next meeting*

Based on this alignment, companies further study the SAR solutions for CA and SUL. In this meeting, according to the contributions submitted, this email discussion thread will focus on the following aspects:

* Topic #1: PC2 band-combination requirements for example combos
* Topic#2: PC2 SAR solutions
	+ Sub-topic 2-1: For PC2 inter-band CA
	+ Sub-topic 2-2: For PC2 SUL configurations
	+ Sub-topic 2-3: Release independency issue

Note that the table for filling comments is assigned just at the bottom of each section of issues.... But the table for collecting comments for CR/TP is still kept in the original position.

# Topic #1: PC2 band-combination requirements for example combos

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations/Abstracts** |
| [R4-2015039](file:///E%3A%5C01%20%E6%A0%87%E5%87%86%5C14%20HPUE%5C02%20UL_interCA%5CRAN4_97_e%5CDocs%5CR4-2015039.zip) | ZTE Corporation | we give some discussion on the cross band isolation MSD for PC2 NR inter-band CA n41-n79. For the three cases, i.e. 23dBm+26dBm, 26dBm+23dBm and 26dBm +26dBm, the MSD values are proposed:Table 2: Reference sensitivity exceptions (MSD) due to cross band isolation for PC2 NR CA n41-n79

|  |
| --- |
| NR Band / Channel bandwidth of the affected DL band |
| UL band | DL band | 5MHz (dB) | 10MHz (dB) | 15MHz (dB) | 20MHz (dB) | 25MHz (dB) | 30 MHz (dB) | 40 MHz (dB) | 50 MHz (dB) | 60 MHz (dB) | 70MHz(dB) | 80 MHz (dB) | 90 MHz (dB) | 100 MHz (dB) |
| n41 | n79 |  |  |  |  |  |  | 3.4 | 3.4 | 3.4 |  | 3.4 |  | 3.4 |
| n79 | n41 |  | 3.5 | 3.3 | 3.2 |  | 3.0 | 2.9 | 2.8 | 2.7 |  | 2.6 | 2.5 | 2.5 |

 |
| [R4-2015266](file:///E%3A%5C01%20%E6%A0%87%E5%87%86%5C14%20HPUE%5C02%20UL_interCA%5CRAN4_97_e%5CDocs%5CR4-2015266.zip) | Xiaomi | Observation 1: No need to consider harmonic and IMD issues for PC2 band combination CA\_n41-n79.Observation 2: Cross band isolation issue shall be re-evaluated for those PC2 cases that one band can support 26dBm if simultaneous Rx/Tx is supported for CA\_n41-n79.Proposal 1: The MSD value due to cross band isolation as illustrated in table 3 is proposed for PC2 in band n41 for CA\_n41-n79 case c and d.Proposal 2: The MSD value due to cross band isolation as illustrated in table 5 is proposed for PC2 in band n79 for CA\_n41-n79 case b and d. |
| [R4-2015190](file:///E%3A%5C01%20%E6%A0%87%E5%87%86%5C14%20HPUE%5C02%20UL_interCA%5CRAN4_97_e%5CDocs%5CR4-2015190.zip) | China Telecom | Proposal 4: It is proposed to define the MSD requirement as 17.8dB for PC2 CA\_n1A-n78A due to IMD4. The detailed analysis can be found in annex. |
| [R4-2015889](file:///E%3A%5C01%20%E6%A0%87%E5%87%86%5C14%20HPUE%5C02%20UL_interCA%5CRAN4_97_e%5CDocs%5CR4-2015889.zip) | China Telecom, ZTE, Huawei, HiSilicon, CATT | Abstract: CR to 38.101-1 Introduce band combination requirements for PC2 CA\_n1A-n78A |

## Open issues summary

*Before e-Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 1-1: PC2 band-combination requirements

This sub-topic will discuss band-combination requirements for PC2 inter-band CA, i.e. CA\_n41A-n79A and CA\_n1A-n78A.

**Issue 1-1-1: Requirements for PC2 CA\_n41A-n79A**

* Proposals
	+ Option 1: For the three cases, i.e. 23dBm+26dBm, 26dBm+23dBm and 26dBm +26dBm, the MSD values are proposed ([R4-2015039](file:///E%3A%5C01%20%E6%A0%87%E5%87%86%5C14%20HPUE%5C02%20UL_interCA%5CRAN4_97_e%5CDocs%5CR4-2015039.zip))

**Table 1: Reference sensitivity exceptions (MSD) due to cross band isolation for PC2 NR CA n41-n79**

|  |
| --- |
| NR Band / Channel bandwidth of the affected DL band |
| UL band | DL band | 5MHz (dB) | 10MHz (dB) | 15MHz (dB) | 20MHz (dB) | 25MHz (dB) | 30 MHz (dB) | 40 MHz (dB) | 50 MHz (dB) | 60 MHz (dB) | 70MHz(dB) | 80 MHz (dB) | 90 MHz (dB) | 100 MHz (dB) |
| n41 | n79 |  |  |  |  |  |  | 3.4 | 3.4 | 3.4 |  | 3.4 |  | 3.4 |
| n79 | n41 |  | 3.5 | 3.3 | 3.2 |  | 3.0 | 2.9 | 2.8 | 2.7 |  | 2.6 | 2.5 | 2.5 |

* + Option 2: The MSD value due to cross band isolation is proposed in table 2 and 3 ([R4-2015266](file:///E%3A%5C01%20%E6%A0%87%E5%87%86%5C14%20HPUE%5C02%20UL_interCA%5CRAN4_97_e%5CDocs%5CR4-2015266.zip))

