**3GPP TSG-RAN** **WG2 Meeting #109bis-e R2-200xxxx**

**Electronic, April 20 – 30, 2020**

**Source: Qualcomm Incorporated**

**Title: Summary of email discussion [AT109bis-e][064][NR15] XDD FRX differentiation (Qualcomm)**

**Document for: Decision**

**Agenda Item: 5.4.3**

# Introduction

This document summarizes the following email discussion.

* [AT109bis-e][064][NR15] XDD FRX differentiation (Qualcomm)

Scope: Reply LS to R1, In this context, clarify the meaning of/how current signaling works. Determine whether clarifications to current TS is needed. Can discuss how to extend if/when needed.

Intended outcome: Approved LS, Report and/or clarification CR (if agreed).

Deadline: April 29 0700 UTC

# Discussion

## UE setting of xDD FRx split capabilities

During the online discussion the following two interpretations were identified on how the UE sets xDD FRx split capabilities when the feature is supported only in one of duplex modes or frequency range.

(The following description is difficult to understand. It is recommended to look at example scenarios further down).

**Interpretation 1** (e.g. [R2-2002573](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_109bis-e/Docs/R2-2002573.zip))

* The UE indicates the feature support for a duplex mode (e.g. TDD), regardless of whether the UE supports the feature in all supported combination(s) of the duplex mode and frequency range(s) (e.g. FR1-TDD, FR2-TDD) according to the reported frequency band capability.
* The UE indicates the feature support for a frequency range (e.g. FR1), regardless of whether the UE supports the feature in all supported combination(s) of the frequency range and duplex mode(s) (e.g. FR1-FDD, FR1-TDD) according to the reported frequency band capability.

**Interpretation 2** (e.g. [R2-2003269](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_109bis-e/Docs/R2-2003269.zip)):

* The UE indicates the feature support for a duplex mode (e.g. TDD), only when the UE supports the feature in all supported combination(s) of the duplex mode and frequency range(s) (e.g. FR1-TDD, FR2-TDD) according to the reported frequency band capability.
* The UE indicates the feature support for a frequency range (e.g. FR1), only when the UE supports the feature in all supported combinations of the frequency range and duplex mode(s) (e.g. FR1-FDD, FR1-TDD) according to the reported frequency band capability.

Let’s look at some scenarios for easier understanding of the two different interpretations above.

**Scenario 1:**

* The UE reports the support for FR1 FDD band, FR1 TDD band, and FR2 TDD band.
* The UE supports the feature only for FR2 TDD
* **With interpretation 1:**
  + The UE includes the capability in tdd-Add-UE-NR/MRDC-Capabilities.
  + The UE includes the capability in fr2-Add-UE-NR/MRDC-Capabilities.
* **With interpretation 2:**
  + The UE does **NOT** include the capability in tdd-Add-UE-NR/MRDC-Capabilities.

(because the UE does not support the feature for TDD with all applicable frequency ranges according to the supported frequency bands; in this case FR1 TDD and FR2 TDD.

* + The UE includes the capability in fr2-Add-UE-NR/MRDC-Capabilities.

(because the UE supports the feature for FR2 with all applicable duplex mode according to the supported frequency bands; in this case FR2 TDD.

**Scenario 2:**

* The UE reports the support for FR1 FDD band and FR2 TDD band.
* The UE supports the feature only for FR2 TDD (same as scenario 1)
* **With interpretation 1:**
  + The UE includes the capability in tdd-Add-UE-NR/MRDC-Capabilities.
  + The UE includes the capability in fr2-Add-UE-NR/MRDC-Capabilities.
* **With interpretation 2:**
  + The UE includes the capability in tdd-Add-UE-NR/MRDC-Capabilities.

(because the UE support the feature for TDD with all applicable frequency range according to the supported frequency bands; in this case only FR2-TDD)

* + The UE includes the capability in fr2-Add-UE-NR/MRDC-Capabilities.

(because the UE support the feature for FR2 with all applicable duplex mode according to the supported frequency bands; in this case only FR2-TDD)

As can be observed, the key difference in interpretation 2 is that the setting of xdd/frx-Add-UE-NR/MRDC-Capabilities is dependent on the supported frequency bands that the UE reports in the UE radio capability.

Companies are requested to provide their comment on the two interpretations as described above.

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| --- | --- |
| **Company name** | **Comments** |
| Qualcomm Incorporated | Our understanding is in line with the interpretation 1. We also see a few technical drawbacks for the interpretation 2.  With the interpretation 1, the network considers that the UE supports the feature in duplex mode + frequency range combination, only if the UE signals the support of the feature for both the duplex mode and the frequency range. With interpretation 2 however, the network needs to look into the xDD FRx split capabilities AND frequency band capability of the UE to derive the true UE capability.  Furthermore, with the interpretation 2, the UE needs to change the setting of xDD FRx split capabilities according to the frequency bands the UE reports. It should be noted that the frequency bands the UE reports is subject to UE capability filter. |
| OPPO | Agree with Qualcomm’s comments. |
| Samsung | We are not sure this interpretation is the main points.  According to the TS 38.306, these xdd/frx-Add-UE-NR/MRDC-Capabilities are set the values only when the feature is different in the supported duplex mode(s) and frequency range(s) of the UE. Share the view on R2-2003454.  For example, we explain our understanding for signalling of dynamicSFI in PHY-Parameters   1. Step 1: UE set the dynamicSFI for supported all xDD/FRx as common signaling  * phy-ParametersXDD-Diff in phy-Parameters * phy-ParametersFRX-Diff in phy-Parameters  1. Step 2: UE include a parameter to set in 4 xdd/frx-Add-UE-NR/MRDC-Capabilities if the supporting of feature in this mode is different with the previous.   If we go back to the scenario 1/2 above, we think the signalling would be below regardless of the reported bands from UE.   1. Step 1: UE set the dynamicSFI to support in phy-ParametersFRX-Diff in phy-Parameters 2. Step 2: Skip this step   If we must select the interpretation above, then we think the interpretation 2 but only scenario 1 is the correct signalling. |
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## “Problematic case”

The problematic case which the UE would not be able to signal true UE capability depends on the interpretation on how the UE sets xDD FRx split capabilities.

* **With interpretation 1 (see Annex 1):**
  + FR1 FDD: Supported
  + FR1 TDD: Not supported
  + FR2 TDD: Supported
* **With interpretation 2 (see Annex 2):**
  + FR1 FDD: Not supported
  + FR1 TDD: Supported
  + FR2 TDD: Not supported
  + The UE supports FR1 FDD, FR1 TDD, and FR2 TDD

Companies are requested to state if they agree to the above or not.

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| **Company name** | **Agree / Disagree** | **Comments** |
| Qualcomm Incorporated | Agree |  |
| OPPO | Agree |  |
| Samsung | Disagree | We agree with that the problematic combination is supporting the FR1-FDD/FR2-TDD and not supporting FR1-TDD.  From signalling this xDD/FRx differenciation, we share the view explained in Huawei’s contribution (R2-2003454). |
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## Need of specification clarification

Companies are requested to provide their comment on whether any clarification of the standard is necessary. If so, how.

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| **Company name** | **Interpretation 1 or 2** | **Comments** |
| Qualcomm Incorporated | Interpretation 1 | We can consider adding expected network behaviour, which will also serve as UE implementation guidance, e.g.   * NOTE: In case the UE signals its capability in fdd-Add-UE-NR/MRDC-Capabilities, tdd-Add-UE-NR/MRDC-Capabilities, fr1-Add-UE-NR/MRDC-Capabilities and/or fr2-Add-UE-NR/MRDC-Capabilities, the network considers that the UE supports the feature in a given combination of duplex mode and frequency range, only if the UE signals the support of the feature for both the duplex mode and the frequency range. |
| OPPO | Interpretation1 | We agree that such kind of is helpful. In addition we are fine not to fix it in Release15 since no such details occur yet. But we think RAN2 should figure out solution for Rel16 for forward compatibility. Following sentence need be added into the NOTE proposed by Qualcomm:  In this Release UE can’t signal that it supports a per UE capability for FR1 FDD band and FR2 TDD band, but not for FR1 TDD band. |
| Samsung |  | Our understanding expressed above is based on the current description in TS 38.306, so if companies will agree on this interpretation, we think no further clarification is needed. Maybe we just capture the RAN2 understanding in the minute. |
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## LS response to RAN1