**Table 2 MSD due to cross band isolation for PC2 in band n41 for CA\_n41-n79 case c and d**

|  |
| --- |
| E-UTRA or NR Band / Channel bandwidth of the affected DL band / MSD |
| UL band | DL band | 5 MHz(dB) | 10 MHz(dB) | 15 MHz(dB) | 20 MHz(dB) | 25 MHz(dB) | 30 MHz(dB) | 40 MHz(dB) | 50 MHz(dB) | 60 MHz(dB) | 80 MHz(dB) | 90 MHz(dB) |
| n41 | n79 |  |  |  |  |  |  | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 |

**Table 3 MSD due to cross band isolation for PC2 in band n79 for CA\_n41-n79 case b and d**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| UL band | DL band | 5 MHz(dB) | 10 MHz(dB) | 15 MHz(dB) | 20 MHz(dB) | 25 MHz(dB) | 30 MHz(dB) | 40 MHz(dB) | 50 MHz(dB) | 60 MHz(dB) | 80 MHz(dB) | 90 MHz(dB) | 100 MHz(dB) |
| n79 | n41 |  | 3.5 | 3.3 | 3.0 |  |  | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 |

* Recommended WF
	+ Collect views on the proposed MSD values according to option 1 and option 2

|  |  |
| --- | --- |
| **Company** | **Comments on Issue 1-1-1: Requirements for PC2 CA\_n41A-n79A** |
| ZTE | Average values can be adopted. |
| Huawei | In option 1 does band n41 support 30MHz in this combo? Besides, a placeholder is missing to implement the discussion. Considering the spectrum regrowth, even the frequency in Band 41 is above 2506, harmonic MSD still needs to be considered. More analysis of MSD for CA\_n41-n79 is needed. |

**Issue 1-1-2: Requirements for PC2 CA\_n1A-n78A**

* Proposals
	+ Define the MSD requirement as 17.8dB as shown in table 4 for PC2 CA\_n1A-n78A due to IMD4 ([R4-2015190](file:///E%3A%5C01%20%E6%A0%87%E5%87%86%5C14%20HPUE%5C02%20UL_interCA%5CRAN4_97_e%5CDocs%5CR4-2015190.zip))

**Table 4: 2DL/2UL interband Reference sensitivity QPSK PREFSENS and uplink/downlink configurations for PC2 CA (**R4-2015889)

|  |  |
| --- | --- |
| Band / Channel bandwidth / NRB / Duplex mode | Source of IMD |
| NR CAConfiguration | NR band | UL Fc (MHz) | UL/DL BW (MHz) | UL CLRB | DL Fc (MHz) | MSD (dB) | Duplex mode |
| CA\_n1A-n78A | n1 | 1950 | 5 | 25 | 2140 | [17.8] | FDD | IMD4 |
| n78 | 3710 | 10 | 50 | 3710 | N/A | TDD | N/A |

* Recommended WF
	+ Collect views on the proposed MSD value and corresponding formal CR of R4-2015889.

|  |  |
| --- | --- |
| **Company** | **Comments on Issue 1-1-2: Requirements for PC2 CA\_n1A-n78A** |
| CHTTL | Not stong views, but would it be good to align this MSD value to the PC2 DC\_1A\_n78A? |

## Companies views’ collection for 1st round

### CRs/TPs comments collection

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| R4-2015889 | Company A |
| Company B |
|  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
| --- | --- |
|  | **Status summary**  |
| **Sub-topic#1** | *Tentative agreements:*For Issue 1-1-1: Requirements for PC2 CA\_n41A-n79A: More analysis is needed based on the comments received. For Issue 1-1-2: Requirements for PC2 CA\_n1A-n78A: * Adopt the proposed MSD value as [17.8dB] which has been aligned with PC2 DC\_1A-n78A.
* Agree the CR R4-2015889.

*Candidate options:**Recommendations for 2nd round: Discuss issue 1-1-1 on 2nd round* |

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### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provides recommendation on CRs/TPs Status update*

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| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation**  |
| R4-2015889 | Agreed |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation**  |
|  |  |

# Topic #2: PC2 SAR solutions

## Companies’ contributions summary

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| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations/Abstracts** |
| R4-2014383 | CATT | Observation 1: If there’s no Tx diversity implementation demands for the single band mode in 2UL CA, current spec already can distinguish the different implementation scenarios for PC2.Proposal 1: Option 2 is selected as the duty cycle based SAR solutions for PC2 inter-band CA.Proposal 2: Option 2 is selected as the duty cycle based SAR solutions for SUL configuration.Observation 2: The solution for the UE behaviour when the scheduling is beyond UE duty cycle capability and/or the capability is absent needs more discussion. |
| R4-2015040 | ZTE Corporation | Proposal 1. For duty cycle based solutions, report both total duty cycle capability and duty cycle of PCell.Proposal 2. The release independence for PC2 inter-band NR CA is from Rel-16. |
| R4-2015190 | China Telecom | Proposal 1: Report one total UL duty cycle capability for PC2 NR inter-band UL CA.Proposal 2: Report the *maxUplinkDutyCycle-CA-PC2* asthesequence of *maxUplinkDutyCycle[1,2,3,4]* for power class 2 case [a,b,c,d] correspondingly.* Proposal 2a: Choose the *Case a* with n50 dutycycle as default for TDD+TDD CA, and choose the *Case b* with n50 dutycycle as default for FDD+TDD CA, when signalling is absent.