RAN2 response to RAN1 LS [R2-2003269](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_109bis-e/Docs/R2-2003269.zip), is going to be slightly different between the two interpretations.

* **With interpretation 1:**
  + RAN2 confirms the current UE capability signaling does not allow the UE to signal support for a feature in the case identified by RAN1.
  + No consensus in RAN2 whether the problematic case should be addressed or not.
  + RAN2 asks RAN1 whether they see the need of a solution where the UE can indicate the support of a feature in the problematic case.
* **With interpretation 2:**
  + RAN2 confirms the current UE capability signaling does not allow the UE to signal support for a feature in a specific case, but such case is different from the one identified by RAN1.
  + No consensus in RAN2 whether the problematic case should be addressed or not ???
  + RAN2 asks RAN1 whether they see the need of a solution where the UE can indicate the support of a feature in the problematic case ???

## Solution to address the “problematic case”

## Further problems to indicate the capabilities for SUL/SDL bands only for FR1 case

According to TS 38.101-1 v16.30, the operating bands in FR1 is defined in Table 5.2-1, see below table.

There are 3 SDL bands (i.e. n29, n75, n76) and 8 SUL bands (i.e. n80, n81, n82, n83, n84, n86, n89, n95) and some bands have corresponding TDD or FDD band but others don’t have any corresponding band.

1. SDL bands

* n29: no corresponding band
* others (n75, n76): have corresponding TDD bands (n50, n51)

1. SUL bands

* n95: have corresponding TDD band (n34)
* others (n80, n81, n82, n83, n84, n86, n89): have corresponding FDD band (n66, n8, n20, n1, n66, n5, n34)

The question is that how the capability parameters for SUL/SDL bands can be signalled, and how the differentiation is applied for this SUL/SDL bands. If there are no exception case (n29 and n95), the simplest way would be the capability parameters for SUL/SDL bands follow the signalling rule of the corresponding bands (i.e. SDL follows the corresponding TDD band, SUL follows the corresponding FDD band).

It would be better to ask this aspect to RAN4 because RAN2 cannot solve this issue without further information.

Do companies agree with that there are no way to signalling rule for SUL/SDL bands? If yes, how we solve this?

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| **Company name** | **View**  **Yes/No** | **Comments** |
| Samsung | Yes | RAN2 need to send LS to ask how UE provide the capabilities for SUL/SDL bands, and how xDD differenciation of SUL/SDL is supported. |
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Table 5.2-1: NR operating bands in FR1