Proposal 3: It is proposed to be release independent from Rel-15 for PC2 NR inter-band UL CA |
| R4-2015192 | China Telecom | Abstract: draft CR to 38.101-1 Introduce SAR solution for UE power class 2 NR inter-band CA with 2UL |
| R4-2015260 | Xiaomi | Observation 1: the UE implementation based solution, i.e. P-MPR should be always allowed for UE meeting SAR issue regardless of CA, DC or non-CA case.Observation 2: Dutycycle based solution is widely adopted in HP UE caseObservation 3: if dutycycle based solution is used, the P-MPR impact on UE maximum permitted output power could be decrease.Proposal 1: Besides the default solution, i.e. UE implementation based solution (P-MPR), the dutycycle based solution can be introduced as a capability for PC2 NR inter-band CA UE meeting SAR issue.Observation 4：If the approach that reporting one capability based on the fixed dutycycle in other band is used, the power configuration does not need to be reported.Proposal 2: For dutycycle based solution, it is proposed that the approach that reporting one capability based on the fixed dutycycle in PCC band is adopted. The number of fixed dutycycle in PCC band shall be FFS. |
| R4-2015287 | Huawei, HiSilicon | Proposal 1: UE reports one scaled dutycycle capability for UL CA combination with 26dbm maximum total output power. |
| R4-2015329 | vivo | Observation 1: There are 3 totally different SAR solutions for SA, ENDC TDD-TDD, ENDC FDD-TDD.Observation 2: For ENDC TDD-TDD/FDD-TDD, the duty cycle of NR bands is reported based on the LTE band configuration/duty cycle.Proposal 1: Reuse the SA, ENDC TDD-TDD, ENDC FDD-TDD HPUE SAR solution as much as possible for inter band CA to reduce complexity.Proposal 2: Reuse ENDC FDD-TDD solution and set 2 reference points in FDD carrier, and to report maximum supported UL duty cycle on TDD carrier for FDD-TDD inter-band CA case. Proposal 3: For the duty cycle values which serve as reference points in FDD carrier, considering forward compatibility and alignment with NR TDD-TDD CA case, the values of reference points are proposed to be reported by UE and [40% 70%] can be default. Proposal 4: Considering NR TDD frame configuration flexibility, based on 2 UL duty cycle reference points on a TDD carrier, which is similar to FDD-TDD EN-DC case, UE reports maximum supported UL duty cycle on another TDD carrier for TDD-TDD inter-band CA case.Proposal 5: Specify a reference band among the two TDD bands. To align with RAN1 power allocation prioritizing order, Pcell or Pscell band is proposed to be reference band.Proposal 6: Considering forward compatibility and UE implementation flexibility, e.g. different capability 23/26dBm in reference TDD carrier, the specific UL duty cycles which serve as reference points are proposed to be reported, rather than fixed values, by UE for TDD-TDD inter-band CA case.Proposal 7: With UE Power class for the band combination and PHR for each carrier reported, no new signaling is needed for the detail power class 2 scenarios.Proposal 8: Confirm it is the maximum output power that is behind the duty cycle reporting, while not to reflect this in the spec to keep the flexibility.Proposal 9: Further discuss the release independency, based on the signaling scheme etc. |
| R4-2015346 | OPPO | Observation 1: Reporting of combined Band X +Band Y duty cycle capability is a possible way for inter-band UL CA HPUE SAR issues.Proposal 1: It is proposed to consider reporting a group of combined maxUplinkdutycycle capabilities for inter-band UL CA HPUE SAR issue. |
| R4-2015983 | Ericsson | Proposal 1: duty cycle reporting should not the basis for UL CA PC2; it is not viable.Proposal 2: to facilitate SAR compliance for UL CA PC2 and prevent dropping of SCells for all CA power classes, specify UE-specific absolute and/or relative power limits (P-Max) modifying the configured maximum output power per serving cell. Proposal 3: the absolute and or relative power limits are set up in an RRC meassage. Then limit to be used by the UE is determined by a MAC-CE or a PDCCH message based on a DCI format, which enables fast adaptation to changing radio conditions (e.g. temporarily disabling limits). This should be liased with RAN1 and RAN2. |
| R4-2016439 | Qualcomm Incorporated | Proposal: Remove the PPowerClass term within the PCMAX\_H for inter-band UL CA. |
| R4-2015041 | ZTE Corporation | Proposal 1. For duty cycle based solutions, report both total duty cycle capability and duty cycle of PCell.Proposal 2. Introduce maximum output power table for both PC3 and PC2 SUL in TS38.101-1. |
| R4-2015191 | China Telecom | Proposal 1: Report one total UL duty cycle capability for PC2 NR SUL configurations.Proposal 2: Report the *maxUplinkDutyCycle-SULcombination-PC2* for power class 2 NR SUL configurations.* Proposal 2a: Choose the value of n50 dutycycle as default when signalling is absent.