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| --- | --- | --- | --- |
| NR operating band | Uplink (UL) *operating band* BS receive / UE transmit  FUL\_low  – FUL\_high | Downlink (DL) *operating band* BS transmit / UE receive  FDL\_low – FDL\_high | Duplex Mode |
| n1 | 1920 MHz – 1980 MHz | 2110 MHz – 2170 MHz | FDD |
| n2 | 1850 MHz – 1910 MHz | 1930 MHz – 1990 MHz | FDD |
| n3 | 1710 MHz – 1785 MHz | 1805 MHz – 1880 MHz | FDD |
| n5 | 824 MHz – 849 MHz | 869 MHz – 894 MHz | FDD |
| n7 | 2500 MHz – 2570 MHz | 2620 MHz – 2690 MHz | FDD |
| n8 | 880 MHz – 915 MHz | 925 MHz – 960 MHz | FDD |
| n12 | 699 MHz – 716 MHz | 729 MHz – 746 MHz | FDD |
| n14 | 788 MHz – 798 MHz | 758 MHz – 768 MHz | FDD |
| n18 | 815 MHz – 830 MHz | 860 MHz – 875 MHz | FDD |
| n20 | 832 MHz – 862 MHz | 791 MHz – 821 MHz | FDD |
| n25 | 1850 MHz – 1915 MHz | 1930 MHz – 1995 MHz | FDD |
| n26 | 814 MHz – 849 MHz | 859 MHz – 894 MHz | FDD |
| n28 | 703 MHz – 748 MHz | 758 MHz – 803 MHz | FDD |
| n29 | N/A | 717 MHz – 728 MHz | SDL |
| n303 | 2305 Mhz – 2315 MHz | 2350 MHz – 2360 MHz | FDD |
| n34 | 2010 MHz – 2025 MHz | 2010 MHz – 2025 MHz | TDD |
| n38 | 2570 MHz – 2620 MHz | 2570 MHz – 2620 MHz | TDD |
| n39 | 1880 MHz – 1920 MHz | 1880 MHz – 1920 MHz | TDD |
| n40 | 2300 MHz – 2400 MHz | 2300 MHz – 2400 MHz | TDD |
| n41 | 2496 MHz – 2690 MHz | 2496 MHz – 2690 MHz | TDD |
| n48 | 3550 MHz – 3700 MHz | 3550 MHz – 3700 MHz | TDD |
| n50 | 1432 MHz – 1517 MHz | 1432 MHz – 1517 MHz | TDD1 |
| n51 | 1427 MHz – 1432 MHz | 1427 MHz – 1432 MHz | TDD |
| n53 | 2483.5 MHz – 2495 MHz | 2483.5 MHz – 2495 MHz | TDD |
| n65 | 1920 MHz – 2010 MHz | 2110 MHz – 2200 MHz | FDD4 |
| n66 | 1710 MHz – 1780 MHz | 2110 MHz – 2200 MHz | FDD |
| n70 | 1695 MHz – 1710 MHz | 1995 MHz – 2020 MHz | FDD |
| n71 | 663 MHz – 698 MHz | 617 MHz – 652 MHz | FDD |
| n74 | 1427 MHz – 1470 MHz | 1475 MHz – 1518 MHz | FDD |
| n75 | N/A | 1432 MHz – 1517 MHz | SDL |
| n76 | N/A | 1427 MHz – 1432 MHz | SDL |
| n77 | 3300 MHz – 4200 MHz | 3300 MHz – 4200 MHz | TDD |
| n78 | 3300 MHz – 3800 MHz | 3300 MHz – 3800 MHz | TDD |
| n79 | 4400 MHz – 5000 MHz | 4400 MHz – 5000 MHz | TDD |
| n80 | 1710 MHz – 1785 MHz | N/A | SUL |
| n81 | 880 MHz – 915 MHz | N/A | SUL |
| n82 | 832 MHz – 862 MHz | N/A | SUL |
| n83 | 703 MHz – 748 MHz | N/A | SUL |
| n84 | 1920 MHz – 1980 MHz | N/A | SUL |
| n86 | 1710 MHz – 1780 MHz | N/A | SUL |
| n89 | 824 MHz – 849 MHz | N/A | SUL |
| n90 | 2496 MHz – 2690 MHz | 2496 MHz – 2690 MHz | TDD5 |
| n91 | 832 MHz – 862 MHz | 1427 MHz – 1432 MHz | FDD9 |
| n92 | 832 MHz – 862 MHz | 1432 MHz – 1517 MHz | FDD9 |
| n93 | 880 MHz – 915 MHz | 1427 MHz – 1432 MHz | FDD9 |
| n94 | 880 MHz – 915 MHz | 1432 MHz – 1517 MHz | FDD9 |
| n958 | 2010 MHz – 2025 MHz | N/A | SUL |
| NOTE 1: UE that complies with the NR Band n50 minimum requirements in this specification shall also comply with the NR Band n51 minimum requirements.  NOTE 2: UE that complies with the NR Band n75 minimum requirements in this specification shall also comply with the NR Band n76 minimum requirements.  NOTE 3: Uplink transmission is not allowed at this band for UE with external vehicle-mounted antennas.  NOTE 4: A UE that complies with the NR Band n65 minimum requirements in this specification shall also comply with the NR Band n1 minimum requirements.  NOTE 5: Unless otherwise stated, the applicability of requirements for Band n90 is in accordance with that for Band n41; a UE supporting Band n90 shall meet the requirements for Band n41. A UE supporting Band n90 shall also support band n41.  NOTE 6: A UE that supports NR Band n66 shall receive in the entire DL operating band.  NOTE 7: A UE that supports NR Band n66 and CA operation in any CA band shall also comply with the minimum requirements specified for the DL CA configurations CA\_n66B and CA\_n66(2A) in the current version of the specification.  NOTE 8: This band is applicable in China only.  NOTE 9: Variable duplex operation does not enable dynamic variable duplex configuration by the network, and is used such that DL and UL frequency ranges are supported independently in any valid frequency range for the band. | | | |