Proposal 3: It is proposed to be release independent from Rel-15 for PC2 NR SUL configurations |
| R4-2015194 | China Telecom | Abstract: draft CR to 38.101-1 Introduce SAR solution for UE power class 2 NR SUL configurations |
| R4-2015286 | Huawei, HiSilicon | Proposal 1: UE reports maximum supported UL duty cycle on the SUL band according to the TDD configuration when configured with SUL + TDD combinations.Proposal 2: PC2 HPUE only falls back maximum output power on TDD band but not SUL band when operating under SUL-TDD band combinations.Proposal 3: The condition for UE power fallbacks is met when either 1) the network configures 23dbm or less Pmax or 2) the network schedules too much UL resources, under SUL-TDD band combinations operating with 26dbm MOP. |
| [R4-2015330](file:///E%3A%5C01%20%E6%A0%87%E5%87%86%5C14%20HPUE%5C02%20UL_interCA%5CRAN4_97_e%5CDocs%5CR4-2015330.zip) | vivo | Proposal 1: Reuse the SA, ENDC TDD-TDD, ENDC FDD-TDD HPUE SAR solution as much as possible for PC2 UE with SUL to reduce complexity.Proposal 2: Considering NR TDD frame configuration flexibility, UE reports maximum supported UL duty cycle on the SUL band based on 2 reference points of NR TDD uplink transmission.Proposal 3: Considering UE implementation flexibility and forward compatibility, the specific reference points are proposed to be reported by PC2 UE with SUL case.Proposal 4: To align with power allocation prioritizing order in 38.213, UE reduces the transmission power on the lower priority carrier.Proposal 5: Confirm it is the maximum output power that is behind the duty cycle reporting, while not to reflect this in the spec to keep the flexibility.Proposal 6: Further discuss the release independency, based on the signaling scheme etc.Observation 1: Whether and how to distinguish the power class 2 scenarios is not applicable to SUL case. |
| [R4-2015345](file:///E%3A%5C01%20%E6%A0%87%E5%87%86%5C14%20HPUE%5C02%20UL_interCA%5CRAN4_97_e%5CDocs%5CR4-2015345.zip) | OPPO | 2.1 The normal handling of SAR*Observation 1: Reporting of maxUplinkdutycycle was widely used to solve HPUE SAR issues.*2.2 Possibility of reusing EN-DC SAR solutions*Observation 2: In TDD+TDD EN-DC, the maxUplinkdutycycle was reported based on fixed LTE TDD UL/DL configuration.**Observation 3: SUL is DCI dynamic scheduling transmission, and there is no fixed UL duty cycle.**Observation 4: The TDD+TDD EN-DC SAR scheme cannot be reused directly.**Observation 5: The FDD+TDD EN-DC scheme is based on two reference FDD band duty cycle which makes the reported NR TDD capability is inaccurate in most of the time.**Proposal 1: SUL SAR solutions should be fully considered rather than directly reuse the legacy TDD+TDD or FDD+TDD EN-DC duty cycle SAR solutions due to possible degraded system performance.*2.3 Potential SUL SAR solutions*Observation 6: SUL has its own special characteristics, i.e. non-simultaneous transmission with NUL, separate power class defined, and already reported NR TDD band duty cycle capability.**Observation 7: One straightforward approach is to reuse the NR TDD band maxUplinkdutycycle, and further report the maxUplinkdutycycle for SUL band, and then combine these two capability together.**Observation 8: With new SUL band duty cycle capability further reported, the SUL+NR TDD SAR can be solved by simple time average of the SUL band and NR TDD band duty cycle capability.**Observation 9: NR TDD and SUL band can be scheduled flexibly and no longer be restricted to one or two fixed duty cycles.**Observation 10: Tight coordination between SUL and NUL BS is not a problem since SUL feature is already under the condition of tight coordination.**Observation 11: Calculation of the total duty cycle in SUL and NUL from UE side is no more work than the current maxUplinkdutycycle in SA or TDD/TDD FDD/TDD NSA HPUE.**Proposal 2: It is proposed to only report maxUplinkdutycycle for SUL band under 26dBm to solve the SAR issue.**Proposal 3: SUL maxUplinkdutycycle capability is only for NW to consider and no restriction on the NW scheduler design as other maxUplinkdutycycle capabilities have done.**Observation 12:* Current *maxUplinkDutyCycle-PC2-FR1* can be extended to SUL band with modification of the description in 38.306 and no new signaling needs to be defined to provide further information to NW.*Observation 13:* Flexibility can be given to UE implementation on calculation of the averaged duty cycle.*Proposal 4: It is proposed to consider reusing the current maxUplinkDutyCycle-PC2-FR1 capability for SUL band capability reporting.* |

## Open issues summary

*Before e-Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 2-1: For PC2 inter-band CA

This sub-topic will discuss SAR schemes/solutions for PC2 inter-band CA.

**Issue 2-1-1: SAR schemes for PC2 inter-band CA**

* Proposals
	+ Duty Cycle based solutions
		- Option 1: Report one total UL duty cycle capability
			* CTC: Report one total UL duty cycle capability for PC2 NR inter-band UL CA.
			* HW: UE reports one scaled dutycycle capability for UL CA combination with 26dbm maximum total output power.
			* ZTE: For duty cycle based solutions, report both total duty cycle capability and duty cycle of PCell.
		- Option 2: Report the duty cycle capabilities per band
			* CATT: Option 2 is selected as the duty cycle based SAR solutions for PC2 inter-band CA.
			* Xiaomi: reporting one capability based on the fixed dutycycle in PCC band is adopted. The number of fixed dutycycle in PCC band shall be FFS.
			* vivo: Reuse ENDC FDD-TDD solution and set 2 reference points in FDD carrier, and to report maximum supported UL duty cycle on TDD carrier for FDD-TDD inter-band CA case. Considering NR TDD frame configuration flexibility, based on 2 UL duty cycle reference points on a TDD carrier, which is similar to FDD-TDD EN-DC case, UE reports maximum supported UL duty cycle on another TDD carrier for TDD-TDD inter-band CA case.
			* OPPO: reporting a group of combined maxUplinkdutycycle capabilities for inter-band UL CA HPUE SAR issue.
			* ZTE: For duty cycle based solutions, report both total duty cycle capability and duty cycle of PCell.
	+ UE implementation based solution, i.e. P-MPR
		- Xiaomi: Considering NR TDD frame configuration flexibility, based on 2 UL duty cycle reference points on a TDD carrier, which is similar to FDD-TDD EN-DC case, UE reports maximum supported UL duty cycle on another TDD carrier for TDD-TDD inter-band CA case.
	+ Other options: Similar to “blind scheme”
		- Ericsson: to facilitate SAR compliance for UL CA PC2 and prevent dropping of SCells for all CA power classes, specify UE-specific absolute and/or relative power limits (P-Max) modifying the configured maximum output power per serving cell.
* Recommended WF
	+ Figure out the capabilities reporting for duty cycle solution
	+ Determine the baseline solution
	+ Discussion on other options

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| --- | --- |
| **Company** | **Comments for Issue 2-1-1: SAR schemes for PC2 inter-band CA** |
| CATT | * + Duty Cycle based solutions

We still have the slight preference of option 2. We understand the intention of the option 1 that the signalling seems cleaner than option 2. And the option 2 has some draw backs that signalling is more complicated and also reference configuration needs to be discussed. However, for the option 1, we’re not sure what’s the exact definition of the total duty cycle capability. Does UE need to measure the every possible configuration possibilities for the bands pair then report the worst case? Should NW configure the UL duty cycle considering the reported capability is the maximum capability? It seems UE needs to do more if option 1 is chosen although the signalling is cleaner. And for the future test case discussion, how to confirm the performance needs more discussion. For example, if 50% is reported, which configuration is used to check the performance?* + UE implementation based solution, i.e. P-MPR

We don’t have strong opinion but think P-MPR can be a candidate when the NW scheduling is beyond UE capability or the capability is absent. |
| Intel | Both option 1 and option 2 can be used. We slightly prefer option 1 due to signalling simplicity. But neither option provides the detail fallback behaviour. The UE fallback behaviour needs to be specified as well.  |
| Xiaomi | * + Duty Cycle based solutions

As mentioned in our paper, the option 1 that Reporting one total UL duty cycle capability has two disadvantages. One is that it is based on the assumption that equal weighting for the SAR effect between bands, which may not be always reasonable in term of actual implementation, the other one is that it is not straightforward for BS to determine whether current dutycycle configuration excess its capacity, as it needs to check through the equation. If we look at the approaches used in NSA FDD+TDD and TDD+TDD, it can be found they are actual the same, that is reporting one capability based on the fixed dutycycle in other band. We think the similar approach could be also used for inter-band CA. Therefore for dutycycle based solution, it is proposed that the approach that reporting one capability based on the fixed dutycycle in PCC band is adopted. The number of fixed dutycycle in PCC band can be for further study.* + UE implementation based solution, i.e. P-MPR

The UE implementation based solution, i.e. P-MPR should be always allowed for UE meeting SAR issue regardless of CA, DC or non-CA case.* + Other options: Similar to “blind scheme”

We think the traditional dutycycle approach and P-MPR shall be reused as much as possible to address SAR issue. |
| Verizon | Issue 2-1-1: SAR schemes for PC2 inter-band CA For the both option 1 and 2, a common problem for us is they are absent of the nonlinear responses for the SAR effects in different band combinations (a, b, c and d), and the nonlinear response of SAR effects in the different total radiated power. Under this way, it is hard for us to make a preference. We also would encourage Ericsson to provide the proposal in detail, including the method difference from early one to derive the UE-specific absolute and/or relative power limits (P-Max) from an RRC message and adaptation to changing radio conditions. |
| China Telecom | Issue 2-1-1: SAR schemes for PC2 inter-band CAActually, we think there is no much difference between option1 and option2 from network scheduling point. Because the dutycycle solution is based on the status of UE working on maximum power and the reporting capability is a reference for network scheduling. But we think the dutycycle capability reporting is more meaningful for indicating UE supporting PC2, especially the specific PC2 scenario (e.g. 23+23.. etc.), rather than the reference duty value. Because the UE has little chance to work just in equal to the reported duty value. Therefore, to simply the capability reporting, we think option1 is better than option2. However, from testing point, we shall determine the reference duty value per band in order to make the test case more clear and feasible. So, we fully agree with the views from Intel, to simplify the capability reporting, we prefer option1 to report total capability. Regarding test case concerned by some companies, it could be further discuss when define in RAN5.Regarding the baseline, we are ok to use P-MPR as baseline solution, in order to make this feature to be release independent from Rel-15.  |
| ZTE | * + Duty Cycle based solutions

It seems our proposal is the combination of option 1 and option 2, i.e. total duty cycle capability and duty cycle of one band(Pcell).We think it is a feasible way to reuse similar approach of PC2 inter-band ENDC as much as possible. For PC2 inter-band ENDC, only total duty cycle capability is reported on top of the known E-UTRA duty cycle, i.e. total duty cycle capability+ E-UTRA(i.e. MCG) duty cycle. With the known E-UTRA duty cycle, the NR band capability/duty cycle can be derived from total duty cycle capability. In the other word, the capability/duty cycle for each band are known. Therefore, we think reporting total duty cycle capability and duty cycle of PCell NR band is a feasible way.In addition,we think reporting the duty cycle of each band or reporting only one total duty cycle maynot distinguish the different cases.* + UE implementation based solution, i.e. P-MPR

It have already been captured in the WF that *UE implementation based solution, i.e. P-MPR.* In our understanding, P-MPR is always allowed for UE meeting SAR issue regardless of CA, DC or non-CA case. |
| OPPO | **Issue 2-1-1: SAR schemes for PC2 inter-band CA**Both Option 1 and Option 2 can work in some level, but prefer Option 2 since the unequal SAR effects under same power level can be considered with Option2.And the reporting could be in a group style like (X1, Y1), (X2, Y2), (X3, Y3)…, then no matter which band is configured as Pcell the other band can know the corresponding max duty cycle. |
| vivo | * + Duty Cycle based solutions