**Proposal 1: xxxx**

# Summary

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# Conclusion

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# Annex 1

**Table-1:** Current UE capability bit setting

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| --- | --- | --- | --- | --- |
| True UE capability | | UE capability bits | | UE capability container |
| **Case 1** | * FR1 FDD: ‘supported’ * FR1 TDD: ‘supported’ * FR2 TDD: ‘supported | FDD | Yes | Common |
| TDD |
| FR1 |
| FR2 |
| **Case 2** | * FR1 FDD: ‘not supported’ * FR1 TDD: ‘not supported’ * FR2 TDD: ‘not supported | FDD | No |  |
| TDD |
| FR1 |
| FR2 |
| **Case 3** | * FR1 FDD: ‘not supported’ * FR1 TDD: ‘supported’ * FR2 TDD: ‘supported | FDD | No |  |
| TDD | Yes | tdd-Add |
| FR1 | Yes | Common |
| FR2 |
| **Case 4** | * FR1 FDD: ‘not supported’ * FR1 TDD: ‘not supported’ * FR2 TDD: ‘supported | FDD | No |  |
| TDD | Yes | tdd-Add |
| FR1 | No |  |
| FR2 | Yes | fr2-Add |
| **Case 5** | * FR1 FDD: ‘not supported’ * FR1 TDD: ‘supported’ * FR2 TDD: ‘not supported | FDD | No |  |
| TDD | Yes | tdd-Add |
| FR1 | Yes | fr1-Add |
| FR2 | No |  |
| **Case 6** | * FR1 FDD: ‘supported’ * FR1 TDD: ‘not supported’ * FR2 TDD: ‘supported | FDD | **Not possible to express** |  |
| TDD |
| FR1 |
| FR2 |
| **Case 7** | * FR1 FDD: ‘supported’ * FR1 TDD: ‘not supported’ * FR2 TDD: ‘not supported | FDD | Yes | fdd-Add |
| TDD | No |  |
| FR1 | Yes | fr1-Add |
| FR2 | No |  |
| **Case 8** | * FR1 FDD: ‘supported’ * FR1 TDD: ‘supported’ * FR2 TDD: ‘not supported | FDD | Yes | Common |
| TDD |
| FR1 | Yes | fr1-Add |
| FR2 | No |  |

# Annex 2

Table indicating support of a feature with FR1/FR2, TDD/FDD differentiation:

Label

1 UE supports the feature for the given FRX/XDD mode

0 UE does not support the feature for the given FRX/XDD

x UE does not support the given FRX/XDD mode

fdd UE includes the feature in fdd-Add-UE-NR/MRDC-Capabilities

tdd UE includes the feature in tdd-Add-UE-NR/MRDC-Capabilities

fr1 UE includes the feature in fr1-Add-UE-NR/MRDC-Capabilities

fr2 UE includes the feature in fr2-Add-UE-NR/MRDC-Capabilities

common UE includes the feature in the common branch for features that do not require FR1/FR2 or FDD/TDD differentiation