Option 1 has basic conceptual problem. The basic assumption of option1 is the SAR effect of two different bands are identical except power class. The duty cycle margin can be used in any of two bands. But the SAR effect differences of different bands can be large, for example, the radiation density is highly related to antenna design. Typical antenna length for 800M can be 4~5 times larger compared to that for 3.5GHz, e.g. 5cm compared to 1cm. It’s possible to have 4-7dB difference in SAR effect under the same MOP. When the SAR effects of different bands are combined, the weighing of each band should be different. One total duty cycle is not able to show all these differences.2 reference points SAR solution in FDD-TDD ENDC can indicate the SAR difference of different band, power class etc. For example, the reference points of a band are 40% and 70%, and if the capability difference of the other band based on the reference points are also 30% (equal to 70%-40%), it implicitly indicates the SAR effect of these 2 bands are similar. If the capability difference of the other band is 15%, it can be deduced the of the other band has twice SAR effect for the same UL transmission, possibly due to frequency band, power class etc.Another benefit of FDD-TDD ENDC solution is that it’s possible to interpolate UE capability when the uplink transmission time on the reference band is not exactly equal to 40% or 70%, thus NW can have more flexibility.The proposed solution:1. The reference band: PCC bandUE report duty cycle capability based on PCC band. 2. The number of reference points: 2 reference points1 reference point cannot indicate the SAR effect difference of different bands. More than 2 reference points introduce more signaling overhead and complexity, but the performance improvement is not much, comparing with 2 reference points.3. How to indicate the reference points Proposed option in our contribution: UE report the reference points and the corresponding capability. Though still viable and quite flexible, considering totally different reference points are reported by UE, it may increase complexity to use it. A new tentative option: two pair of reference points are defined: [40%/70%], [20%/35%], UE chooses one pair reference points to report duty cycle. For example, this can be used for 23dBm/26dBm capability for primary cell. One set of tentative signaling can be as the following table:

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| --- | --- |
| **UE maxUplinkDutyCycle signaling** | **Parameter (for another cell)** |
| ReferenceDutyCycle70and40 | {maxUplinkDutyCycle1, maxUplinkDutyCycle2 } |
| ReferenceDutyCycle35and20 | {maxUplinkDutyCycle1, maxUplinkDutyCycle2 } |

 * + UE implementation based solution, i.e. P-MPR

P-MPR can be default option when there is no capability signalling.* + Other options: Similar to “blind scheme”

It seems only applicable for FDD-TDD case and too much singling overhead for power limit configuration. And also, it has similar issues as ‘blind scheme’. |
| Qualcomm | * Duty cycle based approaches

We don’t have a strong preference for option 1 or option 2 at the moment. However, if pairs of values are reported (band 1, band 2), then there might be a concern that on the complexity increase in the basestation to manage completely different reported capabilties from each UE in the chell.* P-MPR

Similar to the comments of other companies, we believe that P-MPR shall always be available as the baseline for the UE to meet SAR. Duty cycle based approaches are optional enhancements. |
| Ericsson | Issue 2-1-1:We do not support the duty-cycle reporting scheme in Option 1 and Option 2, these types of duty-cycle reporting only impose restrictions on the scheduling without effectively optimizing the UE output power for HPUE CA operation as discussed in R4-2015983 and R4-2010349 for EN-DC. The need for PC3 fallback is not only determined by the time domain behaviour. The only possible is for TDD-TDD, e.g. limiting the sum of the UL duty cycles of the common U-D patterns (static) for the bands to 50%. Then the average would never exceed 23 dBm regardless of the output power and no need for ‘fallback’.We propose to consider ‘other methods’ that work also for FDD-TDD band combinations, e.g. the “blind scheme” that is based on the proposal for resolving the SCell power drop issue discussed in R4-2015978 (the same problem for FR1). The power prioritization rules in 38.213 also apply for UL CA PC2 (and SUL combinations) and must be considered in addition.To Verizon: more details can be found in R4-2015978. Instead of setting power limits on the cell groups by “slow” RRC reconfiguration like for EN-DC PC2, configured limits can be set on the serving cells to reserve power for the TDD but also be temporarily disabled (e.g. if full power needed on FDD or the PCell) by DCI indication that enables “fast” adaptation to changing radio conditions. A complement to the power prioritization (priority) specified in 38.213. In this way the UE behaviour would be under network control. We can provide more details at the next meeting.Proprietary P-MPR methods are also available, Not our first choice, but preferable to duty-cycle reporting.  |
| CMCC | * + Duty Cycle based solutions

Prefer option 2: Report the duty cycle capabilities per band. RAN4 have defined PC2 NR SA bands, PC2 EN-DC SAR solutions based on per band duty cycle reporting. At least for PC2 CA TDD+TDD combination, the per band duty cycles capabilitier method can be reused. We recommend reuse of existing solutions as much as possible, and we have no way to report total duty cycle, such as how to improve the uplink duty cycle capability of a certain band, |
| Huawei | For duty cycle based solution 1 we can have different weighting on carriers reported together with the normalized dutycycle capability.The blind scheme seems introducing another set of Pmax to us. The UE is still relying on either capability reporting or PMPR implementation. |
| CHTTL | As commented by other companies, since P-MPR is always be available, we would like to see other agreeable solution, the P-MPR solution can be the last resort. |
| T-Mobile USA | Option 2 only seems to make sense for TDD+TDD. For FDD+TDD wouldn’t the FDD duty cycle always be 100%? We support the “blind scheme” proposed by Ericsson.  |
| Apple | We have the following feedback related to the Moderator’s suggested WF:o Figure out the capabilities reporting for duty cycle solution: we suggest following Option 1 (one duty cycle for the combination), and the duty cycle should assume the worst case for the configuration and the particular UE implementationo Determine the baseline solution: the baseline shall be the P-MPR approach, as was agreed in the Rel-16 WI on HPUE for FDD-TDD |

**Issue 2-1-2: Power configuration issue for PC2 inter-band CA**

* Proposals for output power limit
	+ Qualcomm: Remove the PPowerClass term within the PCMAX\_H for inter-band UL CA.
* Recommended WF
	+ Collect views on this proposal