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|  | FR1 only | | | |  |  |  |  |  |  |
|  | FDD | TDD |  |  | FDD | TDD |  |  | FDD | TDD |
| FR1 | 1 | 0 |  | FR1 | 0 | 1 |  | FR1 | 1 | 1 |
| FR2 | x | x |  | FR2 | x | x |  | FR2 | x | x |
| fdd | | |  | tdd | | |  | common | | |
|  |  |  |  |  |  |  |  |  |  |  |
|  | FDD | TDD |  |  | FDD | TDD |  |  |  |  |
| FR1 | 1 | x |  | FR1 | x | 1 |  |  |  |  |
| FR2 | x | x |  | FR2 | x | x |  |  |  |  |
| common | | |  | common | | |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  | TDD only | | | |  |  |  |  |  |  |
|  | FDD | TDD |  |  | FDD | TDD |  |  | FDD | TDD |
| FR1 | x | 1 |  | FR1 | x | x |  | FR1 | x | 1 |
| FR2 | x | 1 |  | FR2 | x | 1 |  | FR2 | x | 0 |
| common | | |  | common | | |  | fr1 | | |
|  |  |  |  |  |  |  |  |  |  |  |
|  | FDD | TDD |  |  |  |  |  |  |  |  |
| FR1 | x | 0 |  |  |  |  |  |  |  |  |
| FR2 | x | 1 |  |  |  |  |  |  |  |  |
| fr2 | | |  |  |  |  |  |  |  |  |
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|  | FR1+FR2 | | | |  |  |  |  |  |  |
|  | FDD | TDD |  |  | FDD | TDD |  |  | FDD | TDD |
| FR1 | 1 | 0 |  | FR1 | 0 | 1 |  | FR1 | 0 | 0 |
| FR2 | x | 0 |  | FR2 | x | 0 |  | FR2 | x | 1 |
| fdd | | |  | new signaling | | |  | fr2 | | |
|  |  |  |  |  |  |  |  |  |  |  |
|  | FDD | TDD |  |  | FDD | TDD |  |  | FDD | TDD |
| FR1 | 1 | 1 |  | FR1 | 0 | 1 |  | FR1 | 1 | 0 |
| FR2 | x | 0 |  | FR2 | x | 1 |  | FR2 | x | 1 |
| fr1+fdd | | |  | fr2+tdd | | |  | fr2+fdd | | |
|  |  |  |  |  |  |  |  |  |  |  |
|  | FDD | TDD |  |  | FDD | TDD |  |  | FDD | TDD |
| FR1 | 1 | 1 |  | FR1 | 1 | x |  | FR1 | 0 | x |
| FR2 | x | 1 |  | FR2 | x | 1 |  | FR2 | x | 1 |
| common | | |  | common | | |  | fr2+tdd | | |
|  |  |  |  |  |  |  |  |  |  |  |
|  | FDD | TDD |  |  |  |  |  |  |  |  |
| FR1 | 1 | x |  |  |  |  |  |  |  |  |
| FR2 | x | 0 |  |  |  |  |  |  |  |  |
| fr1+fdd | | |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  | Irrelevant cases | |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  | FDD | TDD |  |  | FDD | TDD |  |  | FDD | TDD |
| FR1 | 0 | x |  | FR1 | x | 0 |  | FR1 | x | x |
| FR2 | x | x |  | FR2 | x | x |  | FR2 | x | 0 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | FDD | TDD |  |  | FDD | TDD |  |  | FDD | TDD |
| FR1 | 0 | 0 |  | FR1 | x | 0 |  | FR1 | 0 | x |
| FR2 | x | x |  | FR2 | x | 0 |  | FR2 | x | 0 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | FDD | TDD |  |  | FDD | TDD |  |  |  |  |
| FR1 | 0 | 0 |  | FR1 | x | x |  |  |  |  |
| FR2 | x | 0 |  | FR2 | x | x |  |  |  |  |