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| **Company** | **Comments for Issue 2-1-2: Power configuration issue for PC2 inter-band CA** |
| Intel | In general, agree with the idea. But not sure 1) if UE co-existence needs re-evaluation due to removing PPowerClass in upper bound of Pcmax. 2) how to address SAR issue, etc  |
| Xiaomi | This should be carefully studied since it may be a challenge to meet the out of band emission such as SEM and spurious emission with the original MPR per band especially for those band combinations that having the poor cross band isolation.In addition, to address SAR issue, even it can be done with a lower dutycyle reporting for a UE with higher transmission power, but when the UL EN-DC scheduling exceeds the UE capability, what is UE behavior in this case, how to fallback? |
| Verizon | We agree the observations and support the idea to remove the PPowerClass in order to make the expressed power limits of a serving cell in a linear scale although more detailed requirements should be studied further and minimize the possible impacts from this change. |
| ZTE | If removing the PPowerClass , then PCMAX\_H will be only limited by the signaling. If the signaled max. output power is very larger (such as >>PPowerClass ), then how to guarantee the SAR and the unwanted emission? |
| OPPO | Idea is interesting, need further study on the impacts. |
| Vivo | Without output power limit, it will be a huge challenge for UE SAR compliance test. The SAR compliance test is verified with MOP, and the positive tolerance also needs be considered, such as: (23+2) dBm for PC3 UE need to reach SAR limit. If we don’t have the output power limit, the SAR limits need be fulfilled with the possible maximum output power. It will have much impact on UE RF design. |
| Qualcomm | Thank you to all companies for the very good questions and comments. I think all companies recognize the value in being able to transmit higher power, but of course, there are some technical points that need to be understood.For Intel, UE coexistence studies drive the ACS and ACLR requirements. In fact, these have already been studied for PC1.5 so we already know that the requirements are the same as for PC2. SAR is addressed with the same approaches for example duty cycle and P-MPR. This has also been studied for PC1.5 where duty cycle of 25% was assumed. We need to ensure that the duty cycle approaches include values that can include maximum 25% duty cycle across the sum of two carriers. For Xiaomi, we defined MPR and A-MPR to meet spurious emission requirements. Those MPR and A-MPR affect the Pcmax\_L limit. Since the proposal does not touch Pcmax\_L and since the PA’s are the same ones for PC2, then the spurious emissions are met when taking MPR and A-MPR as needed. Changing the upper limit Pcmax\_H only allows higher power when MPR and A-MPR are not needed, the the same way that maximum output power for any power class can only be reached when MPR=A-MPR=0. Fallback when scheduling exceeds UE capability is the same; fallback to PC3 for example.For ZTE, it is not our intention to have unlimited Pcmax\_H. If we remove the PPowerClass, the Pcmax\_H is limited by linear sum of Pemax,c. We assume that these take on the value of the reported power class in each CC if there is nothing signaled by the network. So if we have PC2+PC3 UL CA, then the sum would be 23 + 26 and this becomes the upper limit to Pcmax\_H for the UL CA configuration.For vivo, the SAR mechanisms are unchanged – duty cycle reporting and P-MPR. We do agree that the design will need to consider the higher power when reporting duty cycle and using P-MPR, but this can be handled with good design. If the antenna design is not able to meet SAR with reasonable duty cycle at higher power, then the Pcmax\_H is not mandatory. Higher power is allowed, but not required since Pcmax\_L is unchanged but Pcmax\_H is raised. |
| Ericsson | An interesting proposal. Actually Ericsson proposed this for the original “blind scheme” proposal for EN-DC FDD-TDD PC2 assuming a peak power of 23 + 26 dBm in the TDD burst but with a specific “HPUE power class” tailored such that the average over a radio frame is retained at 23 dBm. This was not agreed due to concerns with e.g. unwanted emissions requirements and the proposal was modified such that the power in the TDD burst was capped at 26 dBm. But this is all history.The 23 dBm power class for UL CA PC3 is not artificial in the absence of any means for facilitating SAR compliance, but the 26 dBm cap for UL CA HPUE is somewhat artificial. However, for TDD-TDD combinations for which the sum of the UL duty cycles of the common U-D configurations in both bands is less than 50%, a 26 dBm CA power class would make sense: the average output power would never exceed 23 dBm nominal regardless of the output power (no PC3 ‘fallback’ needed). This in case a 23 dBm average is still the criterium for facilitating SAR compliance (and UE heat management).We are open to a further discussion of the Qualcomm proposal. |
| Huawei | Interesting indeed. We are also open to discuss the proposals furthermore and we expect the discussion to be undertaken in a better placeholder rather than this WI. Decoupling the idea from the established WI specifying SAR compliance for band combination for PC2 seems a just approach. |
| T-Mobile USA | We support this idea.  |
| Apple | We appreciate the thoughtful analysis in the paper and can see the similarity to the PC1.5 discussion previously. We would like ot keep the option for new power classes (such as PC1.5) open for this meeting and to make a decision next meeting. |

### Sub-topic 2-2: For PC2 SUL configurations

This sub-topic will discuss SAR schemes/solutions for PC2 SUL configurations.

**Issue 2-2-1: SAR schemes for PC2 SUL configurations**

* Proposals
	+ Duty Cycle based solutions
		- Option 1: Report one total UL duty cycle capability
			* CTC: Report one total UL duty cycle capability for PC2 NR SUL configurations
			* ZTE: For duty cycle based solutions, report both total duty cycle capability and duty cycle of PCell
		- Option 2: Report the duty cycle capabilities per band
			* Huawei: UE reports maximum supported UL duty cycle on the SUL band according to the TDD configuration when configured with SUL + TDD combinations
			* vivo: Considering NR TDD frame configuration flexibility, UE reports maximum supported UL duty cycle on the SUL band based on 2 reference points of NR TDD uplink transmission.
			* OPPO: It is proposed to only report maxUplinkdutycycle for SUL band
			* ZTE: For duty cycle based solutions, report both total duty cycle capability and duty cycle of Pcell
			* CATT: Option 2 is selected as the duty cycle based SAR solutions for SUL configuration.
* Recommended WF
	+ Figure out the capabilities reporting for duty cycle solution
	+ Determine the baseline solution

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| **Company** | **Comments for Issue 2-2-1: SAR schemes for PC2 SUL configurations** |
| CATT | The same comment as 2-1. We still have slight preference of option 2. One question from our side for other companies’ proposals in option2, why NUL is prioritized that only the duty cycle capability of SUL should be reported. Our understanding is that NUL and SUL should be treated equally when considering SAR schemes. |
| Intel | See comments to Issue 2-1-1. |
| Xiaomi | See comments to 2-1-1 |
| China Telecom | Regarding SUL configuration, because there is only one scenario (23+26) for PC2. We don’t have strong view to report total capability or only for SUL band. But we think keep signaling simplicity is the high priority factor. To make the signaling compatible to further enhance for SUL configurations e.g. 26+26. We could also consider option1. The test case in RAN5 is FFS in similar way treated for CA. |
| ZTE | we think same solutions can be applied to PC2 SUL and PC2 NR inter-band. See comments to 2-1-1  |
| OPPO | Only report the maxUplinkdutycycle for SUL band is enough. But ok to adopt same solution as inter-band CA for simplicity. |
| Vivo | We propose to reuse the solution of issue 2-1-1. How to determine the fallback behavior needs be FFS. |
| CMCC | See comments to Issue 2-1-1. |
| Huawei | No strong view. If weighting reporting is decided for UL CA, SUL also applies it automatically. |

### Sub-topic 2-3: Release independency issue

**Issue 2-3-1: Release independency issue for PC2 inter-band CA**

* Proposals
	+ CTC: It is proposed to be release independent from Rel-15 for PC2 NR inter-band UL CA
	+ ZTE: The release independence for PC2 inter-band NR CA is from Rel-16
	+ vivo: Further discuss the release independency, based on the signaling scheme etc
* Recommended WF
	+ Determine the release

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| **Company** | **Comments for Issue 2-3-1: Release independency issue for PC2 inter-band CA** |
| CATT | It seems the PC2 release independent follows the release independent of the CA. We would like to know if there’s any issue if it’s from R15. |
| Intel | Which release being independent from can be determined by UE behavior when signaling is absent – behavior must be backward compatible. Since early release UEs don’t support such signaling, then their behavior must be same with the new release UEs with signaling absent. |
| Xiaomi | Share the same view with intel |
| China Telecom | It shall be release independent from Rel-15, if P-MPR is the baseline solution which can solve the issue when signaling is absent for R15 and R16 new UE. There is also no impact to the existing UE.  |
| ZTE | In our understanding, so far duty cycle signaling for PC2 ENDC are not supported in Rel-15 RAN2, and it is foreseen that RAN2 will introduce new signaling to support PC2 inter-band FDD-TDD/TDD-TDD CA if duty cycle based solutions is agreed. Also in current spec, inter-band NR CA Pcmax doesn’t support PC2. So release independence from Rel-16 is our preference. |
| OPPO | From Rel-15 is ok with PMPR. |
| Vivo | We prefer to determine this after the total solution is set. |
| Qualcomm | We think Rel-15 is acceptable since the baseline is P-MPR that does not require any of the new reporting. |
| CMCC | It depends on whether there is a new signaling or SAR solution |
| T-Mobile | We agree that shiw should be release independent to Rel-15 as long as new signalling is not required.  |

**Issue 2-3-2: Release independency issue for PC2 SUL configurations**

* Proposals
	+ CTC: It is proposed to be release independent from Rel-15 for PC2 SUL configurations
	+ vivo: Further discuss the release independency, based on the signaling scheme etc
* Recommended WF
	+ Determine the release

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| **Company** | **Comments for Issue 2-3-2: Release independency issue for PC2 SUL configurations** |
| CATT  | Same comment as above. |
| Intel | Same comments to Issue 2-3-1 |
| Xiaomi | Same comment as above. |
| China Telecom | Same comment as above. |
| OPPO | From Rel-15 is ok with PMPR. |
| Vivo | Same comments as above. |
| CMCC | Same comment as above |

## Companies views’ collection for 1st round

### CRs/TPs comments collection

The following two draft CRs will depend on the progress of SAR schemes discussion.

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| --- | --- |
| **CR/TP number** | **Comments collection** |
| R4-2015192 | Ericsson: not endorsed, the duty-cycle reporting proposed is not viable. |
| Company B |
|  |
| R4-2015194 | Ericsson: are options other than duty cycle reporting investigated? |
| Company B |
|  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
| --- | --- |
|  | **Status summary**  |
| **Sub-topic#1** | *Tentative agreements:*UE implementation based solution, i.e. P-MPR is always available as the baseline solution for NR PC2 inter-band CA and SUL configurationsNR PC2 inter-band CA and SUL configurations are release independent from Rel-15 based on the P-MPR solution.*Candidate options:*Duty Cycle based solutions* Option 1: Report the duty cycle capability per band combination (CTC, Intel, ZTE, Huawei, Apple)
	+ Main issue commented by companies：Nonlinear responses for the SAR effects in different band frequencies.
* Option 2: Report the duty cycle capabilities per band (CATT, Xiaomi, ZTE, OPPO, vivo, CMCC)
	+ Main issue commented by companies: Too many pairs of signallings, more detailed signalling design and values need to be provided, especially for the reference band.

Blind scheme solution (Ericsson, Verizon, T-Mobile USA)PCMAX\_H configuration change: Further discussion on the feasibility and impacts*Recommendations for 2nd round:* Further discussion on the SAR solutions, i.e. dutycycle, and “blind scheme” which shall be captured in a WF. |

*Recommendations on WF/LS assignment*

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| --- | --- | --- |
|  | **WF/LS t-doc Title**  | **Assigned Company,****WF or LS lead** |
| #1 | WF on UE PC2 for NR inter-band CA and SUL configurations | China Telecom |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provides recommendation on CRs/TPs Status update*

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| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation**  |
| R4-2015192 | noted |
| R4-2015194 | noted |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

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| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation**  |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |