8 Physical uplink shared channel related procedures

If the UE is configured with a SCG, the UE shall apply the procedures described in this clause for both MCG and SCG

- When the procedures are applied for MCG, the terms 'secondary cell', 'secondary cells' , 'serving cell', 'serving cells' in this clause refer to secondary cell, secondary cells, serving cell, serving cells belonging to the MCG respectively.
- When the procedures are applied for SCG, the terms 'secondary cell', 'secondary cells', 'serving cell', 'serving cells' in this clause refer to secondary cell, secondary cells (not including PSCell), serving cell, serving cells belonging to the SCG respectively. The term 'primary cell' in this clause refers to the PSCell of the SCG.

If a UE is configured with a LAA SCell for UL transmissions, the UE shall apply the procedures described in this clause assuming frame structure type 1 for the LAA SCell unless stated otherwise.

For a non-BL/CE UE, and for FDD and transmission mode 1 and a cell that is not a LAA SCell, there shall be 8 uplink HARQ processes per serving cell for non-subframe bundling operation, i.e. normal HARQ operation, and 3 uplink HARQ processes for subframe bundling operation when parameter *e-HARQ-Pattern-r12* is set to *TRUE* and 4 uplink HARQ processes for subframe bundling operation otherwise. For a non-BL/CE UE, and for FDD and transmission mode 2 and a cell that is not a LAA SCell, there shall be 16 uplink HARQ processes per serving cell for non-subframe bundling operation and there are two HARQ processes associated with a given subframe as described in [8]. The subframe bundling operation is configured by the parameter *ttiBundling* provided by higher layers.

For FDD and a BL/CE UE configured with CEModeA, there shall be at most 8 uplink HARQ processes per serving cell.

For FDD and a BL/CE UE configured with CEModeB, there shall be at most 2 uplink HARQ processes per serving cell.

For a LAA SCell, and transmission mode 1, there shall be 16 uplink HARQ processes. For a LAA SCell, and transmission mode 2, there shall be 32 uplink HARQ processes.

In case higher layers configure the use of subframe bundling for FDD and TDD, the subframe bundling operation is only applied to UL-SCH, such that four consecutive uplink subframes are used.

A BL/CE UE is not expected to be configured with simultaneous PUSCH and PUCCH transmission.

8.0 UE procedure for transmitting the physical uplink shared channel

The term "UL/DL configuration" in this Subclause refers to the higher layer parameter *subframeAssignment* unless specified otherwise.

For a serving cell that is not a LAA SCell, and for FDD and normal HARQ operation, the UE shall upon detection on a given serving cell of a PDCCH/EPDCCH with DCI format 0/4 and/or a PHICH transmission in subframe *n* intended for the UE, perform a corresponding PUSCH transmission in subframe *n+4* according to the PDCCH/EPDCCH and PHICH information if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8].

For FDD-TDD and normal HARQ operation and a PUSCH for serving cell c with frame structure type 1, the UE shall upon detection of a PDCCH/EPDCCH with DCI format 0/4 and/or a PHICH transmission in subframe *n* intended for the UE, perform a corresponding PUSCH transmission for serving cell *c* in subframe *n+4* according to the PDCCH/EPDCCH and PHICH information if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8].

For normal HARQ operation, if the UE detects a PHICH transmission and if the most recent PUSCH transmission for the same transport block was using spatial multiplexing according to Subclause 8.0.2 and the UE does not detect a PDCCH/EPDCCH with DCI format 4 in subframe *n* intended for the UE, the UE shall perform the corresponding PUSCH retransmission in the associated subframe according to the PHICH information, and using the number of transmission layers and precoding matrix according to the most recent PDCCH/EPDCCH, if the number of negatively

acknowledged transport blocks is equal to the number of transport blocks indicated in the most recent PDCCH/EPDCCH associated with the corresponding PUSCH.

For normal HARQ operation, if the UE detects a PHICH transmission and if the most recent PUSCH transmission for the same transport block was using spatial multiplexing according to Subclause 8.0.2 and the UE does not detect a PDCCH/EPDCCH with DCI format 4 in subframe *n* intended for the UE, and if the number of negatively acknowledged transport blocks is not equal to the number of transport blocks indicated in the most recent PDCCH/EPDCCH associated with the corresponding PUSCH then the UE shall perform the corresponding PUSCH retransmission in the associated subframe according to the PHICH information, using the precoding matrix with codebook index 0 and the number of transmission layers equal to number of layers corresponding to the negatively acknowledged transport block from the most recent PDCCH/EPDCCH. In this case, the UL DMRS resources are calculated according to the cyclic shift field for DMRS [3] in the most recent PDCCH/EPDCCH with DCI format 4 associated with the corresponding PUSCH transmission and number of layers corresponding to the negatively acknowledged transport block.

If a UE is configured with the carrier indicator field for a given serving cell, the UE shall use the carrier indicator field value from the detected PDCCH/EPDCCH with uplink DCI format to determine the serving cell for the corresponding PUSCH transmission.

For FDD and normal HARQ operation, if a PDCCH/EPDCCH with CSI request field set to trigger an aperiodic CSI report, as described in Subclause 7.2.1, is detected by a UE on subframe *n*, then on subframe *n+4* UCI is mapped on the corresponding PUSCH transmission, when simultaneous PUSCH and PUCCH transmission is not configured for the UE.

For FDD and a BL/CE UE configured with CEModeA, if an MPDCCH with CSI request field set to trigger an aperiodic CSI report, as described in Subclause 7.2.1, is detected by a UE on subframe *n*, then on subframe *n+4* UCI is mapped on the corresponding PUSCH transmission, including all subframe repetitions of the PUSCH transmission.

For FDD-TDD and normal HARQ operation, for a serving cell with frame structure type 1, if a PDCCH/EPDCCH with CSI request field set to trigger an aperiodic CSI report, as described in Subclause 7.2.1, is detected by a UE on subframe *n*, then on subframe *n+4* UCI is mapped on the corresponding PUSCH transmission, when simultaneous PUSCH and PUCCH transmission is not configured for the UE.

For TDD, if a UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for at least one serving cell, if the UE is configured with one serving cell or if the UE is configured with more than one serving cell and the TDD UL/DL configuration of all the configured serving cells is the same, then for a given serving cell, the serving cell UL/DL configuration is the UL-reference UL/DL configuration.

For TDD, if a UE is configured with more than one serving cell and if the UL/DL configurations of at least two serving cells are different, if the serving cell is a primary cell or if the UE is not configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell, the serving cell UL/DL configuration is the UL-reference UL/DL configuration.

For TDD, if a UE is configured with more than one serving cell and if the UL/DL configurations of at least two serving cells are different and if the serving cell is a secondary cell and if the UE is configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell, then for the serving cell, the UL reference UL/DL configuration is given in Table 8-0A corresponding to the pair formed by (other serving cell UL/DL configuration, serving cell UL/DL configuration).

For FDD-TDD and primary cell frame structure type 2, if a serving cell is a primary cell, the serving cell UL/DL configuration is the UL-reference UL/DL configuration for the serving cell.

For FDD-TDD if the UE is not configured to monitor PDCCH/EPDCCH in another serving cell for scheduling a secondary serving cell with frame structure type 2, the serving cell UL/DL configuration is the UL-reference UL/DL configuration for the serving cell.

For FDD-TDD, and for secondary serving cell *c* with frame structure type 2, if the UE is configured to monitor PDCCH/EPDCCH in another serving cell with frame structure type 1 for scheduling the serving cell, the serving cell UL/DL configuration is the UL-reference UL/DL configuration for the serving cell.

For FDD-TDD, if a UE is configured with more than one serving cell with frame structure type 2, and if the serving cell is a secondary cell with frame structure type 2 and if the UE is configured to monitor PDCCH/EPDCCH in another

serving cell with frame structure type 2 for scheduling the serving cell, then for the serving cell, the UL reference UL/DL configuration is given in Table 8-0A corresponding to the pair formed by (other serving cell UL/DL configuration, serving cell UL/DL configuration).

Table 8-0A: UL-reference UL/DL Configuration for serving cell based on the pair formed by (other serving cell UL/DL configuration, serving cell UL/DL configuration)

Set #	(other serving cell UL/DL configuration, serving cell UL/DL configuration)	UL-reference UL/DL configuration
Set 1	(1,1),(1,2),(1,4),(1,5)	1
	(2,2),(2,5)	2
	(3,3),(3,4),(3,5)	3
	(4,4),(4,5)	4
	(5,5)	5
Set 2	(1,0),(2,0),(3,0),(4,0),(5,0)	0
	(2,1),(4,1),(5,1)	1
	(5,2)	2
	(4,3),(5,3)	3
	(5,4)	4
	(1,6),(2,6),(3,6),(4,6),(5,6)	6
Set 3	(3,1)	1
	(3,2),(4,2)	2
	(1,3),(2,3)	3
	(2,4)	4
Set 4	(0,0),(6,0)	0
	(0,1),(0,2),(0,4),(0,5),(6,1),(6,2),(6,5)	1
	(0,3),(6,3)	3
	(6,4)	4
	(0,6),(6,6)	6

If a UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for a serving cell, for a radio frame of the serving cell, PUSCH transmissions can occur only in subframes that are indicated by eIMTA-UL/DL-configuration as uplink subframe(s) for the serving cell unless specified otherwise.

For TDD and normal HARQ operation, if a PDCCH/EPDCCH with CSI request field set to trigger an aperiodic CSI report, as described in Subclause 7.2.1, is detected by a UE on subframe *n*, then on subframe *n+k* UCI is mapped on the corresponding PUSCH transmission where *k* is given by Table 8-2, when simultaneous PUSCH and PUCCH transmission is not configured for the UE.

For TDD and a BL/CE UE configured with CEModeA, if an MPDCCH with CSI request field set to trigger an aperiodic CSI report, as described in Subclause 7.2.1, is detected by a UE on subframe *n*, then on subframe *n+k* UCI is mapped on the corresponding PUSCH transmission, including all subframe repetitions of the PUSCH transmission, where *k* is given by Table 8-2.
For FDD-TDD normal HARQ operation, for a serving cell with frame structure type 2, if a PDCCH/EPDCCH with CSI request field set to trigger an aperiodic CSI report on the serving cell, as described in Subclause 7.2.1, is detected by a UE on subframe *n*, then on subframe *n+k* UCI is mapped on the corresponding PUSCH transmission where *k* is given by Table 8-2 and the "TDD UL/DL configuration" refers to the UL-reference UL/DL configuration for the serving cell, when simultaneous PUSCH and PUCCH transmission is not configured for the UE.

When a UE is configured with higher layer parameter *ttiBundling* and configured with higher layer parameter *e-HARQ-Pattern-r12* set to *FALSE* or not configured, for FDD and subframe bundling operation, the UE shall upon detection of a PDCCH/EPDCCH with DCI format 0 in subframe *n* intended for the UE, and/or a PHICH transmission in subframe *n-5* intended for the UE, perform a corresponding first PUSCH transmission in the bundle in subframe *n+4* according to the PDCCH/EPDCCH and PHICH information if a transport block corresponding to the HARQ process of the first PUSCH transmission is generated as described in [8].

When a UE is configured with higher layer parameter *ttiBundling* and configured with higher layer parameter *e-HARQ-Pattern-r12* set to *TRUE*, for FDD and subframe bundling operation, the UE shall upon detection of a PDCCH/EPDCCH with DCI format 0 in subframe *n* intended for the UE, and/or a PHICH transmission in subframe *n-1* intended for the UE, perform a corresponding first PUSCH transmission in the bundle in subframe *n+4* according to the

PDCCH/EPDCCH and PHICH information if a transport block corresponding to the HARQ process of the first PUSCH transmission is generated as described in [8].

For both FDD and TDD serving cells, the NDI as signalled on PDCCH/EPDCCH, the RV as determined in Subclause 8.6.1, and the TBS as determined in Subclause 8.6.2, shall be delivered to higher layers.

For a non-BL/CE UE, for TDD and transmission mode 1, the number of HARQ processes per serving cell shall be determined by the UL/DL configuration (Table 4.2-2 of [3]), as indicated in Table 8-1 if the UE is not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, otherwise as indicated in Table 8-1a. For TDD and transmission mode 2, the number of HARQ processes per serving cell for non-subframe bundling operation shall be twice the number determined by the UL/DL configuration (Table 4.2-2 of [3]) as indicated in Table 8-1 if the UE is not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, otherwise as indicated in Table 8-1a and there are two HARQ processes associated with a given subframe as described in [8]. For TDD and both transmission mode 1 and transmission mode 2, the "TDD UL/DL configuration" in Table 8-1 and Table 8-1a refers to the UL-reference UL/DL configuration for the serving cell if UL-reference UL/DL configuration is defined for the serving cell and refers to the serving cell UL/DL configuration otherwise.

For a BL/CE UE configured with CEModeA and for TDD, the maximum number of HARQ processes per serving cell shall be determined by the UL/DL configuration (Table 4.2-2 of [3]) according to the normal HARQ operation in Table 8-1. For TDD a BL/CE UE configured with CEModeB is not expected to support more than 2 uplink HARQ processes per serving cell.

Table 8-1: Number of synchronous UL HARQ processes for TDD

TDD UL/DL configuration	Number of HARQ processes for normal HARQ operation	Number of HARQ processes for subframe bundling operation
0	7	3
1	4	2
2	2	N/A
3	3	N/A
4	2	N/A
5	1	N/A
6	6	3

Table 8-1a: Number of synchronous UL HARQ processes for TDD and UE configured with *symPUSCH-UpPts-r14*

TDD UL/DL configuration	Number of HARQ processes for normal HARQ operation	Number of HARQ processes for subframe bundling operation
0	9	N/A
1	6	N/A
2	4	2
3	4	2
4	3	N/A
5	2	N/A
6	8	N/A

For TDD, if the UE is not configured with *EIMTA-MainConfigServCell-r12* for any serving cell, and if a UE is configured with one serving cell, or if the UE is configured with more than one serving cell and the TDD UL/DL configuration of all the configured serving cells is the same,

- For TDD UL/DL configurations 1-6 and normal HARQ operation and UE not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, the UE shall upon detection of a PDCCH/EPDCCH with uplink DCI format and/or a PHICH transmission in subframe *n* intended for the UE, perform a corresponding PUSCH transmission in subframe *n+k*, with *k* given in Table 8-2, according to the PDCCH/EPDCCH and PHICH information if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8].

- For TDD UL/DL configuration 0 and normal HARQ operation the UE shall upon detection of a PDCCH/EPDCCH with uplink DCI format and/or a PHICH transmission in subframe *n* intended for the UE, perform a corresponding PUSCH transmission in subframe *n+k* if a transport block corresponding to the HARQ

process of the PUSCH transmission is generated as described in [8] and if the MSB of the UL index in the PDCCH/EPDCCH with uplink DCI format is set to 1 or PHICH is received in subframe *n*=0 or 5 in the resource corresponding to $I_{PHICH} = 0$, as defined in Subclause 9.1.2, or PHICH is received in subframe *n*=1 or 6 corresponding to PUSCH transmission in subframe *n-5* for UE configured with higher layer parameter *symPUSCH-UpPts* for the serving cell, with *k* given in Table 8-2 if the UE is not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, otherwise *k* given in Table 8-2g. If, for TDD UL/DL configuration 0 and normal HARQ operation, the LSB of the UL index in the DCI format 0/4 is set to 1 in subframe *n* or a PHICH is received in subframe *n*=0 or 5 in the resource corresponding to $I_{PHICH} = 1$, as defined in Subclause 9.1.2, or PHICH is received in subframe *n*=1 or 6 corresponding to PUSCH transmission in subframe *n-4*, the UE shall perform a corresponding PUSCH transmission in subframe *n+7* if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8]. If, for TDD UL/DL configuration 0, both the MSB and LSB of the UL index in the PDCCH/EPDCCH with uplink DCI format are set in subframe *n*, the UE shall perform a corresponding PUSCH transmission in both subframes *n+ k* and *n+7* if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8], with *k* given in Table 8-2 if the UE is not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, otherwise *k* given in Table 8-2g.

- For TDD UL/DL configurations 1-5 and normal HARQ operation and UE configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, the UE shall upon detection of a PDCCH/EPDCCH with uplink DCI format in subframe *n* intended for the UE, and/or a PHICH transmission intended for the UE in subframe *n+l* with *l* given in Table 8-2h, perform a corresponding PUSCH transmission in subframe *n+k*, with *k* given in Table 8-2g, according to the PDCCH/EPDCCH and/or PHICH information if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8].

- For TDD UL/DL configuration 6 and normal HARQ operation and UE configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, the UE shall upon detection of a PDCCH/EPDCCH with uplink DCI format and/or a PHICH transmission in subframe *n* intended for the UE, perform a corresponding PUSCH transmission in subframe *n+k* if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8] and if the MSB of the UL index in the PDCCH/EPDCCH with uplink DCI format is set to 1 or PHICH is received in subframe *n*=1 or 6 or 9, or PHICH is received in subframe *n*=0 corresponding to PUSCH transmission in subframe *n-6*, or PHICH is received in subframe *n*=5 corresponding to PUSCH transmission in subframe *n-7*, with *k* given in Table 8-2g. If, for TDD UL/DL configuration 6 and normal HARQ operation, the LSB of the UL index in the DCI format 0/4 is set to 1 in subframe *n*, or PHICH is received in subframe *n*=0 or 5 corresponding to PUSCH transmission in subframe *n-4*,the UE shall perform a corresponding PUSCH transmission in subframe *n+6* if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8]. If, for TDD UL/DL configuration 6, both the MSB and LSB of the UL index in the PDCCH/EPDCCH with uplink DCI format are set in subframe *n*, the UE shall perform a corresponding PUSCH transmission in both subframes *n+ k* and *n+6* if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8], with *k* given in Table 8-2g. The UE is not expected to receive LSB of the UL index in PDCCH/EPDCCH with uplink DCI format set to 1 in subframe *n=9*.

For TDD, if a UE is configured with more than one serving cell and the TDD UL/DL configuration of at least two configured serving cells is not the same or if the UE is configured with *EIMTA-MainConfigServCell-r12* for at least one serving cell, or FDD-TDD,

- For a serving cell with an UL-reference UL/DL configurations belonging to {1,2,3,4,5,6} and normal HARQ operation and UE not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, the UE shall upon detection of a PDCCH/EPDCCH with uplink DCI format and/or a PHICH transmission in subframe *n* intended for the UE, perform a corresponding PUSCH transmission in subframe *n+k* for the serving cell according to the PDCCH/EPDCCH and/or PHICH information if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8], with *k* given in Table 8-2, where the "TDD UL/DL Configuration" given in Table 8-2 refers to the UL-reference UL/DL configuration.

- For a serving cell with UL-reference UL/DL configuration 0 and normal HARQ operation the UE shall upon detection of a PDCCH/EPDCCH with uplink DCI format and/or a PHICH transmission in subframe *n* intended for the UE, perform a corresponding PUSCH transmission in subframe *n+k* for the serving cell if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8] and if the MSB of the UL index in the PDCCH/EPDCCH with uplink DCI format is set to 1 or PHICH is received in subframe *n*=0 or 5 in the resource corresponding to $I_{PHICH} = 0$, as defined in Subclause 9.1.2, or PHICH is received in subframe *n*=1 or 6 corresponding to PUSCH transmission in subframe *n-5* for UE configured with higher layer parameter *symPUSCH-UpPts* for the serving cell, with *k* given in Table 8-2 if the UE is not

configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, otherwise *k* given in Table 8-2g. If, for a serving cell with UL-reference UL/DL configuration 0 and normal HARQ operation, the LSB of the UL index in the DCI format 0/4 is set to 1 in subframe *n* or a PHICH is received in subframe *n*=0 or 5 in the resource corresponding to $I_{PHICH} = 1$, as defined in Subclause 9.1.2, or PHICH is received in subframe *n*=1 or 6 corresponding to PUSCH transmission in subframe *n-4*, the UE shall perform a corresponding PUSCH transmission in subframe *n+7* for the serving cell if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8]. If, for a serving cell with UL-reference UL/DL configuration 0, both the MSB and LSB of the UL index in the PDCCH/EPDCCH with uplink DCI format are set in subframe *n*, the UE shall perform a corresponding PUSCH transmission in both subframes *n+ k* and *n+7* for the serving cell if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8], with *k* given in Table 8-2 if the UE is not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, otherwise *k* given in Table 8-2g, where the "TDD UL/DL Configuration" given in Table 8-2 and Table 8-2g refers to the UL-reference UL/DL configuration.

- For a serving cell with an UL-reference UL/DL configurations belonging to {1,2,3,4,5} and normal HARQ operation and UE configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, the UE shall upon detection of a PDCCH/EPDCCH with uplink DCI format in subframe *n* intended for the UE, and/or a PHICH transmission intended for the UE in subframe *n+l* with *l* given in Table 8-2h, perform a corresponding PUSCH transmission in subframe *n+k* for the serving cell according to the PDCCH/EPDCCH and/or PHICH information if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8], with *k* given in Table 8-2g, where the "TDD UL/DL Configuration" given in Table 8-2g and Table 8-2h refers to the UL-reference UL/DL configuration.

- For a serving cell with UL-reference UL/DL configuration configuration 6 and normal HARQ operation and UE configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, the UE shall upon detection of a PDCCH/EPDCCH with uplink DCI format and/or a PHICH transmission in subframe *n* intended for the UE, perform a corresponding PUSCH transmission in subframe *n+k* if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8] and if the MSB of the UL index in the PDCCH/EPDCCH with uplink DCI format is set to 1 or PHICH is received in subframe *n*=1 or 6 or 9, or PHICH is received in subframe *n*=0 corresponding to PUSCH transmission in subframe *n-6*, or PHICH is received in subframe *n*=5 corresponding to PUSCH transmission in subframe *n-7*, with *k* given in Table 8-2g. If, for a serving cell with UL-reference UL/DL configuration 6 and normal HARQ operation, the LSB of the UL index in the DCI format 0/4 is set to 1 in subframe *n*, or PHICH is received in subframe *n*=0 or 5 corresponding to PUSCH transmission in subframe *n-4*, the UE shall perform a corresponding PUSCH transmission in subframe *n+6* if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8]. If, for a serving cell with UL-reference UL/DL configuration 6, both the MSB and LSB of the UL index in the PDCCH/EPDCCH with uplink DCI format are set in subframe *n*, the UE shall perform a corresponding PUSCH transmission in both subframes *n+ k* and *n+6* if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8], with *k* given in Table 8-2g, where the "TDD UL/DL Configuration" given in Table 8-2g refers to the UL-reference UL/DL configuration. The UE is not expected to receive LSB of the UL index in PDCCH/EPDCCH with uplink DCI format set to 1 in subframe *n=9*.

For TDD UL/DL configurations 1, 2, 3 and 6 and subframe bundling operation, the UE shall upon detection of a PDCCH/EPDCCH with DCI format 0 in subframe *n* intended for the UE, and/or a PHICH transmission intended for the UE in subframe *n-l* with *l* given in Table 8-2a, perform a corresponding first PUSCH transmission in the bundle in subframe *n+k* according to the PDCCH/EPDCCH and/or PHICH information if a transport block corresponding to the HARQ process of the first PUSCH transmission is generated as described in [8], with *k* given in Table 8-2 if the UE is not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, otherwise *k* given in Table 8-2g.

For TDD UL/DL configuration 0 and subframe bundling operation, the UE shall upon detection of a PDCCH/EPDCCH with DCI format 0 in subframe *n* intended for the UE, and/or a PHICH transmission intended for the UE in subframe *n-l* with *l* given in Table 8-2a, perform a corresponding first PUSCH transmission in the bundle in subframe *n+k* according to the PDCCH/EPDCCH and PHICH information if a transport block corresponding to the HARQ process of the first PUSCH transmission is generated as described in [8] and if the MSB of the UL index in the DCI format 0 is set to 1 or if $I_{PHICH} = 0$, as defined in Subclause 9.1.2, with *k* given in Table 8-2. If, for TDD UL/DL configuration 0 and subframe bundling operation, the LSB of the UL index in the PDCCH/EPDCCH with DCI format 0 is set to 1 in subframe *n* or if $I_{PHICH} = 1$, as defined in Subclause 9.1.2, the UE shall perform a corresponding first PUSCH transmission in the bundle in subframe *n+7*, according to the PDCCH/EPDCCH and PHICH information if a transport block corresponding to the HARQ process of the first PUSCH transmission is generated as described in [8].

Table 8-2: *k* for TDD configurations 0-6

TDD UL/DL Configuration	subframe number *n*									
	0	1	2	3	4	5	6	7	8	9
0	4	6				4	6			
1		6			4		6			4
2				4					4	
3	4								4	4
4									4	4
5									4	
6	7	7				7	7			5

Table 8-2a: *l* for TDD configurations 0, 1, 2, 3 and 6

TDD UL/DL Configuration	subframe number *n*									
	0	1	2	3	4	5	6	7	8	9
0	9	6				9	6			
1		2			3		2			3
2		3		0			3		0	
3	1							7	0	1
6	5	5				6	6			8

Table 8-2g: *k* for TDD configurations 0-6 and UE configured with *symPUSCH-UpPts-r14*

TDD UL/DL Configuration	subframe number *n*									
	0	1	2	3	4	5	6	7	8	9
0	4	5				4	5			
1	6	6			4	6	6			4
2		5		4			5		4	
3	4							4	4	4
4								4	4	4
5								4	4	
6	7	7				7	7			5

Table 8-2h: *l* for TDD configurations 1-5 and UE configured with *symPUSCH-UpPts-r14*

TDD UL/DL Configuration	subframe number *n*									
	0	1	2	3	4	5	6	7	8	9
1	1	0			0	1	0			0
2		2		0			2		0	
3	0							1	0	0
4								1	0	0
5								1	0	

For BL/CE UEs, the higher layers indicate the set of BL/CE UL subframes according to *fdd-DownlinkOrTddSubframeBitmapBR* and *fdd-UplinkSubframeBitmapBR* [11].

A BL/CE UE shall upon detection on a given serving cell of an MPDCCH with DCI format 6-0A/6-0B intended for the UE, perform a corresponding PUSCH transmission in subframe(s) $n+k_i$ if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8] with $i = 0, 1, \ldots, N-1$ according to the MPDCCH, where

- subframe n is the last subframe in which the MPDCCH is transmitted; and
- $x \le k_0 < k_1 < \ldots, k_{N-1}$ and the value of $N \in \{n1, n2, \ldots n_{\max}\}$ is determined by the *repetition number* field in the corresponding DCI, where
  - if the UE is configured with higher layer parameter *ce-pdsch-puschEnhancement-config* with value 'On' $n1, n2, \ldots n_{\max}$ are given by {1,2,4,8,12,16,24,32}

  - otherwise, $n1, n2, \ldots n_{\max}$ are given in Table 8-2b and Table 8-2c; and

- in case *N>1*, subframe(s) $n+k_i$ with *i=0,1,…,N-1* are *N* consecutive BL/CE UL subframe(s) starting with subframe *n+x*, and in case *N=1*, $k_0=x$;

- for FDD, *x = 4*;

- for TDD UL/DL configurations 1-6, or for TDD UL/DL configuration 0 and a BL/CE UE in CEModeB, the value of *x* is given as the value of *k* in Table 8-2 for the corresponding TDD UL/DL configuration; If the value x is not given in Table 8-2 for subframe *n*, denote subframe *n'* as the first downlink/special subframe which has a value in Table 8-2 after subframe *n*, and substitute *n* with *n'* in the above procedure for performing the PUSCH transmission.

- for TDD UL/DL configuration 0 and a BL/CE UE in CEModeA and N=1, if the MSB of the UL index in the MPDCCH with DCI format 6-0A is set to 1, the value of *x* is given as the value of *k* in Table 8-2 for the corresponding TDD UL/DL configuration; if the LSB of the UL index in the MPDCCH with DCI format 6-0A is set to 1, *x = 7*. The UE is not expected to receive DCI format 6-0A with both the MSB and LSB of the UL index set to 1 when *N>1*. In case both the MSB and LSB of the UL index are set to 1, the HARQ process number of the PUSCH corresponding the MSB of the UL index is $n_{\text{HARQ\_ID}}$ and the HARQ process number of the PUSCH corresponding the LSB of the UL index is $(n_{\text{HARQ\_ID}}+1) \bmod 7$, where $n_{\text{HARQ\_ID}}$ is determined according to the *HARQ process number* field in DCI format 6-0A

- The higher layer parameter *ttiBundling* is not applicable to BL/CE UEs.

- For a BL/CE UE, in case a PUSCH transmission with a corresponding MPDCCH collides with a PUSCH transmission without a corresponding MPDCCH in a subframe *n*, the PUSCH transmission without a corresponding MPDCCH is dropped from subframe *n*.

- For a BL/CE UE, in case of collision between at least one physical resource block to be used for PUSCH transmission and physical resource blocks corresponding to configured PRACH resources for BL/CE UEs or non-BL/CE UEs (defined in [3]) in a same subframe, the PUSCH transmission is dropped in that subframe.

- For a BL/CE UE in half-duplex FDD operation, in case a PUSCH transmission including half-duplex guard subframe without a corresponding MPDCCH collides partially or fully with a PDSCH transmission with a corresponding MPDCCH, the PUSCH transmission without a corresponding MPDCCH is dropped.

- For a BL/CE UE in half-duplex FDD operation and configured with *ce-pdsch-puschEnhancement-config*, in case a PUSCH transmission including half-duplex guard subframe collides partially or fully with a PDSCH transmission without a corresponding MPDCCH, the PUSCH transmission is dropped.

For BL/CE UEs, and for a PUSCH transmission starting in subframe $n+k_0$ without a corresponding MPDCCH, the UE shall adjust the PUSCH transmission in subframe(s) $n+k_i$ with *i = 0, 1, …, N-1*, where

- $0 \le k_0 < k_1 < \ldots, k_{N-1}$ and the value of $N \in \{n1, n2, \ldots n_{\max}\}$ is determined by the *repetition number* field in the activation DCI, where $n1, n2, \ldots n_{\max}$ are given in Table 8-2b and Table 8-2c; and

- in case *N>1*, subframe(s) $n+k_i$ with *i=0,1,…,N-1* are *N* consecutive BL/CE UL subframe(s), and in case *N=1*, $k_0=0$;

Table 8-2b: PUSCH repetition levels (DCI Format 6-0A)

Higher layer parameter '*pusch-maxNumRepetitionCEmodeA*'	$\{n1, n2, n3, n4\}$
Not configured	{1,2,4,8}
16	{1,4,8,16}
32	{1,4,16,32 }

Table 8-2c: PUSCH repetition levels (DCI Format 6-0B)

Higher layer parameter '*pusch-maxNumRepetitionCEmodeB*'	$\{n1, n2, \ldots, n8\}$
Not configured	{4,8,16,32,64,128,256,512}
192	{1,4,8,16,32,64,128,192}
256	{4,8,16,32,64,128,192,256}
384	{4,16,32,64,128,192,256,384}
512	{4,16,64,128,192,256,384,512}
768	{8,32,128,192,256,384,512,768}
1024	{4,8,16,64,128,256,512,1024}
1536	{4,16,64,256,512,768,1024,1536}
2048	{4,16,64,128,256,512,1024,2048}

A UE configured with parameter *pusch-EnhancementsConfig* shall upon detection on a given serving cell of an PDCCH/EPDCCH with DCI Format 0C intended for the UE, perform a corresponding PUSCH transmission in subframe(s) $n+k_i$ if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8] with $i = 0, 1, \ldots, N-1$ according to the PDCCH/EPDCCH, where

- subframe n is the last subframe in which the PDCCH/EPDCCH is transmitted; and
- $x \le k_0 < k_1 < \ldots, k_{N-1}$ and the value of N is given by Table 8-2k based on the *repetition number* field in the corresponding DCI Format 0C; and
- in case $N>1$, subframe(s) $n+k_i$ with $i=0,1,\ldots,N-1$ are N consecutive UL subframe(s) starting with subframe $n+x$, and in case $N=1$, $k_0=x$;
- for FDD, $x = 4$;
- for TDD UL/DL configurations 1-6, the value of x is given as the value of k in Table 8-2 for the corresponding TDD UL/DL configuration; If the value x is not given in Table 8-2 for subframe n, denote subframe n' as the first downlink/special subframe which has a value in Table 8-2 after subframe n, and substitute n with n' in the above procedure for performing the PUSCH transmission.
- for TDD UL/DL configuration 0 and N=1, if the MSB of the UL index in the PDCCH with DCI format 0C is set to 1, the value of x is given as the value of k in Table 8-2 for the corresponding TDD UL/DL configuration; if the LSB of the UL index in the PDCCH with DCI format 0C is set to 1, $x = 7$. The UE is not expected to receive DCI format 0C with both the MSB and LSB of the UL index set to 1 when $N>1$. In case both the MSB and LSB of the UL index are set to 1, the HARQ process number of the PUSCH corresponding the MSB of the UL index is $n_{\text{HARQ\_ID}}$ and the HARQ process number of the PUSCH corresponding the LSB of the UL index is $(n_{\text{HARQ\_ID}}+1) \bmod 7$, where $n_{\text{HARQ\_ID}}$ is determined according to the *HARQ process number* field in DCI format 0C

Table 8-2k: PUSCH repetition levels (DCI Format 0C)

Repetition Number field in DCI Format 0C	Number of repetitions *N*
000	1
001	2
010	4
011	8
100	12
101	16
110	24
111	32

For a serving cell that is a LAA SCell, a UE shall

- upon detection of an PDCCH/ EPDCCH with DCI format 0A/0B/4A/4B and with 'PUSCH trigger A' field set to '0' in subframe *n* intended for the UE, or
- upon detection of PDCCH/ EPDCCH with DCI format 0A/0B/4A/4B in subframe *n-p* with 'PUSCH trigger A' field set to '1' intended for the UE for the serving cell and that has not been triggered by a 'PUSCH trigger B' field set to '1' received prior to subframe *n* on the serving cell, with *p>=1* and *p<=v*, and upon detection of PDCCH with DCI CRC scrambled by CC-RNTI and with 'PUSCH trigger B' field set to '1' in subframe *n* on the serving cell

perform a corresponding PUSCH transmission, conditioned on the channel access procedures described in clause 15.2.1, in subframe(s) *n+l+k+i* with *i = 0, 1, …, N-1* according to the PDCCH/EPDCCH and HARQ process ID $\mathrm{mod}(n_{\mathrm{HARQ\_ID}}+i, N_{HARQ})$, where

- *N* =1 for DCI format 0A/4A, and value of *N* is determined by the 'number of scheduled subframes' field in the corresponding DCI format 0B/4B.
  - The UE is configured the maximum value of N by higher layer parameter *maxNumberOfSchedSubframes-Format0B* for DCI format 0B and higher layer parameter *maxNumberOfSchedSubframes-Format4B* for DCI format 4B;
- value of timing offset k is determined by the 'Timing offset' field in the corresponding DCI 0A/0B/4A/4B according to Table 8-2d if 'PUSCH trigger A' field set to '0' or Table 8-2e otherwise;
- value of $n_{\mathrm{HARQ\_ID}}$ is determined by the HARQ process number field in the corresponding DCI format 0A/0B/4A/4B and $N_{HARQ}=16$;
- for 'PUSCH trigger A' field set to '0' in the corresponding DCI format 0A/0B/4A/4B,
  - *l* = 4
- otherwise
  - value of *l* is the UL offset as determined by the 'UL duration and offset' field in the corresponding DCI with CRC scrambled by CC-RNTI according to the procedure in Subclause 13A, if 'PUSCH trigger B' field set to '1',
  - value of validation duration *v* is determined by the 'Timing offset' field in the corresponding PDCCH/ EPDCCH with DCI format 0A/0B/4A/4B according to Table 8-2f
  - the smallest value of *l+k* supported by the UE is included in the *UE-EUTRA-Capability*
  - the value of *p+l+k* is at least 4

Table 8-2d: Timing offset k for DCI format 0A/0B/4A/4B with 'PUSCH trigger A' field set to '0'.

Value of 'Timing offset' field	k
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	10
1011	11
1100	12
1101	13
1110	14
1111	15

Table 8-2e: Timing offset k for DCI format 0A/0B/4A/4B with 'PUSCH trigger A' field set to '1'.

Value of the first two bits of 'Timing offset' field	k
00	0
01	1
10	2
11	3

Table 8-2f: Validation duration v for DCI format 0A/0B/4A/4B with 'PUSCH trigger A' field set to '1'.

Value of the last two bits of 'Timing offset' field	v
00	8
01	12
10	16
11	20

For a LAA SCell, a UE is not expected to receive more than one uplink scheduling grant for a subframe.

For a LAA SCell, the HARQ process ID shall be delivered to higher layers.

A UE is semi-statically configured via higher layer signalling to transmit PUSCH transmissions signalled via PDCCH/EPDCCH according to one of two uplink transmission modes, denoted mode 1 - 2.

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the C-RNTI, the UE shall decode the PDCCH according to the combination defined in Table 8-3 and transmit the corresponding PUSCH if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8]. The scrambling initialization of this PUSCH corresponding to these PDCCHs and the PUSCH retransmission for the same transport block is by C-RNTI.

If a UE is configured by higher layers to decode EPDCCHs with the CRC scrambled by the C-RNTI, the UE shall decode the EPDCCH according to the combination defined in Table 8-3A and transmit the corresponding PUSCH if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8]. The scrambling initialization of this PUSCH corresponding to these EPDCCHs and the PUSCH retransmission for the same transport block is by C-RNTI.

If a UE is configured with a higher layer parameter *pusch-EnhancementsConfig*, the UE shall decode PDCCH/EPDCCH DCI format 0C in UE specific search space. In this case the UE is not required to decode/monitor DCI format 0 in the UE specific search space.

If a UE is configured with a higher layer parameter *pusch-EnhancementsConfig*, the UE may assume that PDCCH/EPDCCH for a PUSCH retransmission of a transport block will occur in the UE specific search space if the PDCCH/EPDCCH for the corresponding initial PUSCH transmission for the same transport block was decoded in the UE specific search space.

If a UE is configured with a higher layer parameter *pusch-EnhancementsConfig*, the UE may assume that PDCCH/EPDCCH for a PUSCH retransmission of a transport block will occur in the common search space if the PDCCH/EPDCCH for the corresponding initial PUSCH transmission for the same transport block was decoded in the common search space.

If a UE is configured by higher layers to decode MPDCCHs with the CRC scrambled by the C-RNTI, the UE shall decode the MPDCCH according to the combination defined in Table 8-3B and transmit the corresponding PUSCH if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8]. The scrambling initialization of this PUSCH corresponding to these MPDCCHs and the PUSCH retransmission for the same transport block is by C-RNTI.

Transmission mode 1 is the default uplink transmission mode for a UE until the UE is assigned an uplink transmission mode by higher layer signalling.

When a UE configured in transmission mode 2 receives a DCI Format 0/0A/0B/0C uplink scheduling grant, it shall assume that the PUSCH transmission is associated with transport block 1 and that transport block 2 is disabled.

Table 8-3: PDCCH and PUSCH configured by C-RNTI

Transmission mode	DCI format	Search Space	Transmission scheme of PUSCH corresponding to PDCCH
Mode 1	DCI format 0	Common and UE specific by C-RNTI	Single-antenna port, port 10 (see Subclause 8.0.1)
	DCI format 0A or 0B or 0C	UE specific by C-RNTI	Single-antenna port, port 10 (see Subclause 8.0.1)
Mode 2	DCI format 0	Common and UE specific by C-RNTI	Single-antenna port, port 10 (see Subclause 8.0.1)
	DCI format 0A or 0B or 0C	UE specific by C-RNTI	Single-antenna port, port 10 (see Subclause 8.0.1)
	DCI format 4 or 4A or 4B	UE specific by C-RNTI	Closed-loop spatial multiplexing (see Subclause 8.0.2)

Table 8-3A: EPDCCH and PUSCH configured by C-RNTI

Transmission mode	DCI format	Search Space	Transmission scheme of PUSCH corresponding to EPDCCH
Mode 1	DCI format 0 or 0A or 0B or 0C	UE specific by C-RNTI	Single-antenna port, port 10 (see Subclause 8.0.1)
Mode 2	DCI format 0 or 0A or 0B or 0C	UE specific by C-RNTI	Single-antenna port, port 10 (see Subclause 8.0.1)
	DCI format 4 or 4A or 4B	UE specific by C-RNTI	Closed-loop spatial multiplexing (see Subclause 8.0.2)

Table 8-3B: MPDCCH and PUSCH configured by C-RNTI

Transmission mode	DCI format	Search Space	Transmission scheme of PUSCH corresponding to MPDCCH
Mode 1	DCI format 6-0A or 6-0B	Type0-common (only for 6-0A) and UE specific by C-RNTI	Single-antenna port, port 10 (see Subclause 8.0.1)

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the C-RNTI and is also configured to receive random access procedures initiated by "PDCCH orders", the UE shall decode the PDCCH according to the combination defined in Table 8-4.

If a UE is configured by higher layers to decode EPDCCHs with the CRC scrambled by the C-RNTI and is also configured to receive random access procedures initiated by "PDCCH orders", the UE shall decode the EPDCCH according to the combination defined in Table 8-4A.

If a UE is configured by higher layers to decode MPDCCHs with the CRC scrambled by the C-RNTI and is also configured to receive random access procedures initiated by "PDCCH orders", the UE shall decode the MPDCCH according to the combination defined in Table 8-4B.

Table 8-4: PDCCH configured as "PDCCH order" to initiate random access procedure

DCI format	Search Space
DCI format 1A	Common and UE specific by C-RNTI

Table 8-4A: EPDCCH configured as "PDCCH order" to initiate random access procedure

DCI format	Search Space
DCI format 1A	UE specific by C-RNTI

Table 8-4B: MPDCCH configured as "PDCCH order" to initiate random access procedure

DCI format	Search Space
DCI format 6-1A or 6-1B	Type0-common (only for 6-1A) and UE specific by C-RNTI

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the SPS C-RNTI or UL-SPS-V-RNTI, the UE shall decode the PDCCH according to the combination defined in Table 8-5 and transmit the corresponding PUSCH if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8].
The scrambling initialization of this PUSCH corresponding to these PDCCHs and PUSCH retransmission for the same transport block is by SPS C-RNTI or UL-SPS-V-RNTI. The scrambling initialization of initial transmission of this PUSCH without a corresponding PDCCH and the PUSCH retransmission for the same transport block is by SPS C-RNTI or UL-SPS-V-RNTI.

If a UE is configured by higher layers to decode EPDCCHs with the CRC scrambled by the SPS C-RNTI or UL-SPS-V-RNTI, the UE shall decode the EPDCCH according to the combination defined in Table 8-5A and transmit the corresponding PUSCH if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8].
The scrambling initialization of this PUSCH corresponding to these EPDCCHs and PUSCH retransmission for the same transport block is by SPS C-RNTI or UL-SPS-V-RNTI. The scrambling initialization of initial transmission of this PUSCH without a corresponding EPDCCH and the PUSCH retransmission for the same transport block is by SPS C-RNTI or UL-SPS-V-RNTI.

If a UE is configured by higher layers to decode MPDCCHs with the CRC scrambled by the SPS C-RNTI, the UE shall decode the MPDCCH according to the combination defined in Table 8-5B and transmit the corresponding PUSCH if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8].
The scrambling initialization of this PUSCH corresponding to these MPDCCHs and PUSCH retransmission for the same transport block is by SPS C-RNTI. The scrambling initialization of initial transmission of this PUSCH without a corresponding MPDCCH and the PUSCH retransmission for the same transport block is by SPS C-RNTI.

Table 8-5: PDCCH and PUSCH configured by SPS C-RNTI or UL-SPS-V-RNTI

Transmission mode	DCI format	Search Space	Transmission scheme of PUSCH corresponding to PDCCH
Mode 1	DCI format 0	Common and UE specific by C-RNTI	Single-antenna port, port 10 (see Subclause 8.0.1)
Mode 2	DCI format 0	Common and UE specific by C-RNTI	Single-antenna port, port 10 (see Subclause 8.0.1)

Table 8-5A: EPDCCH and PUSCH configured by SPS C-RNTI or UL-SPS-V-RNTI

Transmission mode	DCI format	Search Space	Transmission scheme of PUSCH corresponding to PDCCH
Mode 1	DCI format 0	UE specific by C-RNTI	Single-antenna port, port 10 (see Subclause 8.0.1)
Mode 2	DCI format 0	UE specific by C-RNTI	Single-antenna port, port 10 (see Subclause 8.0.1)

Table 8-5B: MPDCCH and PUSCH configured by SPS C-RNTI

Transmission mode	DCI format	Search Space	Transmission scheme of PUSCH corresponding to PDCCH
Mode 1	DCI format 6-0A	Type0-common (only for 6-0A) and UE specific by C-RNTI	Single-antenna port, port 10 (see Subclause 8.0.1)

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the Temporary C-RNTI regardless of whether UE is configured or not configured to decode PDCCHs with the CRC scrambled by the C-RNTI, the UE shall decode the PDCCH according to the combination defined in Table 8-6 and transmit the corresponding PUSCH. The scrambling initialization of PUSCH corresponding to these PDCCH is by Temporary C-RNTI.

If a UE is configured by higher layers to decode MPDCCHs with the CRC scrambled by the Temporary C-RNTI regardless of whether UE is configured or not configured to decode MPDCCHs with the CRC scrambled by the C-RNTI during random access procedure, the UE shall decode the MPDCCH according to the combination defined in Table 8-6A and transmit the corresponding PUSCH. The scrambling initialization of PUSCH corresponding to these MPDCCH is by Temporary C-RNTI.

If a Temporary C-RNTI is set by higher layers, the scrambling of PUSCH corresponding to the Random Access Response Grant in Subclause 6.2 and the PUSCH retransmission for the same transport block is by Temporary C-RNTI. Else, the scrambling of PUSCH corresponding to the Random Access Response Grant in Subclause 6.2 and the PUSCH retransmission for the same transport block is by C-RNTI.

If a UE is also configured by higher layers to decode MPDCCH with CRC scrambled by the C-RNTI during random access procedure, the UE shall decode the MPDCCH according to the combination defined in Table 8-6A and transmit the corresponding PUSCH. The scrambling initialization of PUSCH corresponding to these MPDCCH is by C-RNTI.

Table 8-6: PDCCH configured by Temporary C-RNTI

DCI format	Search Space
DCI format 0	Common

Table 8-6A: MPDCCH configured by Temporary C-RNTI and/or C-RNTI during random access procedure

DCI format	Search Space
DCI format 6-0A, 6-0B	Type2-Common

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the TPC-PUCCH-RNTI, the UE shall decode the PDCCH according to the combination defined in table 8-7. The notation 3/3A implies that the UE shall receive either DCI format 3 or DCI format 3A depending on the configuration.

If a UE is configured by higher layers to decode MPDCCHs with the CRC scrambled by the TPC-PUCCH-RNTI, the UE shall decode the MPDCCH according to the combination defined in table 8-7A. The notation 3/3A implies that the UE shall receive either DCI format 3 or DCI format 3A depending on the configuration.

Table 8-7: PDCCH configured by TPC-PUCCH-RNTI

DCI format	Search Space
DCI format 3/3A	Common

Table 8-7A: MPDCCH configured by TPC-PUCCH-RNTI

DCI format	Search Space
DCI format 3/3A	Type0-Common (for CEModeA only)

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the TPC-PUSCH-RNTI, the UE shall decode the PDCCH according to the combination defined in table 8.8. The notation 3/3A implies that the UE shall receive either DCI format 3 or DCI format 3A depending on the configuration.

If a UE is configured by higher layers to decode MPDCCHs with the CRC scrambled by the TPC-PUSCH-RNTI, the UE shall decode the MPDCCH according to the combination defined in table 8.8A. The notation 3/3A implies that the UE shall receive either DCI format 3 or DCI format 3A depending on the configuration.

Table 8-8: PDCCH configured by TPC-PUSCH-RNTI

DCI format	Search Space
DCI format 3/3A	Common

Table 8-8A: MPDCCH configured by TPC-PUSCH-RNTI

DCI format	Search Space
DCI format 3/3A	Type0-Common (for CEModeA only)

If the UE is configured by higher layers to decode PDCCHs with the CRC scrambled by higher layer parameter *srs-TPC-RNTI-r14*, the UE shall decode the PDCCH according to the combination defined in Table 8-8B.

Table 8-8B: PDCCH configured by higher layer parameter *srs-TPC-RNTI-r14*

DCI format	Search Space
DCI format 3B	Common

8.0.1 Single-antenna port scheme

For the single-antenna port transmission schemes (port 10) of the PUSCH, the UE transmission on the PUSCH is performed according to Subclause 5.3.2A.1 of [3].

8.0.2 Closed-loop spatial multiplexing scheme

For the closed-loop spatial multiplexing transmission scheme of the PUSCH, the UE transmission on the PUSCH is performed according to the applicable number of transmission layers as defined in Subclause 5.3.2A.2 of [3].

8.1 Resource allocation for PDCCH/EPDCCH with uplink DCI format

Two resource allocation schemes Type 0 and Type 1 are supported for PDCCH/EPDCCH with uplink DCI format 0/4.

Resource allocation scheme Type 0 or Type 2 or Type 4 are supported for MPDCCH with uplink DCI format.

Resource allocation scheme Type 3 is supported for a LAA SCell and PDCCH/EPDCCH with uplink DCI format 0A/0B/4A/4B.

If the resource allocation type bit is not present in the uplink DCI format, only resource allocation type 0 is supported.

If the resource allocation type bit is present in the uplink DCI format, the selected resource allocation type for a decoded PDCCH/EPDCCH is indicated by a resource allocation type bit where type 0 is indicated by 0 value and type 1 is indicated otherwise. The UE shall interpret the resource allocation field depending on the resource allocation type bit in the PDCCH/EPDCCH with uplink DCI format detected.

8.1.1 Uplink resource allocation type 0

The resource allocation information for uplink resource allocation type 0 indicates to a scheduled UE a set of contiguously allocated virtual resource block indices denoted by n_{VRB}. A resource allocation field in the scheduling grant consists of a resource indication value (*RIV*) corresponding to a starting resource block (RB_{START}) and a length in terms of contiguously allocated resource blocks ($L_{\mathrm{CRBs}} \geq 1$).

For a BL/CE UE,

- uplink resource allocation type 0 is only applicable for UE configured with CEModeA, and
- $N_{\mathrm{RB}}^{\mathrm{UL}}$ is always set to 6 in this subclause regardless of the system bandwidth.

The resource indication value is defined by

if $(L_{\mathrm{CRBs}} - 1) \leq \lfloor N_{\mathrm{RB}}^{\mathrm{UL}} / 2 \rfloor$ then

$$RIV = N_{\mathrm{RB}}^{\mathrm{UL}} (L_{\mathrm{CRBs}} - 1) + RB_{\mathrm{START}}$$

else

$$RIV = N_{\mathrm{RB}}^{\mathrm{UL}} (N_{\mathrm{RB}}^{\mathrm{UL}} - L_{\mathrm{CRBs}} + 1) + (N_{\mathrm{RB}}^{\mathrm{UL}} - 1 - RB_{\mathrm{START}})$$

8.1.2 Uplink resource allocation type 1

The resource allocation information for uplink resource allocation type 1 indicates to a scheduled UE two sets of resource blocks with each set including one or more consecutive resource block groups of size *P* as given in table 7.1.6.1-1 assuming $N_{\mathrm{RB}}^{\mathrm{UL}}$ as the system bandwidth. A combinatorial index *r* consists of $\left\lceil \log_2 \left(\binom{\left\lceil N_{RB}^{UL} / P + 1 \right\rceil}{4} \right) \right\rceil$ bits.

The bits from the resource allocation field in the scheduling grant represent *r* unless the number of bits in the resource allocation field in the scheduling grant is

- smaller than required to fully represent *r*, in which case the bits in the resource allocation field in the scheduling grant occupy the LSBs of *r* and the value of the remaining bits of *r* shall be assumed to be 0; or
- larger than required to fully represent *r*, in which case *r* occupies the LSBs of the resource allocation field in the scheduling grant.

The combinatorial index *r* corresponds to a starting and ending RBG index of resource block set 1, s_0 and $s_1 - 1$, and resource block set 2, s_2 and $s_3 - 1$ respectively, where *r* is given by equation $r = \sum_{i=0}^{M-1} \binom{N - s_i}{M - i}$ defined in Subclause

7.2.1 with M=4 and $N = \left\lceil N_{\mathrm{RB}}^{\mathrm{UL}} / P \right\rceil + 1$. Subclause 7.2.1 also defines ordering properties and range of values that s_i (RBG indices) map to. Only a single RBG is allocated for a set at the starting RBG index if the corresponding ending RBG index equals the starting RBG index.

8.1.3 Uplink resource allocation type 2

Uplink resource allocation type 2 is only applicable for BL/CE UE configured with CEModeB. The resource allocation information for uplink resource allocation type 2 indicates to a scheduled UE a set of contiguously allocated resource blocks within a narrowband as given in Table 8.1.3-1

Table 8.1.3-1: Resource block(s) allocation for BL/CE UE configured with CEModeB.

Value of resource allocation field	Allocated resource blocks
'000'	0
'001'	1
'010'	2
'011'	3
'100'	4
'101'	5
'110'	0 and 1
'111'	2 and 3

8.1.4 Uplink resource allocation type 3

Uplink resource allocation type 3 is only applicable for a LAA SCell. The resource allocation information for uplink resource allocation type 3 indicates to a scheduled UE a set of allocated resource blocks, $RB_{\mathrm{START}} + l + i \cdot N$ where, $N = \left\lfloor N_{\mathrm{RB}}^{\mathrm{UL}} / 10 \right\rfloor$, $i = 0,1,\cdots 9$.

For $N_{\mathrm{RB}}^{\mathrm{UL}} = 100$, a resource allocation field in the scheduling grant consists of a resource indication value (*RIV*). For $N_{\mathrm{RB}}^{\mathrm{UL}} = 100$ and $0 \le RIV < N(N+1)/2$, $l = 0,1,\cdots L-1$ and the resource indication value corresponds to the starting resource block (RB_{START}) and the value of L ($L \ge 1$). The resource indication value is defined by,

if $(L-1) \le \lfloor N/2 \rfloor$ then

$$RIV = N(L-1) + RB_{\mathrm{START}}$$

else

$$RIV = N(N-L+1) + (N-1-RB_{\mathrm{START}})$$

For $N_{\mathrm{RB}}^{\mathrm{UL}} = 100$ and $RIV \ge N(N+1)/2$, the resource indication value corresponds to the starting resource block (RB_{START}) and the set of values l according to Table 8.1.4-1.

Table 8.1.4-1: RB_{START} and l for $RIV \ge N(N+1)/2$.

$RIV - N(N+1)/2$	RB_{START}	l
0	0	{0, 5}
1	0	{0, 1, 5, 6}
2	1	{0, 5}
3	1	{0, 1, 2, 3, 5, 6, 7, 8}
4	2	{0, 5}
5	2	{0, 1, 2, 5, 6, 7}
6	3	{0, 5}
7	4	{0, 5}

For $N_{\mathrm{RB}}^{\mathrm{UL}} = 50$, the resource allocation field indicates a bitmap of the allocated values of *l* where *l* = 0,1,2,3,4. The order of set of resource blocks to bitmap bit mapping is in such way that *l* = 0 to *l = 4* are mapped to MSB to LSB of the bitmap respectively. The set of resource blocks is allocated to the UE if the corresponding bit value in the bitmap is 1, and the set of resource blocks are not allocated otherwise.

8.1.5 Uplink resource allocation type 4

Uplink resource allocation type 4 is only applicable for BL/CE UEs configured with CEModeA and configured with higher layer parameter *ce-pusch-maxBandwidth-config* with value 5MHz. The resource allocation information for uplink resource allocation type 4 indicates to a scheduled UE a set of contiguously allocated resource blocks as follows.

- the set of contiguously allocated resource blocks are indicated using resource block groups where each resource block group is a set of $P = 3$consecutive resource blocks and resource block group indices are determined as described sub clause 8.1.5.1 where $N_{RBG}^{UL} = \left\lfloor \frac{N'^{UL}_{RB}}{P} \right\rfloor$ and $N'^{UL}_{RB} = 6 \cdot \left\lfloor \frac{N_{RB}^{UL}}{6} \right\rfloor$.

- the resource allocation field in the scheduling grant consists of a resource block group indication value (*RBGIV*) corresponding to a starting resource block group index (RBG_{start}) and a length in terms of contiguously allocated resource block groups ($L_{CRBGs} > 2$). The resource block group indication value is determined from *RBGIV'* by $RBGIV = \lfloor RBGIV'/11 \rfloor \cdot 32 + RBGIV' \bmod 11 + 21$ and *RBGIV'* is defined by

  if $(L_{CRBGs} - 1) \le (M/2)$

  $$RBGIV' = (2N_{RBG}^{UL} - K)(L_{CRBGs} - 3) + RBG_{start}$$

  Else

  $$RBGIV' = (2N_{RBG}^{UL} - K)(M - L_{CRBGs} + 1) - RBG_{start} - 1$$

  where, for $N_{\mathrm{RB}}^{\mathrm{UL}} > 15$, $K = 9$, $M = 8$, and for $N_{\mathrm{RB}}^{\mathrm{UL}} = 15$, $K = 5$, $M = 4$.

  - For odd N_{RB}^{UL}, if the resource allocation computed using the *RBGIV* includes PRBs on both sides of the centre PRB, the resource allocation is updated by removing the PRB with the largest PRB index and including the centre PRB.

8.1.5.1 UL Resource Block Groups

The uplink resource block groups of size P are numbered $n_{\mathrm{RBG}} = 0,\ldots,N_{\mathrm{RBG}}^{\mathrm{UL}} - 1$ in order of increasing physical resource-block number where uplink resource block group n_{RBG} is composed of physical resource-block indices

$$\begin{cases} P \cdot n_{\mathrm{RBG}} + i_0 + i & \text{if } N_{\mathrm{RB}}^{\mathrm{UL}} \bmod 2 = 0 \\ P \cdot n_{\mathrm{RBG}} + i_0 + i & \text{if } N_{\mathrm{RB}}^{\mathrm{UL}} \bmod 2 = 1 \text{ and } n_{\mathrm{RBG}} < N_{\mathrm{RBG}}^{\mathrm{UL}}/2 \\ P \cdot n_{\mathrm{RBG}} + i_0 + i + 1 & \text{if } N_{\mathrm{RB}}^{\mathrm{UL}} \bmod 2 = 1 \text{ and } n_{\mathrm{RBG}} \ge N_{\mathrm{RBG}}^{\mathrm{UL}}/2 \end{cases}$$

where

$$i = 0,1,\ldots,P-1$$

$$i_0 = \left\lfloor \frac{N_{\mathrm{RB}}^{\mathrm{UL}}}{2} \right\rfloor - \frac{6 \cdot \lfloor N_{\mathrm{RB}}^{\mathrm{UL}}/6 \rfloor}{2}$$

8.2 UE sounding procedure

If the UE is configured with a PUCCH-SCell, the UE shall apply the procedures described in this clause for both primary PUCCH group and secondary PUCCH group unless stated otherwise

- When the procedures are applied for the primary PUCCH group, the terms 'secondary cell', 'secondary cells', 'serving cell', and 'serving cells' in this clause refer to secondary cell, secondary cells, serving cell or serving cells belonging to the primary PUCCH group respectively unless stated otherwise.
- When the procedures are applied for secondary PUCCH group, the terms 'secondary cell', 'secondary cells', 'serving cell' and 'serving cells' in this clause refer to secondary cell, secondary cells (not including the PUCCH-SCell), serving cell, serving cells belonging to the secondary PUCCH group respectively unless stated otherwise. The term 'primary cell' in this clause refers to the PUCCH-SCell of the secondary PUCCH group.

A UE shall transmit Sounding Reference Symbol (SRS) on per serving cell SRS resources based on two trigger types:

- trigger type 0: higher layer signalling
- trigger type 1: DCI formats 0/0A/0B/4/4A/4B/1A/6-0A/6-1A for FDD, TDD, and frame structure type 3 and DCI formats 2B/2C/2D/3B for TDD, and frame structure type 3.

A UE is not expected to be configured with SRS trigger type 0 on a LAA SCell.

In case both trigger type 0 and trigger type 1 SRS transmissions would occur in the same subframe in the same serving cell, the UE shall only transmit the trigger type 1 SRS transmission.

A UE may be configured with SRS parameters for trigger type 0 and trigger type 1 on each serving cell. A BL/CE UE configured with CEModeB is not expected to be configured with SRS parameters for trigger type 0 and trigger type 1. The following SRS parameters are serving cell specific and semi-statically configurable by higher layers for trigger type 0 and for trigger type 1.

- Number of combs K_{TC} as defined in Subclause 5.5.3.2 of [3] for trigger type 0 and each configuration of trigger type 1, if configured
- srs-UpPtsAdd: two or four additional SC-FDMA symbols in UpPTS as defined in [11] for trigger type 0 and trigger type 1, if configured
- Transmission comb $\bar{k}_{TC}$, as defined in Subclause 5.5.3.2 of [3] for trigger type 0 and each configuration of trigger type 1
- Starting physical resource block assignment n_{RRC}, as defined in Subclause 5.5.3.2 of [3] for trigger type 0 and each configuration of trigger type 1 for a serving cell that is not a LAA SCell. For a serving cell that is a LAA SCell, $n_{RRC} = 0$.
- *duration*: single or indefinite (until disabled), as defined in [11] for trigger type 0
- *srs-ConfigIndex* I_{SRS} for SRS periodicity T_{SRS} and SRS subframe offset T_{offset}, as defined in Table 8.2-1 and Table 8.2-2 for trigger type 0 and SRS periodicity $T_{\text{SRS},1}$ and SRS subframe offset $T_{offset,1}$, as defined in Table 8.2-4 and Table 8.2-5 trigger type 1 for a serving cell that is not a LAA SCell
- SRS bandwidth B_{SRS}, as defined in Subclause 5.5.3.2 of [3] for trigger type 0 and each configuration of trigger type 1 for a serving cell that is not a LAA SCell. For a serving cell that is a LAA SCell, $B_{\text{SRS}} = 0$.
- Frequency hopping bandwidth, b_{hop}, as defined in Subclause 5.5.3.2 of [3] for trigger type 0
- Cyclic shift n_{SRS}^{cs}, as defined in Subclause 5.5.3.1 of [3] for trigger type 0 and each configuration of trigger type 1
- Number of antenna ports N_p for trigger type 0 and each configuration of trigger type 1

- SRS subframe for each configuration of trigger type 1 for a serving cell that is a LAA SCell and DCI format 4B

For a TDD serving cell,

- If the serving cell not configured for PUSCH/PUCCH transmission, or if the UE supports *ce-srsEnhancement-r14*
  - For trigger type 0, the UE can be configured with more than one configuration of *SoundingRS-UL-ConfigDedicatedUpPTsExt* and/or *SoundingRS-UL-ConfigDedicated*, and the SRS parameters in each of the configurations shall be used.
  - For trigger type 1, the UE can be configured with more than one configuration of *SoundingRS-UL-ConfigDedicatedAperiodicUpPTsExt* and/or *SoundingRS-UL- ConfigDedicatedAperiodic*, and the SRS parameters in each of the configurations shall be used.
- Otherwise
  - For trigger type 0, if *SoundingRS-UL-ConfigDedicatedUpPTsExt* is configured, the SRS parameters in *SoundingRS-UL-ConfigDedicatedUpPTsExt* shall be used; otherwise, *SoundingRS-UL-ConfigDedicated* shall be used.
  - For trigger type 1, if *SoundingRS-UL-ConfigDedicatedAperiodicUpPTsExt* is configured, the SRS parameters in *SoundingRS-UL-ConfigDedicatedAperiodicUpPTsExt* shall be used; otherwise, *SoundingRS-UL-ConfigDedicatedAperiodic* shall be used.

For trigger type 1 and DCI format 4/4A/4B three sets of SRS parameters, *srs-ConfigApDCI-Format4*, are configured by higher layer signalling. The 2-bit SRS request field [4] in DCI format 4/4A/4B indicates the SRS parameter set given in Table 8.1-1. For trigger type 1 and DCI format 0/0A/0B /6-0A, a single set of SRS parameters, *srs-ConfigApDCI-Format0*, is configured by higher layer signalling. For trigger type 1 and DCI formats 1A/2B/2C/2D/6-1A, a single common set of SRS parameters, *srs-ConfigApDCI-Format1a2b2c*, is configured by higher layer signalling. For a serving cell that is not a LAA SCell, the SRS request field is 1 bit [4] for DCI formats 0/1A/2B/2C/2D/6-0A/6-1A, with a type 1 SRS triggered if the value of the SRS request field is set to '1'. For a serving cell that is a LAA SCell, the SRS timing offset field is 3 bits [4] for DCI formats 1A/2B/2C/2D, with a type 1 SRS triggered if the value of the SRS timing offset field is not set to '000'. The SRS request field is 1 bit [4] for DCI formats 0A, with a type 1 SRS triggered if the value of the SRS request field is set to '1'. The 2-bit SRS request field [4] in DCI format 0B indicates the type 1 SRS triggering and PUSCH subframe (as determined in Subclause 8.0) with SRS as given in Table 8.2-0A.

For a serving cell that is not a LAA SCell, a 1-bit SRS request field shall be included in DCI formats 0/1A for frame structure type 1 and 0/1A/2B/2C/2D for frame structure type 2 if the UE is configured with SRS parameters for DCI formats 0/1A/2B/2C/2D by higher-layer signalling. A 1-bit SRS request field shall be included in DCI formats 6-0A/6-1A, the value of which is reserved if the UE is not configured with SRS parameters for DCI formats 6-0A/6-1A by higher layer signalling.

For a TDD serving cell not configured for PUSCH/PUCCH transmission, and trigger type 1, a SRS request field [4] shall be included in DCI format 3B if the value of the higher layer parameter *fieldTypeFormat3B* is set to 3 or 4. If the UE is configured with more than 5 TDD serving cells without PUSCH/PUCCH transmission, a single SRS request field is included in DCI format 3B for a set of the TDD serving cells without PUSCH/PUCCH transmission as given in Table 8.2-0C; otherwise one or more SRS request fields is included in DCI format 3B each corresponding to a TDD serving cell without PUSCH/PUCCH transmission as configured by higher layers. If the UE is configured with no more than 5 TDD serving cells without PUSCH/PUCCH transmission, and the UE does not support transmit antenna selection or multi-antenna transmission, the SRS request field [4] in DCI format 3B is 1-bit, 2-bits otherwise. For the 1-bit SRS request field [4] in DCI format 3B, a type 1 SRS is triggered if the value of the SRS request field is set to '1' with SRS parameters, *srs-ConfigApDCI-Format1a2b2c*, configured by higher layer signalling. For the 2-bit SRS request field [4] in DCI format 3B, and UE configured with no more than 5 TDD serving cells without PUSCH/PUCCH transmission, the SRS request field indicates the SRS parameter set given in Table 8.1-1 with the three sets of SRS parameters, *srs-ConfigApDCI-Format4*, configured by higher layer signalling. For the 2-bit SRS request field [4] in Table 8.2-0C and DCI format 3B, and UE configured with more than 5 TDD serving cells without PUSCH/PUCCH transmission, SRS parameters, *srs-ConfigApDCI-Format1a2b2c*, configured by higher layer signalling for the associated serving cell, is used if a type 1 SRS is triggered.

Table 8.1-1: SRS request value for trigger type 1 in DCI format 4/4A/4B

Value of SRS request field	Description
'00'	No type 1 SRS trigger
'01'	The 1st SRS parameter set configured by higher layers
'10'	The 2nd SRS parameter set configured by higher layers
'11'	The 3rd SRS parameter set configured by higher layers

Table 8.2-0A: SRS request value for trigger type 1 in DCI format 0B

Value of SRS request field	Description
'00'	No type 1 SRS trigger
'01'	Type 1 SRS trigger and first scheduled PUSCH subframe
'10'	Type 1 SRS trigger and second scheduled PUSCH subframe
'11'	Type 1 SRS trigger and last scheduled PUSCH subframe

Table 8.2-0C: SRS request value for trigger type 1 in DCI format 3B and for UE configured with more than 5 TDD serving cells without PUSCH/PUCCH transmission

Value of SRS request field	Description
'00'	No type 1 SRS trigger for a 1st set of serving cells configured by higher layers
'01'	Type 1 SRS trigger for a 2nd set of serving cells configured by higher layers
'10'	Type 1 SRS trigger for a 3rd set of serving cells configured by higher layers
'11'	Type 1 SRS trigger for a 4th set of serving cells configured by higher layers

For a serving cell that is not a LAA SCell, the serving cell specific SRS transmission bandwidths C_{SRS} are configured by higher layers. The allowable values are given in Subclause 5.5.3.2 of [3].

For a serving cell that is not a LAA SCell, the serving cell specific SRS transmission sub-frames are configured by higher layers. The allowable values are given in Subclause 5.5.3.3 of [3].

For a TDD serving cell, SRS transmissions can occur in UpPTS and uplink subframes of the UL/DL configuration indicated by the higher layer parameter *subframeAssignment* for the serving cell.

When closed-loop UE transmit antenna selection is enabled for a given serving cell for a UE that supports transmit antenna selection, the index $a(n_{SRS})$, of the UE antenna that transmits the SRS at time n_{SRS} is given by

$a(n_{SRS}) = n_{SRS} \bmod 2$, for both partial and full sounding bandwidth, and when frequency hopping is disabled (i.e., $b_{hop} \geq B_{SRS}$),

$$a(n_{SRS}) = \begin{cases} (n_{SRS} + \lfloor n_{SRS}/2 \rfloor + \beta \cdot \lfloor n_{SRS}/K \rfloor) \bmod 2 & \text{when } K \text{ is even} \\ n_{SRS} \bmod 2 & \text{when } K \text{ is odd} \end{cases} \quad , \beta = \begin{cases} 1 & \text{where } K \bmod 4 = 0 \\ 0 & \text{otherwise} \end{cases}$$

when frequency hopping is enabled (i.e., $b_{hop} < B_{SRS}$),

where values B_{SRS}, b_{hop}, N_b, and n_{SRS} are given in Subclause 5.5.3.2 of [3], and $K = \prod_{b'=b_{hop}}^{B_{SRS}} N_{b'}$ (where $N_{b_{hop}} = 1$ regardless of the N_b value), except when a single SRS transmission is configured for the UE. If a UE is configured with more than one serving cell, and for a group of cells belonging to bands that are signalled to be switched together in *txAntennaSwitchUL* the UE is not expected to transmit SRS on different antenna ports simultaneously. If a UE is configured with more than one serving cell, and for a group of cells belonging to bands that are signalled to be switched together in *txAntennaSwitchUL* the UE is not expected to transmit SRS and PUSCH on different antenna ports simultaneously.

A UE may be configured to transmit SRS on N_p antenna ports of a serving cell where N_p may be configured by higher layer signalling. For PUSCH transmission mode 1 $N_p \in \{0,1,2,4\}$ and for PUSCH transmission mode 2 $N_p \in \{0,1,2\}$ with two antenna ports configured for PUSCH and $N_p \in \{0,1,4\}$ with 4 antenna ports configured for PUSCH. A UE configured for SRS transmission on multiple antenna ports of a serving cell shall transmit SRS for all the configured transmit antenna ports within one SC-FDMA symbol of the same subframe of the serving cell. The SRS transmission bandwidth and starting physical resource block assignment are the same for all the configured antenna ports of a given serving cell. The UE does not support a value of K_{TC} set to '4', if the UE is configured for SRS transmission on 4 antenna ports of a serving cell.

If a UE is not configured with multiple TAGs and the UE is not configured with the parameter *srs-UpPtsAdd* for trigger type 1, or if a UE is not configured with multiple TAGs and the UE is not configured with more than one serving cell of different CPs, or if a UE is configured for PUSCH transmission in UpPTS and a SRS transmission overlaps with a PUSCH transmission on the same symbol in UpPTS within a TDD serving cell, the UE shall not transmit SRS in a symbol whenever SRS and PUSCH transmissions happen to overlap in the same symbol, except when the SRS is on a TDD serving cell not configured for PUSCH/PUCCH transmission. For the case when an SRS transmission in a first serving cell happens to overlap in the same symbol as a PUSCH transmission in a second serving cell, and the first and second serving cells are in the same TAG, same band, and use the same cyclic prefix, the UE may drop the SRS transmission.

For TDD serving cell, and UE not configured with additional SC-FDMA symbols in UpPTS, when one SC-FDMA symbol exists in UpPTS of the given serving cell, it can be used for SRS transmission, when two SC-FDMA symbols exist in UpPTS of the given serving cell, both can be used for SRS transmission and for trigger type 0 SRS both can be assigned to the same UE. For TDD serving cell, and if the UE is configured with two or four additional SC-FDMA symbols in UpPTS of the given serving cell, all can be used for SRS transmission and for trigger type 0 SRS at most two SC-FDMA symbols out of the configured additional SC-FDMA symbols in UpPTS can be assigned to the same UE, except for UE not configured for PUSCH/PUCCH transmission or for UE supporting *ce-srsEnhancement-r14*, where all can be assigned to the same UE.

If a UE is not configured with multiple TAGs and the UE is not configured with the parameter *srs-UpPtsAdd* for trigger type 1, or if a UE is not configured with multiple TAGs and the UE is not configured with more than one serving cell of different CPs, or if a UE is configured with multiple TAGs and SRS and PUCCH format 2/2a/2b happen to coincide in the same subframe in the same serving cell, except when the SRS is on a TDD serving cell not configured for PUSCH/PUCCH transmission,

- The UE shall not transmit type 0 triggered SRS whenever type 0 triggered SRS and PUCCH format 2/2a/2b transmissions happen to coincide in the same subframe;
- The UE shall not transmit type 1 triggered SRS whenever type 1 triggered SRS and PUCCH format 2a/2b or format 2 with HARQ-ACK transmissions happen to coincide in the same subframe;
- The UE shall not transmit PUCCH format 2 without HARQ-ACK whenever type 1 triggered SRS and PUCCH format 2 without HARQ-ACK transmissions happen to coincide in the same subframe.

If a UE is not configured with multiple TAGs and the UE is not configured with the parameter *srs-UpPtsAdd* for trigger type 1, or if a UE is not configured with multiple TAGs and the UE is not configured with more than one serving cell of different CPs, or if a UE is configured with multiple TAGs and SRS and PUCCH happen to coincide in the same subframe in the same serving cell, except when the SRS is on a TDD serving cell not configured for PUSCH/PUCCH transmission,

- The UE shall not transmit SRS whenever SRS transmission and PUCCH transmission carrying HARQ-ACK and/or positive SR happen to coincide in the same subframe if the parameter *ackNackSRS-SimultaneousTransmission* is *FALSE*;
- For FDD-TDD and primary cell frame structure 1, the UE shall not transmit SRS in a symbol whenever SRS transmission and PUCCH transmission carrying HARQ-ACK and/or positive SR using shortened format as defined in Subclauses 5.4.1, 5.4.2A, 5.4.2B, and 5.4.2C of [3] happen to overlap in the same symbol if the parameter *ackNackSRS-SimultaneousTransmission* is *TRUE*.

- Unless otherwise prohibited, the UE shall transmit SRS whenever SRS transmission and PUCCH transmission carrying HARQ-ACK and/or positive SR using shortened format as defined in Subclauses 5.4.1 and 5.4.2A of [3] happen to coincide in the same subframe if the parameter *ackNackSRS-SimultaneousTransmission* is *TRUE*.

If a UE is not configured with multiple TAGs and the UE is not configured with the parameter *srs-UpPtsAdd* for trigger type 1, or if a UE is not configured with multiple TAGs and the UE is not configured with more than one serving cell of different CPs, the UE shall not transmit SRS whenever SRS transmission on any serving cells and PUCCH transmission carrying HARQ-ACK and/or positive SR using normal PUCCH format as defined in Subclauses 5.4.1 and 5.4.2A of [3] happen to coincide in the same subframe.

In UpPTS, whenever SRS transmission instance overlaps with the PRACH region for preamble format 4 or exceeds the range of uplink system bandwidth configured in the serving cell, the UE shall not transmit SRS.

For a TDD serving cell d not configured for PUSCH/PUCCH transmission, denote as $s_0(d)$ the corresponding serving cell whose UL transmissions may be interrupted as signalled by *srs-SwitchFromServCellIndex*. Define the set $S(d)$= $\{s_0(d)\ldots s_{N-1}(d)\}$ as the set of serving cells that meet the all the following conditions:

- $\{s_0(d)\ldots s_{N-1}(d)\}$ are in the same band as $s_0(d)$.
- $\{s_0(d)\ldots s_{N-1}(d)\}$ have the same CP as s_0(d).
- $\{s_0(d)\ldots s_{N-1}(d)\}$ are in the same TAG as s_0(d).

The following prioritization rules shall be applied when transmitting SRS over serving cell d when the simultaneous transmission of SRS and other signal/channel would result in uplink transmissions beyond the UE's indicated uplink carrier aggregation capability included in the *UE-EUTRA-Capability* [12]:

- If PUSCH/PUCCH transmission carrying HARQ-ACK/positive SR/RI/PTI/CRI and/or PRACH on a serving cell in set *S(d)* overlaps in the same symbol with the SRS transmission (including any interruption due to uplink or downlink RF retuning time [10]) on serving cell *d*, then the UE shall not transmit SRS. Otherwise,
- if PUSCH transmission carrying aperiodic CSI on a serving cell in set *S(d)* overlaps in the same symbol with the SRS transmission (including any interruption due to uplink or downlink RF retuning time [10]) in serving cell *d*, and if the SRS transmission is a type 0 SRS transmission, then the UE shall not transmit the type 0 SRS. Otherwise,
- if PUSCH transmission on a serving cell in set *S(d)* overlaps in more than one symbol with the SRS transmission (including any interruption due to uplink or downlink RF retuning time [10]) in serving cell *d*, then the UE shall drop the PUSCH transmission. If PUCCH/SRS transmission on a serving cell in set *S(d)* overlaps in the same symbol with the SRS transmission (including any interruption due to uplink or downlink RF retuning time [10]) on serving cell *d*, the UE shall drop the PUCCH/SRS transmission.

In case an SRS transmission in subframe N on serving cell d is dropped due to a collision with a higher priority transmission (as defined above) in subframe N+1, and there is a lower priority transmission (as defined above) in subframe N that would have been dropped had the transmission in subframe N+1 not occurred, the UE is not required to transmit the lower priority transmission in subframe N.

The parameter *ackNackSRS-SimultaneousTransmission* provided by higher layers determines if a UE is configured to support the transmission of HARQ-ACK on PUCCH and SRS in one subframe. If it is configured to support the transmission of HARQ-ACK on PUCCH and SRS in one subframe, then in the cell specific SRS subframes of the primary cell,

- if the UE transmits PUCCH format 1/1a/1b/3, the UE shall transmit HARQ-ACK and SR using the shortened PUCCH format as defined in Subclauses 5.4.1 and 5.4.2A of [3], where the HARQ-ACK or the SR symbol corresponding to the SRS location is punctured.
- If the UE transmits PUCCH format 4/5 partly or fully overlapping with the cell specific SRS bandwidth in the cell specific SRS subframes of the primary cell, then UE shall transmit UCI using the shortened PUCCH format as defined in Subclauses 5.4.2B and 5.4.2C of [3].

For PUCCH format 1/1a/1b/3, this shortened PUCCH format shall be used in a cell specific SRS subframe of the primary cell even if the UE does not transmit SRS in that subframe. For PUCCH format 4/5, this shortened PUCCH format shall be used if the PUCCH transmission partly or fully overlaps with the cell-specific SRS bandwidth in the cell specific SRS subframes of the primary cell even if the UE does not transmit SRS in that subframe, or if the UE transmits SRS in that subframe even if the PUCCH format 4/5 does not partly or fully overlap with the cell-specific

SRS. The cell specific SRS subframes are defined in Subclause 5.5.3.3 of [3]. Otherwise, the UE shall use the normal PUCCH format 1/1a/1b as defined in Subclause 5.4.1 of [3] or normal PUCCH format 3 as defined in Subclause 5.4.2A or normal PUCCH format 4 as defined in Subclause 5.4.2B or normal PUCCH format 5 as defined in Subclause 5.4.2C of [3].

For a BL/CE UE not configured with the higher layer parameter *srs-UpPtsAdd*, for a SRS transmission in subframe *n* and if the UE transmits PUSCH/PUCCH in subframe *n* and/or *n+1*, the UE shall not transmit the SRS in subframe *n* if the SRS transmission bandwidth in subframe *n* is not completely within the narrowband of PUSCH/PUCCH in subframe *n* and/or *n+1*

A BL/CE UE not configured with the higher layer parameter *srs-UpPtsAdd* shall not transmit SRS in UpPTS if SRS frequency location is different from DwPTS reception narrowband in the same special subframe.

For a TDD serving cell, c_1, not configured for PUSCH/PUCCH transmission, the UE is not expected to be configured with SRS resource(s) such that the SRS transmission (including any interruption due to uplink or downlink RF retuning time [10]) may overlap in time with PDCCH monitoring in subframes 0 or 5 on serving cell c_2, if the UE is not capable of simultaneous transmission and reception on serving cell c_1 and serving cell c_2.

Trigger type 0 SRS configuration of a UE in a serving cell for SRS periodicity, T_{SRS}, and SRS subframe offset, T_{offset}, is defined in Table 8.2-1 and Table 8.2-2, for FDD and TDD serving cell, respectively. The periodicity T_{SRS} of the SRS transmission is serving cell specific and is selected from the set {2, 5, 10, 20, 40, 80, 160, 320} ms or subframes.
For the SRS periodicity T_{SRS} of 2 ms in TDD serving cell configured for PUSCH and/or PUCCH transmission, two SRS resources are configured in a half frame containing UL subframe(s) of the given serving cell. For the SRS periodicity T_{SRS} of 2 ms in TDD serving cell not configured for PUSCH/PUCCH transmission, two or more SRS resources are configured in a half frame containing UL subframe(s) of the given serving cell.

Type 0 triggered SRS transmission instances in a given serving cell for TDD serving cell with $T_{\text{SRS}} > 2$ and for FDD serving cell are the subframes satisfying $(10 \cdot n_f + k_{\text{SRS}} - T_{offset}) \bmod T_{\text{SRS}} = 0$, where for FDD $k_{\text{SRS}} = \{0,1,...,9\}$ is the subframe index within the frame, for TDD serving cell, if the UE is configured with the parameter *srs-UpPtsAdd* for trigger type 0, k_{SRS} is defined in Table 8.2-6; otherwise k_{SRS} is defined in Table 8.2-3. The SRS transmission instances for TDD serving cell with $T_{\text{SRS}} = 2$ are the subframes satisfying $(k_{\text{SRS}} - T_{offset}) \bmod 5 = 0$.

For TDD serving cell, and a UE configured for type 0 triggered SRS transmission in serving cell *c*, and the UE configured with the parameter *EIMTA-MainConfigServCell-r12* for serving cell *c*, if the UE does not detect an UL/DL configuration indication for radio frame *m* (as described in Subclause 13.1), the UE shall not transmit trigger type 0 SRS in a subframe of radio frame *m* that is indicated by the parameter *eimta-HARQ-ReferenceConfig-r12* as a downlink subframe unless the UE transmits PUSCH in the same subframe.

For a serving cell that is not a LAA SCell, trigger type 1 SRS configuration of a UE in a serving cell for SRS periodicity, $T_{\text{SRS},1}$, and SRS subframe offset, $T_{offset,1}$, is defined in Table 8.2-4 and Table 8.2-5, for FDD and TDD serving cell, respectively. The periodicity $T_{\text{SRS},1}$ of the SRS transmission is serving cell specific and is selected from the set {2, 5, 10} ms or subframes.
For the SRS periodicity $T_{\text{SRS},1}$ of 2 ms in TDD serving cell configured for PUSCH and/or PUCCH transmission, two SRS resources are configured in a half frame containing UL subframe(s) of the given serving cell. For the SRS periodicity $T_{\text{SRS},1}$ of 2 ms in TDD serving cell not configured for PUSCH/PUCCH transmission, two or more SRS resources are configured in a half frame containing UL subframe(s) of the given serving cell.

For TDD serving cell configured for PUSCH and/or PUCCH transmission, and a UE configured for type 1 triggered SRS transmission in serving cell *c* and configured with the parameter *srs-UpPtsAdd*, the UE is not expected to receive trigger type 1 SRS configurations with SRS periodicity $T_{\text{SRS},1}$ of 2 ms.

A UE configured for type 1 triggered SRS transmission in serving cell *c* and not configured with a carrier indicator field shall transmit SRS on serving cell *c* upon detection of a positive SRS request in PDCCH/EPDCCH/MPDCCH scheduling PUSCH/PDSCH on serving cell *c*.

A UE configured for type 1 triggered SRS transmission in serving cell *c* and configured with a carrier indicator field shall transmit SRS on serving cell *c* upon detection of a positive SRS request in PDCCH/EPDCCH scheduling PUSCH/PDSCH with the value of carrier indicator field corresponding to serving cell *c*.

For a serving cell that is not a LAA SCell, a non-BL/CE UE configured for type 1 triggered SRS transmission on serving cell *c* upon detection of a positive SRS request in subframe *n* of serving cell *c* shall commence SRS transmission in the first subframe satisfying $n+k, k \geq 4$ and

$(10 \cdot n_f + k_{\text{SRS}} - T_{offset,1}) \bmod T_{\text{SRS},1} = 0$ for TDD serving cell *c* with $T_{\text{SRS},1} > 2$ and for FDD serving cell *c*,

$(k_{\text{SRS}} - T_{offset,1}) \bmod 5 = 0$ for TDD serving cell *c* with $T_{\text{SRS},1} = 2$

where for FDD serving cell *c* $k_{\text{SRS}} = \{0,1,...,9\}$ is the subframe index within the frame n_f, for TDD serving cell *c*, if the UE is configured with the parameter *srs-UpPtsAdd* for trigger type 1, k_{SRS} is defined in Table 8.2-6; otherwise k_{SRS} is defined in Table 8.2-3. For a TDD serving cell not configured for PUSCH/PUCCH transmission and the positive SRS request detected in PDCCH/EPDCCH scheduling PDSCH and the UE configured with *soundingRS-FlexibleTiming-r14* by higher layer signalling, if the SRS transmission (including any interruption due to uplink or downlink RF retuning time [10]) in the first subframe $n+k, k \geq 4$ happens to overlap with a HARQ-ACK transmission for any serving cell, the UE shall commence SRS transmission in subframe *n* + *k* + *l*, where *l* = max(5, $T_{\text{SRS},1}$).

For a type 1 SRS triggered for more than one TDD serving cell in DCI format 3B and UE configured with more than 5 TDD serving cells without PUSCH/PUCCH transmission, the order of the triggered SRS transmission on the serving cells follow the order of the serving cells in the indicated set of serving cells configured by higher layers. For a type 1 SRS triggered for more than one TDD serving cell in DCI format 3B and UE configured with no more than 5 TDD serving cells without PUSCH/PUCCH transmission, the order of the triggered SRS transmission on the serving cells follow the order of the serving cells with type 1 SRS triggered in the DCI. The SRS resource for the *n*-th (*n*>=2) SRS transmission is determined such that it is the first SRS resource on or after the SRS resource for the (*n*-1)-th SRS transmission provided it does not collide with any previous SRS transmission triggered in the DCI format 3B, or interruption due to UL or DL RF retuning time [10].

For a serving cell *c* that is a LAA SCell, a UE configured for type 1 triggered SRS transmission on serving cell *c* upon detection of a positive SRS request in subframe *n* of serving cell *c* shall commence SRS transmission, conditioned on the channel access procedures described in clause 15.2.1, in subframe $n+k$, where

- *k* corresponds to the scheduled PUSCH subframe determined in Subclause 8.0 if SRS is triggered in DCI format 0A/4A,
- *k* is determined from Table 8.2-0A and the corresponding scheduled PUSCH subframe determined in Subclause 8.0 if SRS is triggered in DCI format 0B,
- $k = m + \bmod(l, N)$ where the value of *l* is determined from SRS subframe parameter for the indicated SRS parameter set in Table 8.1, *m* is determined from the first scheduled PUSCH subframe determined in Subclause 8.0 and *N* is determined by the procedure in Subclause 8.0 if SRS is triggered in DCI format 4B,
- $k = 3 + l$ where the value of *l* is determined by the SRS timing offset field in the corresponding DCI if SRS is triggered in DCI format 1A/2B/2C/2D according to Table 8.2-0B.

Table 8.2-0B: *l* for SRS trigger type 1 in DCI format 1A/2B/2C/2D

Value of SRS timing offset field	*l*
'000'	No type 1 SRS trigger
'001'	1
'010'	2
'011'	3
'100'	4
'101'	5
'110'	6
'111'	7

A BL/CE UE configured for type 1 triggered SRS transmission on serving cell *c* upon detection of a positive SRS request of serving cell *c* shall commence SRS transmission in the first subframe satisfying $n+k, k \geq 4$, where subframe *n* is the last subframe in which the DCI format 6-0A/6-1A with the positive SRS request is transmitted, and

$(10 \cdot n_f + k_{\text{SRS}} - T_{offset,1}) \bmod T_{\text{SRS},1} = 0$ for TDD serving cell *c* with $T_{\text{SRS},1} > 2$ and for FDD serving cell *c*,

$(k_{\text{SRS}} - T_{offset,1}) \bmod 5 = 0$ for TDD serving cell *c* with $T_{\text{SRS},1} = 2$ where for FDD serving cell *c* $k_{\text{SRS}} = \{0,1,...,9\}$ is the subframe index within the frame n_f, for TDD serving cell *c*, if the UE is configured with the parameter *srs-UpPtsAdd* for trigger type 1, k_{SRS} is defined in Table 8.2-6; otherwise k_{SRS} is defined in Table 8.2-3.

A UE configured for type 1 triggered SRS transmission is not expected to receive type 1 SRS triggering events associated with different values of trigger type 1 SRS transmission parameters, as configured by higher layer signalling, for the same subframe and the same serving cell.

For a serving cell that is a LAA SCell, a UE configured for type 1 triggered SRS transmission is not expected to receive type 1 SRS triggering event in DCI format 0B associated with a subframe that is not scheduled for PUSCH transmission for the same serving cell.

A UE configured for type 1 triggered SRS transmission and more than one TDD serving cell without PUSCH/PUCCH transmission is not expected to receive type 1 SRS triggering events that can result in uplink transmissions beyond the UE's indicated uplink carrier aggregation capability included in the *UE-EUTRA-Capability* [12].

For TDD serving cell *c*, and a UE configured with *EIMTA-MainConfigServCell-r12* for a serving cell *c*, the UE shall not transmit SRS in a subframe of a radio frame that is indicated by the corresponding eIMTA-UL/DL-configuration as a downlink subframe.

A UE shall not transmit SRS whenever SRS and a PUSCH transmission corresponding to a Random Access Response Grant or a retransmission of the same transport block as part of the contention based random access procedure coincide in the same subframe.

Table 8.2-1: UE Specific SRS Periodicity T_{SRS} and Subframe Offset Configuration T_{offset} for trigger type 0, FDD

SRS Configuration Index I_{SRS}	SRS Periodicity T_{SRS} (ms)	SRS Subframe Offset T_{offset}
0 – 1	2	I_{SRS}
2 – 6	5	$I_{\text{SRS}} - 2$
7 – 16	10	$I_{\text{SRS}} - 7$
17 – 36	20	$I_{\text{SRS}} - 17$
37 – 76	40	$I_{\text{SRS}} - 37$
77 – 156	80	$I_{\text{SRS}} - 77$
157 – 316	160	$I_{\text{SRS}} - 157$
317 – 636	320	$I_{\text{SRS}} - 317$
637 – 1023	reserved	reserved

Table 8.2-2: UE Specific SRS Periodicity T_{SRS} and Subframe Offset Configuration T_{offset} for trigger type 0, TDD

SRS Configuration Index I_{SRS}	SRS Periodicity T_{SRS} (ms)	SRS Subframe Offset T_{offset}
0	2	0, 1
1	2	0, 2
2	2	1, 2
3	2	0, 3
4	2	1, 3
5	2	0, 4
6	2	1, 4
7	2	2, 3
8	2	2, 4
9	2	3, 4
10 – 14	5	I_{SRS} – 10
15 – 24	10	I_{SRS} – 15
25 – 44	20	I_{SRS} – 25
45 – 84	40	I_{SRS} – 45
85 – 164	80	I_{SRS} – 85
165 – 324	160	I_{SRS} – 165
325 – 644	320	I_{SRS} – 325
645 – 1023	reserved	reserved

Table 8.2-3: k_{SRS} for TDD

	subframe index *n*										
	0	1		2	3	4	5	6		7	8	9
		1st symbol of UpPTS	2nd symbol of UpPTS					1st symbol of UpPTS	2nd symbol of UpPTS			
k_{SRS} in case UpPTS length of 2 symbols		0	1	2	3	4		5	6	7	8	9
k_{SRS} in case UpPTS length of 1 symbol		1		2	3	4		6		7	8	9

Table 8.2-4: UE Specific SRS Periodicity $T_{SRS,1}$ and Subframe Offset Configuration $T_{offset,1}$ for trigger type 1, FDD

SRS Configuration Index I_{SRS}	SRS Periodicity $T_{SRS,1}$ (ms)	SRS Subframe Offset $T_{offset,1}$
0 – 1	2	I_{SRS}
2 – 6	5	I_{SRS} – 2
7 – 16	10	I_{SRS} – 7
17 – 31	reserved	reserved

Table 8.2-5: UE Specific SRS Periodicity $T_{\mathrm{SRS},1}$ and Subframe Offset Configuration $T_{offset,1}$ for trigger type 1, TDD

SRS Configuration Index I_{SRS}	SRS Periodicity $T_{\mathrm{SRS},1}$ (ms)	SRS Subframe Offset $T_{offset,1}$
0	reserved	reserved
1	2	0, 2
2	2	1, 2
3	2	0, 3
4	2	1, 3
5	2	0, 4
6	2	1, 4
7	2	2, 3
8	2	2, 4
9	2	3, 4
10 – 14	5	I_{SRS} – 10
15 – 24	10	I_{SRS} – 15
25 – 31	reserved	reserved

Table 8.2-6: k_{SRS} for TDD and UE configured with two or four additional SC-FDMA symbols in UpPTS

	subframe index *n*														
	0	1				2	3	4	5	6				7	8	9
		1st symbol of UpPTS	2nd symbol of UpPTS	3rd symbol of UpPTS	4th symbol of UpPTS					1st symbol of UpPTS	2nd symbol of UpPTS	3rd symbol of UpPTS	4th symbol of UpPTS			
k_{SRS} in case UpPTS length of 4 symbols		0	1	2	3					5	6	7	8			
k_{SRS} in case UpPTS length of 2 symbols		2	3							7	8					

8.3 UE HARQ-ACK procedure

For FDD, and serving cell with frame structure type 1, an HARQ-ACK received on the PHICH assigned to a UE in subframe *i* is associated with the PUSCH transmission in subframe *i*-4.

For FDD-TDD, and serving cell with frame structure type 1, and UE not configured to monitor PDCCH/EPDCCH in another serving cell with frame structure type 2 for scheduling the serving cell, an HARQ-ACK received on the PHICH assigned to a UE in subframe *i* is associated with the PUSCH transmission in subframe *i*-4.

For FDD-TDD, if a serving cell is a secondary cell with frame structure type 1 and if the UE is configured to monitor PDCCH/EPDCCH in another serving cell with frame structure type 2 for scheduling the serving cell, then an HARQ-ACK received on the PHICH assigned to a UE in subframe *i* is associated with PUSCH transmission on the serving cell in subframe *i*-6.

For TDD, if the UE is not configured with *EIMTA-MainConfigServCell-r12* for any serving cell and, if a UE is configured with one serving cell, or if the UE is configured with more than one serving cell and the TDD UL/DL configuration of all the configured serving cells is the same,

- For frame structure type 2 UL/DL configuration 1-6, an HARQ-ACK received on the PHICH assigned to a UE in subframe *i* is associated with the PUSCH transmission in the subframe *i-k* as indicated by the following Table 8.3-1 if the UE is not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, otherwise as indicated by the following Table 8.3-2.

- For frame structure type 2 UL/DL configuration 0, an HARQ-ACK received on the PHICH in the resource corresponding to $I_{PHICH} = 0$, as defined in Subclause 9.1.2, assigned to a UE in subframe *i* is associated with the PUSCH transmission in the subframe *i-k* as indicated by the following Table 8.3-1 if the UE is not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, otherwise as indicated by the following Table 8.3-2. For frame structure type 2 UL/DL configuration 0, an HARQ-ACK received on the PHICH in the resource corresponding to $I_{PHICH} = 1$, as defined in Subclause 9.1.2, assigned to a UE in subframe *i* is associated with the PUSCH transmission in the subframe *i*-6.

For TDD, if a UE is configured with more than one serving cell and the TDD UL/DL configuration of at least two configured serving cells is not the same, or if the UE is configured with *EIMTA-MainConfigServCell-r12* for at least one serving cell, or FDD-TDD and serving cell is frame structure type 2,

- For serving cell with an UL-reference UL/DL configuration (defined in Subclause 8.0) belonging to {1,2,3,4,5,6}, an HARQ-ACK received on the PHICH assigned to a UE in subframe *i* is associated with the PUSCH transmission in the subframe *i-k* for the serving cell as indicated by the following Table 8.3-1 if the UE is not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, otherwise as indicated by the following Table 8.3-2, where "TDD UL/DL Configuration" in Table 8.3-1 and Table 8.3-2 refers to the UL-reference UL/DL Configuration.

- For a serving cell with UL-reference UL/DL configuration 0 (defined in Subclause 8.0), an HARQ-ACK received on the PHICH in the resource corresponding to $I_{PHICH} = 0$, as defined in Subclause 9.1.2, assigned to a UE in subframe *i* is associated with the PUSCH transmission in the subframe *i-k* for the serving cell as indicated by the following Table 8.3-1 if the UE is not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, otherwise as indicated by the following Table 8.3-2, where "TDD UL/DL Configuration" in Table 8.3-1 and Table 8.3-2 refers to the UL-reference UL/DL configuration. For a serving cell with UL-reference UL/DL configuration 0, an HARQ-ACK received on the PHICH in the resource corresponding to $I_{PHICH} = 1$, as defined in Subclause 9.1.2, assigned to a UE in subframe *i* is associated with the PUSCH transmission in the subframe *i*-6 for the serving cell.

- For FDD-TDD, if a serving cell is a secondary cell with UL-reference UL/DL configuration 0 and if the UE is configured to monitor PDCCH/EPDCCH in another serving cell with frame structure type 1 for scheduling the serving cell, for downlink subframe *i*, if a transport block was transmitted in the associated PUSCH subframe *i*-6 for the serving cell then PHICH resource corresponding to that transport block is not present in subframe *i*.

For a BL/CE UE, the UE is not expected to receive PHICH corresponding to a transport block.

If a UE is configured with a LAA SCell for UL transmissions, the UE is not expected to receive PHICH corresponding to a transport block on the LAA SCell.

Table 8.3-1: *k* for TDD configurations 0-6

TDD UL/DL Configuration	subframe number *i*									
	0	1	2	3	4	5	6	7	8	9
0	7	4				7	4			
1		4			6		4			6
2				6					6	
3	6								6	6
4									6	6
5									6	
6	6	4				7	4			6

Table 8.3-2: *k* for TDD configurations 0-6 and UE configured with *symPUSCH-UpPts-r14*

TDD UL/DL Configuration	subframe number *i*									
	0	1	2	3	4	5	6	7	8	9
0	7	5,4				7	5,4			
1		5,4			6		5,4			6
2				7,6					7,6	
3	6								7,6	6
4									7,6	6
5									7,6	
6	6,4	4				7,4	4			6

For a non-BL/CE UE, the physical layer in the UE shall deliver indications to the higher layers as follows:

For FDD, and for TDD with a UE configured with one serving cell, and for TDD with a UE configured with more than one serving cell and with TDD UL/DL configuration of all configured serving cells the same, and UE is not configured with *EIMTA-MainConfigServCell-r12* for any serving cell, for downlink or special subframe *i*, if a transport block was transmitted in the associated PUSCH subframe then:

if ACK is decoded on the PHICH corresponding to that transport block in subframe *i*, or if that transport block is disabled by PDCCH/EPDCCH received in downlink or special subframe *i*, ACK for that transport block shall be delivered to the higher layers; else NACK for that transport block shall be delivered to the higher layers.

For TDD, if the UE is configured with more than one serving cell, and if at least two serving cells have different UL/DL configurations, or the UE is configured with *EIMTA-MainConfigServCell-r12* for at least one serving cell, or for FDD-TDD, for downlink or special subframe *i*, if a transport block was transmitted in the associated PUSCH subframe then:

if ACK is decoded on the PHICH corresponding to that transport block in subframe *i*, or if that transport block is disabled by PDCCH/EPDCCH received in downlink or special subframe *i*, ACK for that transport block shall be delivered to the higher layers; or

if a PHICH resource corresponding to that transport block is not present in subframe *i* or if UE is not expected to receive PHICH corresponding to that transport block in subframe *i*, ACK for that transport block shall be delivered to the higher layers.

else NACK for that transport block shall be delivered to the higher layers.

8.4 UE PUSCH hopping procedure

The UE shall perform PUSCH frequency hopping if the single bit Frequency Hopping (FH) field in a corresponding PDCCH/EPDCCH with DCI format 0 is set to 1 and the uplink resource block assignment is type 0 otherwise no PUSCH frequency hopping is performed.

A UE performing PUSCH frequency hopping shall determine its PUSCH Resource Allocation (RA) for the first slot of a subframe (*S1*) including the lowest index PRB ($n_{PRB}^{S1}(n)$) in subframe *n* from the resource allocation field in the latest PDCCH/EPDCCH with DCI format 0 for the same transport block. If there is no PDCCH/EPDCCH for the same transport block, the UE shall determine its hopping type based on

- the hopping information in the most recent semi-persistent scheduling assignment PDCCH/EPDCCH, when the initial PUSCH for the same transport block is semi-persistently scheduled or
- the random access response grant for the same transport block, when the PUSCH is initiated by the random access response grant.

The resource allocation field in DCI format 0 excludes either 1 or 2 bits used for hopping information as indicated by Table 8.4-1 below where the number of PUSCH resource blocks is defined as

$$N_{RB}^{PUSCH} = \begin{cases} N_{RB}^{UL} - \tilde{N}_{RB}^{HO} - \left(N_{RB}^{UL} \bmod 2\right) & \text{Type 1 PUSCH hopping} \\ N_{RB}^{UL} & \text{Type 2 } \mathrm{N_{sb}} = 1 \text{ PUSCH hopping} \\ N_{RB}^{UL} - \tilde{N}_{RB}^{HO} & \text{Type 2 } \mathrm{N_{sb}} > 1 \text{ PUSCH hopping} \end{cases}$$

For type 1 and type 2 PUSCH hopping, $\tilde{N}_{\mathrm{RB}}^{\mathrm{HO}} = N_{\mathrm{RB}}^{\mathrm{HO}} + 1$ if $N_{\mathrm{RB}}^{\mathrm{HO}}$ is an odd number where $N_{\mathrm{RB}}^{\mathrm{HO}}$ defined in [3]. $\tilde{N}_{\mathrm{RB}}^{\mathrm{HO}} = N_{\mathrm{RB}}^{\mathrm{HO}}$ in other cases. The size of the resource allocation field in DCI format 0 after excluding either 1 or 2 bits shall be $y = \left\lceil \log_2(N_{\mathrm{RB}}^{\mathrm{UL}}(N_{\mathrm{RB}}^{\mathrm{UL}}+1)/2) \right\rceil - N_{UL\_hop}$, where N_{UL_hop} = 1 or 2 bits. The number of contiguous RBs that can be assigned to a type-1 hopping user is limited to $\lfloor 2^y / N_{\mathrm{RB}}^{\mathrm{UL}} \rfloor$. The number of contiguous RBs that can be assigned to a type-2 hopping user is limited to $\min\left(\lfloor 2^y / N_{\mathrm{RB}}^{\mathrm{UL}} \rfloor, \lfloor N_{\mathrm{RB}}^{\mathrm{PUSCH}} / N_{sb} \rfloor\right)$, where the number of sub-bands N_{sb} is given by higher layers.

A UE performing PUSCH frequency hopping shall use one of two possible PUSCH frequency hopping types based on the hopping information. PUSCH hopping type 1 is described in Subclause 8.4.1 and type 2 is described in Subclause 8.4.2.

Table 8.4-1: Number of Hopping Bits N_{UL_hop} vs. System Bandwidth

System BW N_{RB}^{UL}	#Hopping bits for 2nd slot RA (N_{UL_hop})
6-49	1
50-110	2

The parameter *Hopping-mode* provided by higher layers determines if PUSCH frequency hopping is "inter-subframe" or "intra and inter-subframe".

8.4.1 Type 1 PUSCH hopping

For PUSCH hopping type 1 the hopping bit or bits indicated in Table 8.4-1 determine $\tilde{n}_{PRB}(i)$ as defined in Table 8.4-2. The lowest index PRB ($n_{PRB}^{S1}(i)$) of the 1st slot RA in subframe *i* is defined as $n_{PRB}^{S1}(i) = \tilde{n}_{PRB}^{S1}(i) + \tilde{N}_{\mathrm{RB}}^{\mathrm{HO}} / 2$, where $n_{PRB}^{S1}(i) = RB_{START}$, and RB_{START} is obtained from the uplink scheduling grant as in Subclause 8.4 and Subclause 8.1.

The lowest index PRB ($n_{PRB}(i)$) of the 2nd slot RA in subframe *i* is defined as $n_{PRB}(i) = \tilde{n}_{PRB}(i) + \tilde{N}_{\mathrm{RB}}^{\mathrm{HO}} / 2$.

The set of physical resource blocks to be used for PUSCH transmission are L_{CRBs} contiguously allocated resource blocks from PRB index $n_{PRB}^{S1}(i)$ for the 1st slot, and from PRB index $n_{PRB}(i)$ for the 2nd slot, respectively, where L_{CRBs} is obtained from the uplink scheduling grant as in Subclause 8.4 and Subclause 8.1.

If the *Hopping-mode* is "inter-subframe", the 1st slot RA is applied to even CURRENT_TX_NB, and the 2nd slot RA is applied to odd CURRENT_TX_NB, where CURRENT_TX_NB is defined in [8].

8.4.2 Type 2 PUSCH hopping

In PUSCH hopping type 2 the set of physical resource blocks to be used for transmission in slot n_{s} is given by the scheduling grant together with a predefined pattern according to [3] Subclause 5.3.4.
If the system frame number is not acquired by the UE yet, the UE shall not transmit PUSCH with type-2 hopping and $N_{sb} > 1$ for TDD, where N_{sb} is defined in [3].

Table 8.4-2: PDCCH/EPDCCH DCI format 0 hopping bit definition

System BW N_{RB}^{UL}	Number of Hopping bits	Information in hopping bits	$\tilde{n}_{PRB}(i)$
6 – 49	1	0	$\left(\left\lfloor N_{RB}^{PUSCH} / 2 \right\rfloor + \tilde{n}_{PRB}^{S1}(i)\right) \bmod N_{RB}^{PUSCH}$,
		1	Type 2 PUSCH Hopping
50 – 110	2	00	$\left(\left\lfloor N_{RB}^{PUSCH} / 4 \right\rfloor + \tilde{n}_{PRB}^{S1}(i)\right) \bmod N_{RB}^{PUSCH}$
		01	$\left(-\left\lfloor N_{RB}^{PUSCH} / 4 \right\rfloor + \tilde{n}_{PRB}^{S1}(i)\right) \bmod N_{RB}^{PUSCH}$
		10	$\left(\left\lfloor N_{RB}^{PUSCH} / 2 \right\rfloor + \tilde{n}_{PRB}^{S1}(i)\right) \bmod N_{RB}^{PUSCH}$
		11	Type 2 PUSCH Hopping

8.5 UE Reference Symbol (RS) procedure

If UL sequence-group hopping or sequence hopping is configured in a serving cell, it applies to all Reference Symbols (SRS, PUSCH and PUCCH RS). If disabling of the sequence-group hopping and sequence hopping is configured for the UE in the serving cell through the higher-layer parameter *Disable-sequence-group-hopping*, the sequence-group hopping and sequence hopping for PUSCH RS are disabled.

8.6 Modulation order, redundancy version and transport block size determination

To determine the modulation order, redundancy version and transport block size for the physical uplink shared channel, the UE shall first

- for a cell that is not a LAA SCell, read the "modulation and coding scheme and redundancy version" field (I_{MCS}) if the UE is a non-BL/CE UEs and read the "modulation and coding scheme" field (I_{MCS}) if the UE is a BL/CE UE, and
- for a cell that is a LAA SCell, read the "modulation and coding scheme " field (I_{MCS}) and "redundancy version" field (*rv*), and
- check the "CSI request" bit field, and
- compute the total number of allocated PRBs (N_{PRB}) based on the procedure defined in Subclause 8.1, and
- compute the number of coded symbols for control information.

8.6.1 Modulation order and redundancy version determination

For a non-BL/CE UE and for $0 \le I_{\text{MCS}} \le 28$, the modulation order (Q_m) is determined as follows, where $Q_m = Q_m'$ unless specified otherwise:

- If the UE is capable of supporting 64QAM in PUSCH and is not capable of supporting 256QAM in PUSCH and has not been configured by higher layers to transmit only QPSK and 16QAM, the modulation order is given by Q_m' in Table 8.6.1-1.
- If the UE is capable of supporting 256QAM in PUSCH, and has not been configured by higher layers to transmit only QPSK and 16QAM and has not been configured with higher layer parameter *Enable256QAM*, the modulation order is given by Q_m' in Table 8.6.1-1.
- If the UE is capable of supporting 256QAM in PUSCH and configured with higher layer parameter *Enable256QAM*, the modulation order is given by Q_m' in Table 8.6.1-3,
  - if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet1-DCI-Format0=TRUE*, the associated DCI is of format 0/0A/0B mapped onto the UE specific search space and with CRC scrambled by the C-RNTI, and the subframe of the PUSCH belongs to uplink power control subframe set 1, or,
  - if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet1-DCI-Format4=TRUE*, the associated DCI is of format 4/4A/4B mapped onto the UE specific search space and with CRC scrambled by the C-RNTI, and the subframe of the PUSCH belongs to uplink power control subframe set 1, or,
  - if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet2-DCI-Format0=TRUE*, the associated DCI is of format 0/0A/0B mapped onto the UE specific search space and with CRC scrambled by the C-RNTI, and the subframe of the PUSCH belongs to uplink power control subframe set 2, or,
  - if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet2-DCI-Format4=TRUE*, the associated DCI is of format 4/4A/4B mapped onto the UE specific search space and with CRC scrambled by the C-RNTI, and the subframe of the PUSCH belongs to uplink power control subframe set 2, or,
  - if higher layer parameter *tpc-SubframeSet* is not configured, higher layer parameter *dci-Format0=TRUE*, and the associated DCI is of format 0/0A/0B mapped onto the UE specific search space and with CRC scrambled by the C-RNTI, or,

- if higher layer parameter *tpc-SubframeSet* is not configured, higher layer parameter *dci-Format4=TRUE*, and the associated DCI is of format 4/4A/4B mapped onto the UE specific search space and with CRC scrambled by the C-RNTI,

- otherwise, the modulation order is given by Q'_m in Table 8.6.1-1.

- If the UE is not capable of supporting 64QAM in PUSCH or has been configured by higher layers to transmit only QPSK and 16QAM, Q'_m is first read from Table 8.6.1-1. The modulation order is set to $Q'_m = \min(4, Q'_m)$.

- If the parameter *ttiBundling* provided by higher layers is set to *TRUE*, then the modulation order is set to $Q_m = 2$. Resource allocation size is restricted to $N_{\text{PRB}} \le 3$ applies in this case if the UE does not indicate support by higher layers to operate without it.

- If the UE is configured with higher layer parameter *pusch-EnhancementsConfig*, and if the PDCCH corresponding to the PUSCH transmission is located in UE specific search space, then Q'_m is first obtained according to the procedure above. The modulation order (Q_m) is determined as follows.

  - If the uplink DCI modulation override bit is set to zero, or if Q'_m =2

    - then $Q_m = Q'_m$

  - otherwise

    - if Q'_m =8 then Q_m = 6,

    - if Q'_m =6 then Q_m = 4,

    - if Q'_m =4 then Q_m = 2.

For a non-BL/CE UE and for $29 \le I_{\text{MCS}} \le 31$ the modulation order (Q_m) is determined as follows:

- if DCI format 0/0A/0B is used and $I_{\text{MCS}} = 29$ and N =1 (determined by the procedure in Subclause 8.0) or, if DCI format 4 is used and only 1 TB is enabled and $I_{\text{MCS}} = 29$ for the enabled TB and the signalled number of transmission layers is 1 or if DCI format 4A/4B is used and $I_{\text{MCS}} = 29$ for both TBs and N =1 (determined by the procedure in Subclause 8.0), and if

  - the "CSI request" bit field is 1 bit and the bit is set to trigger an aperiodic report and, $N_{\text{PRB}} \le 4$ or,

  - the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for one serving cell according to Table 7.2.1-1A, and, $N_{\text{PRB}} \le 4$ or,

  - the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for more than one serving cell according to Table 7.2.1-1A and, $N_{\text{PRB}} \le 20$ or,

  - the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for one CSI process according to Table 7.2.1-1B and $N_{\text{PRB}} \le 4$ or,

  - the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for more than one CSI process according to Table 7.2.1-1B and $N_{\text{PRB}} \le 20$ or,

  - the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for one CSI process or {CSI process, CSI subframe set}-pair according to Table 7.2.1-1C and $N_{\text{PRB}} \le 4$ or,

- the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for more than one CSI process and/or {CSI process, CSI subframe set}-pair according to Table 7.2.1-1C and $N_{\mathrm{PRB}} \le 20$, or
- the "CSI request" bit field is 3 bits and is triggering an aperiodic CSI report for one CSI process according to Table 7.2.1-1D or Table 7.2.1-1E or Table 7.2.1-1F or Table 7.2.1-1G and $N_{\mathrm{PRB}} \le 4$, or
- the "CSI request" bit field is 3 bits and is triggering an aperiodic CSI report for 2 to 5 CSI processes according to Table 7.2.1-1D or Table 7.2.1-1E or Table 7.2.1-1F or Table 7.2.1-1G and $N_{\mathrm{PRB}} \le 20$, or
- the "CSI request" bit field is 3 bits and is triggering an aperiodic CSI report for more than 5 CSI processes according to Table 7.2.1-1D or Table 7.2.1-1E or Table 7.2.1-1F or Table 7.2.1-1G, or
- the "CSI request" bit field in DCI format 0A/0B/4A/4B is set to trigger an aperiodic CSI report, or
- the "CSI request" bit field is 4 bits and is triggering an aperiodic CSI report for one CSI process according to Table 7.2.1-1H or Table 7.2.1-1I and $N_{\mathrm{PRB}} \le 4$, or
- the "CSI request" bit field is 4 bits and is triggering an aperiodic CSI report for 2 to 5 CSI processes according to Table 7.2.1-1H or Table 7.2.1-1I and $N_{\mathrm{PRB}} \le 20$, or
- the "CSI request" bit field is 4 bits and is triggering an aperiodic CSI report for more than 5 CSI processes according to Table 7.2.1-1H or Table 7.2.1-1I, or
- the "CSI request" bit field is 5 bits and is triggering an aperiodic CSI report for one CSI process according to Table 7.2.1-1J or Table 7.2.1-1K and $N_{\mathrm{PRB}} \le 4$, or
- the "CSI request" bit field is 5 bits and is triggering an aperiodic CSI report for 2 to 5 CSI processes according to Table 7.2.1-1J or Table 7.2.1-1K and $N_{\mathrm{PRB}} \le 20$, or
- the "CSI request" bit field is 5 bits and is triggering an aperiodic CSI report for more than 5 CSI processes according to Table 7.2.1-1J or Table 7.2.1-1K, or
- the "CSI request" bit field in DCI is set to trigger an aperiodic CSI report and UE is configured with higher layer parameter *advancedCodebookEnabled*,

then the modulation order is set to $Q_m = 2$.

- Otherwise,
  - For a cell that is not a LAA SCell, the modulation order shall be determined from the DCI transported in the latest PDCCH/EPDCCH with DCI format 0/4 for the same transport block using $0 \le I_{\mathrm{MCS}} \le 28$. If there is no PDCCH/EPDCCH with DCI format 0/4 for the same transport block using $0 \le I_{\mathrm{MCS}} \le 28$, the modulation order shall be determined from
    - the most recent semi-persistent scheduling assignment PDCCH/EPDCCH, when the initial PUSCH for the same transport block is semi-persistently scheduled, or,
    - the random access response grant for the same transport block, when the PUSCH is initiated by the random access response grant.

For a cell that is not a LAA SCell, and a non-BL/CE UE,

- if the UE is configured with higher layer parameter *enable256QAM*, and if the PDCCH corresponding to the PUSCH transmission is located in UE specific search space with CRC scrambled by the C-RNTI, the UE shall use I_{MCS} and Table 8.6.1-3 to determine the redundancy version (rv_{idx}) to use in the physical uplink shared channel,
  - if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet1-DCI-Format0=TRUE*, the associated DCI is of format 0/0A/0B, and the subframe of the PUSCH belongs to uplink power control subframe set 1, or,

- if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet1-DCI-Format4=TRUE*, the associated DCI is of format 4/4A/4B, and the subframe of the PUSCH belongs to uplink power control subframe set 1, or,
- if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet2-DCI-Format0=TRUE*, the associated DCI is of format 0/0A/0B, and the subframe of the PUSCH belongs to uplink power control subframe set 2, or,
- if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet2-DCI-Format4=TRUE*, the associated DCI is of format 4/4A/4B, and the subframe of the PUSCH belongs to uplink power control subframe set 2, or,
- if higher layer parameter *tpc-SubframeSet* is not configured, higher layer parameter *dci-Format0=TRUE*, and the associated DCI is of format 0/0A/0B, or,
- if higher layer parameter *tpc-SubframeSet* is not configured, higher layer parameter *dci-Format4=TRUE*, and the associated DCI is of format 4/4A/4B;

- otherwise, the UE shall use I_{MCS} and Table 8.6.1-1 to determine the redundancy version (rv_{idx}) to use in the physical uplink shared channel.

For a LAA SCell and DCI format 0A/4A, the redundancy version (rv_{idx}) to use in the physical uplink shared channel is given by $rv_{\mathrm{idx}} = rv$.

For a LAA SCell and DCI format 0B/4B, the redundancy version (rv_{idx}) to use in the physical uplink shared channel is given by $rv_{\mathrm{idx}} = 2 \cdot rv$.

Table 8.6.1-1: Modulation, TBS index and redundancy version table for PUSCH

MCS Index I_{MCS}	Modulation Order Q'_m	TBS Index I_{TBS}	Redundancy Version rv_{idx}
0	2	0	0
1	2	1	0
2	2	2	0
3	2	3	0
4	2	4	0
5	2	5	0
6	2	6	0
7	2	7	0
8	2	8	0
9	2	9	0
10	2	10	0
11	4	10	0
12	4	11	0
13	4	12	0
14	4	13	0
15	4	14	0
16	4	15	0
17	4	16	0
18	4	17	0
19	4	18	0
20	4	19	0
21	6	19	0
22	6	20	0
23	6	21	0
24	6	22	0
25	6	23	0
26	6	24	0
27	6	25	0
28	6	26	0
29	reserved		1
30			2
31			3

For a BL/CE UE

- if the UE is configured with CEModeA, and higher layer parameter *ce-pusch-nb-maxTbs-config* configured with value '*On*', and if the MPDCCH corresponding to the PUSCH transmission is located in UE-specific search space, the modulation order is determined according to table 8.6.1-2A.
- if the UE is configured with higher layer parameter *ce-pdsch-puschEnhancement-config* with value 'On', and if the *Modulation order override* field in the DCI is set to 1, the modulation order is set to $Q_m = 2$
- otherwise, the modulation order is determined according to table 8.6.1-2.

A BL/CE UE configured with CEModeB is not expected to receive a DCI format 6-0B indicating $I_{\text{MCS}} > 10$.

For BL/CE UEs or for UEs configured with higher layer parameter *PUSCH-EnhancementsConfig*, the same redundancy version is applied to PUSCH transmitted in a given block of N_{acc} consecutive subframes. The subframe number of the first subframe in each block of N_{acc} consecutive subframes, denoted as $n_{\text{abs},1}$, satisfies $n_{\text{abs},1} \bmod N_{\text{acc}} = 0$. Denote i_0 as the subframe number of the first uplink subframe intended for PUSCH. For BL/CE UEs, the PUSCH transmission spans $N_{\text{abs}}^{\text{PUSCH}}$ consecutive subframes including non-BL/CE subframes where the PUSCH transmission is postponed. For the j^{th} block of N_{acc} consecutive subframes within the set of $N_{\text{abs}}^{\text{PUSCH}}$ subframes, the redundancy version (rv_{idx}) is determined according to Table 7.1.7.1-2 using $rv = \left(j + rv_{DCI}\right) \bmod 4$, where $j = 0,1,\ldots, J^{\text{PUSCH}} - 1$, and $J^{\text{PUSCH}} = \left\lceil \dfrac{N_{\text{abs}}^{\text{PUSCH}} + (i_0 \bmod N_{acc})}{N_{\text{acc}}} \right\rceil$. The J^{PUSCH} blocks of subframes are sequential in time, starting with $j = 0$ to which subframe i_0 belongs. For a BL/CE UE configured in CEModeA or a UE configured with higher layer parameter *PUSCH-EnhancementsConfig*, $N_{\text{acc}} = 1$ and rv_{DCI} is determined by the 'Redundancy version' field in DCI format 6-0A. For a BL/CE UE configured with CEModeB, $N_{\text{acc}} = 4$ for FDD and $N_{\text{acc}} = 5$ for TDD, and $rv_{DCI} = 0$. For UEs configured with higher layer parameter *PUSCH-EnhancementsConfig*, $N_{abs}^{PUSCH} = N_{rep}^{PUSCH}$.

Table 8.6.1-2: Modulation and TBS index table for PUSCH

MCS Index I_{MCS}	Modulation Order Q_m	TBS Index I_{TBS}
0	2	0
1	2	1
2	2	2
3	2	3
4	2	4
5	2	5
6	2	6
7	2	7
8	2	8
9	2	9
10	2	10
11	4	10
12	4	11
13	4	12
14	4	13
15	4	14

Table 8.6.1-2A: Modulation and TBS index table for PUSCH

MCS Index I_{MCS}	Modulation Order Q_m	TBS Index I_{TBS}
0	2	0
1	2	2
2	2	4
3	2	5
4	2	6
5	2	8
6	2	10
7	4	10
8	4	12
9	4	14
10	4	16
11	4	17
12	4	18
13	4	19
14	4	20
15	4	21

Table 8.6.1-3: Modulation, TBS index and redundancy version table for PUSCH

MCS Index I_{MCS}	Modulation Order Q'_m	TBS Index I_{TBS}	Redundancy Version rv_{idx}
0	2	0	0
1	2	2	0
2	2	4	0
3	2	6	0
4	2	8	0
5	2	10	0
6	4	11	0
7	4	12	0
8	4	13	0
9	4	14	0
10	4	16	0
11	4	17	0
12	4	18	0
13	4	19	0
14	6	20	0
15	6	21	0
16	6	22	0
17	6	23	0
18	6	24	0
19	6	25	0
20	6	27	0
21	6	28	0
22	6	29	0
23	8	30	0
24	8	31	0
25	8	32	0
26	8	32A	0
27	8	33	0
28	8	34	0
29	reserved		1
30			2
31			3

Table 8.6.1-4: Void

8.6.2 Transport block size determination

For a non-BL/CE UE and for $0 \le I_{MCS} \le 28$, the UE shall first determine the TBS index (I_{TBS}) using I_{MCS} except if the transport block is disabled in DCI format 4/4A/4B as specified below. For a transport block that is not mapped to two-layer spatial multiplexing, the TBS is determined by the procedure in Subclause 7.1.7.2.1. For a transport block that is mapped to two-layer spatial multiplexing, the TBS is determined by the procedure in Subclause 7.1.7.2.2.

The UE shall determine the TBS index (I_{TBS}) using I_{MCS} and Table 8.6.1-3, if the UE is configured with higher layer parameter *enable256QAM*, and if the PDCCH corresponding to the PUSCH transmission is located in UE specific search space with CRC scrambled by the C-RNTI, and

- if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet1-DCI-Format0=TRUE*, the associated DCI is of format 0/0A/0B, and the subframe of the PUSCH belongs to uplink power control subframe set 1, or,
- if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet1-DCI-Format4=TRUE*, the associated DCI is of format 4/4A/4B, and the subframe of the PUSCH belongs to uplink power control subframe set 1, or,
- if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet2-DCI-Format0=TRUE*, the associated DCI is of format 0/0A/0B, and the subframe of the PUSCH belongs to uplink power control subframe set 2, or,
- if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet2-DCI-Format4=TRUE*, the associated DCI is of format 4/4A/4B, and the subframe of the PUSCH belongs to uplink power control subframe set 2, or,
- if higher layer parameter *tpc-SubframeSet* is not configured, higher layer parameter *dci-Format0=TRUE*, and the associated DCI is of format 0/0A/0B, or,
- if higher layer parameter *tpc-SubframeSet* is not configured, higher layer parameter *dci-Format4=TRUE*, and the associated DCI is of format 4/4A/4B;

otherwise, the UE shall determine the TBS index (I_{TBS}) using I_{MCS} and Table 8.6.1-1.

If the UE is configured with higher layer parameter *symPUSCH-UpPts-r14*, *ttiBundling=FALSE*, and the transport block is transmitted in UpPTS of the special subframe in frame structure type 2, then

- for special subframe configuration with up to 3 UpPTS SC-FDMA data symbols:
  - set the Table 7.1.7.2.1-1 column indicator to $\max\{\lfloor N_{PRB} \times 0.125 \rfloor, 1\}$ instead of N_{PRB}
- otherwise:
  - set the Table 7.1.7.2.1-1 column indicator to $\max\{\lfloor N_{PRB} \times 0.375 \rfloor, 1\}$ instead of N_{PRB}.

For a non-BL/CE UE and for $29 \le I_{MCS} \le 31$,

- if DCI format 0/0A/0B is used and $I_{MCS} = 29$ and N =1 (determined by the procedure in Subclause 8.0) or, if DCI format 4 is used and only 1 TB is enabled and $I_{MCS} = 29$ for the enabled TB and the number of transmission layers is 1 or if DCI format 4A/4B is used and $I_{MCS} = 29$ for both TBs and N =1 (determined by the procedure in Subclause 8.0), and if
  - the "CSI request" bit field is 1 bit and is set to trigger an aperiodic CSI report and $N_{PRB} \le 4$ or,
  - the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for one serving cell according to Table 7.2.1-1A, and , $N_{PRB} \le 4$ or,

- the "CSI request" bit field is 2 bits and is triggering aperiodic CSI report for more than one serving cell according to Table 7.2.1-1A and, $N_{PRB} \le 20$ or,
- the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for one CSI process according to Table 7.2.1-1B and $N_{PRB} \le 4$ or,
- the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for more than one CSI process according to Table 7.2.1-1B and, $N_{PRB} \le 20$ or,
- the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for one CSI process or {CSI process, CSI subframe set}-pair according to Table 7.2.1-1C and $N_{PRB} \le 4$ or,
- the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for more than one CSI process and/or {CSI process, CSI subframe set}-pair according to Table 7.2.1-1C and $N_{PRB} \le 20$, or
- the "CSI request" bit field is 3 bits and is triggering an aperiodic CSI report for one CSI process according to Table 7.2.1-1D or Table 7.2.1-1E or Table 7.2.1-1F or Table 7.2.1-1G and $N_{PRB} \le 4$, or
- the "CSI request" bit field is 3 bits and is triggering an aperiodic CSI report for 2 to 5 CSI processes according to Table 7.2.1-1D or Table 7.2.1-1E or Table 7.2.1-1F or Table 7.2.1-1G and $N_{PRB} \le 20$, or
- the "CSI request" bit field is 3 bits and is triggering an aperiodic CSI report for more than 5 CSI processes according to Table 7.2.1-1D or Table 7.2.1-1E or Table 7.2.1-1F or Table 7.2.1-1G, or
- the "CSI request" bit field in DCI format 0A/0B/4A/4B is set to trigger an aperiodic CSI report, or
- the "CSI request" bit field is 4 bits and is triggering an aperiodic CSI report for one CSI process according to Table 7.2.1-1H or Table 7.2.1-1I and $N_{PRB} \le 4$, or
- the "CSI request" bit field is 4 bits and is triggering an aperiodic CSI report for 2 to 5 CSI processes according to Table 7.2.1-1H or Table 7.2.1-1I and $N_{PRB} \le 20$, or
- the "CSI request" bit field is 4 bits and is triggering an aperiodic CSI report for more than 5 CSI processes according to Table 7.2.1-1H or Table 7.2.1-1I, or
- the "CSI request" bit field is 5 bits and is triggering an aperiodic CSI report for one CSI process according to Table 7.2.1-1J or Table 7.2.1-1K and $N_{PRB} \le 4$, or
- the "CSI request" bit field is 5 bits and is triggering an aperiodic CSI report for 2 to 5 CSI processes according to Table 7.2.1-1J or Table 7.2.1-1K and $N_{PRB} \le 20$, or
- the "CSI request" bit field is 5 bits and is triggering an aperiodic CSI report for more than 5 CSI processes according to Table 7.2.1-1J or Table 7.2.1-1K, or
- the "CSI request" bit field in DCI is set to trigger an aperiodic CSI report and UE is configured with higher layer parameter *advancedCodebookEnabled*,

then there is no transport block for the UL-SCH and only the control information feedback for the current PUSCH reporting mode is transmitted by the UE.

- Otherwise, the transport block size shall be determined from the initial PDCCH/EPDCCH for the same transport block using $0 \le I_{MCS} \le 28$. If there is no initial PDCCH/EPDCCH with an uplink DCI format for the same transport block using $0 \le I_{MCS} \le 28$, the transport block size shall be determined from
  - the most recent semi-persistent scheduling assignment PDCCH/EPDCCH, when the initial PUSCH for the same transport block is semi-persistently scheduled, or,

- the random access response grant for the same transport block, when the PUSCH is initiated by the random access response grant.

In DCI format 4 a transport block is disabled if either the combination of $I_{\mathrm{MCS}} = 0$ and $N_{\mathrm{PRB}} > 1$ or the combination of $I_{\mathrm{MCS}} = 28$ and $N_{\mathrm{PRB}} = 1$ is signalled, otherwise the transport block is enabled.

In DCI formats 4A/4B a transport block is disabled if $I_{\mathrm{MCS}} = 29$ and otherwise the transport block is enabled.

If DCI format 4B is used and $I_{\mathrm{MCS}} = 29$ for both TBs, UE is not expected to receive the value of $N > 1$ as determined by the procedure in Subclause 8.0.

If DCI format 0B is used and $I_{\mathrm{MCS}} = 29$, UE is not expected to receive the value of $N > 1$ as determined by the procedure in Subclause 8.0.

For a BL/CE UE configured with CEModeA and a PUSCH transmission not scheduled by the Random Access Response Grant,

- if the UE is configured with higher layer parameter *ce-pusch-nb-maxTbs-config* with value '*On*', and if the MPDCCH corresponding to the PUSCH transmission is located in UE-specific search space, the UE shall first determine the TBS index (I_{TBS}) using I_{MCS} and Table 8.6.1-2A;

- otherwise, the UE shall first determine the TBS index (I_{TBS}) using I_{MCS} and Table 8.6.1-2.

For a BL/CE UE configured with CEModeA,

- if the UE is configured with higher layer parameter *ce-pusch-maxBandwidth-config* with value 5MHz, the TBS is determined by the procedure in Subclause 7.1.7.2.1, for $0 \le I_{\mathrm{TBS}} \le 14$

- otherwise, the TBS is determined by the procedure in Subclause 7.1.7.2.1.

For a BL/CE UE configured with CEModeA and a PUSCH transmission scheduled by the Random Access Response Grant, the UE shall determine the TBS index by the procedure in Subclause 6.2.

For a BL/CE UE configured with CEModeB, the TBS is determined according to the procedure in Subclause 7.1.7.2.1 for $0 \le I_{\mathrm{TBS}} \le 10$, and N_{PRB} =6 when resource allocation field is '110' or '111' otherwise N_{PRB} = 3.

8.6.3 Control information MCS offset determination

Offset values are defined for single codeword PUSCH transmission and multiple codeword PUSCH transmission. Single codeword PUSCH transmission offsets $\beta_{offset}^{HARQ-ACK}$, β_{offset}^{RI} and β_{offset}^{CQI} shall be configured to values according to Table 8.6.3-1,2,3 with the higher layer signalled indexes $I_{offset}^{HARQ-ACK}$ if the UE transmits no more than 22 HARQ-ACK bits on a PUSCH or if $I_{offset,X}^{HARQ-ACK}$ is not configured, I_{offset}^{RI}, and I_{offset}^{CQI}, respectively. Single codeword PUSCH transmission offset $\beta_{offset}^{HARQ-ACK}$ shall be configured to values according to [Table 8.6.3-1] with the higher layer signalled index $I_{offset,X}^{HARQ-ACK}$ if the UE transmits more than 22 HARQ-ACK bits on a PUSCH and $I_{offset,X}^{HARQ-ACK}$ is configured. Multiple codeword PUSCH transmission offsets $\beta_{offset}^{HARQ-ACK}$, β_{offset}^{RI} and β_{offset}^{CQI} shall be configured to values according to Table 8.6.3-1,2,3 with the higher layer signalled indexes $I_{offset,MC}^{HARQ-ACK}$ if the UE transmits no more than 22 HARQ-ACK bits on a PUSCH or if $I_{offset,MC,X}^{HARQ-ACK}$ is not configured, $I_{offset,MC}^{RI}$ and $I_{offset,MC}^{CQI}$, respectively. Multiple codeword PUSCH transmission offset $\beta_{offset}^{HARQ-ACK}$ shall be configured to values according to [Table 8.6.3-1] with the higher layer signalled index $I_{offset,MC,X}^{HARQ-ACK}$ if the UE transmits more than 22 HARQ-ACK bits on a PUSCH and $I_{offset,MC,X}^{HARQ-ACK}$ is configured.

If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell c, and if a subframe belongs to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12*, then for that subframe, the UE shall use

- the higher layer indexes $I_{offset,set2}^{HARQ-ACK}$, $I_{offset,set2,X}^{HARQ-ACK}$, $I_{offset,set2}^{RI}$ and $I_{offset,set2}^{CQI}$ in place of $I_{offset}^{HARQ-ACK}$, $I_{offset,X}^{HARQ-ACK}$, I_{offset}^{RI}, and I_{offset}^{CQI} respectively in Tables 8.6.3-1,2,3, to determine $\beta_{offset}^{HARQ-ACK}$, β_{offset}^{RI} and β_{offset}^{CQI} respectively for single codeword PUSCH transmissions, and

- the higher layer indexes $I_{offset,MC,set2}^{HARQ-ACK}$, $I_{offset,MC,set2,X}^{HARQ-ACK}$, $I_{offset,MC,set2}^{RI}$ and $I_{offset,MC,set2}^{CQI}$ in place of $I_{offset,MC}^{HARQ-ACK}$, $I_{offset,MC,X}^{HARQ-ACK}$, $I_{offset,MC}^{RI}$ and $I_{offset,MC}^{CQI}$ respectively in Tables 8.6.3-1,2,3, to determine $\beta_{offset}^{HARQ-ACK}$, β_{offset}^{RI} and β_{offset}^{CQI} respectively for multiple codeword PUSCH transmissions.

Table 8.6.3-1: Mapping of HARQ-ACK offset values and the index signalled by higher layers

$I_{offset}^{HARQ-ACK}$ or $I_{offset,MC}^{HARQ-ACK}$	$\beta_{offset}^{HARQ-ACK}$
0	2.000
1	2.500
2	3.125
3	4.000
4	5.000
5	6.250
6	8.000
7	10.000
8	12.625
9	15.875
10	20.000
11	31.000
12	50.000
13	80.000
14	126.000
15	1.0

Table 8.6.3-2: Mapping of RI offset values and the index signalled by higher layers

I_{offset}^{RI} or $I_{offset,MC}^{RI}$	β_{offset}^{RI}
0	1.250
1	1.625
2	2.000
3	2.500
4	3.125
5	4.000
6	5.000
7	6.250
8	8.000
9	10.000
10	12.625
11	15.875
12	20.000
13	reserved
14	reserved
15	reserved

Table 8.6.3-3: Mapping of CQI offset values and the index signalled by higher layers

I_{offset}^{CQI} or $I_{offset,MC}^{CQI}$	β_{offset}^{CQI}
0	reserved
1	reserved
2	1.125
3	1.250
4	1.375
5	1.625
6	1.750
7	2.000
8	2.250
9	2.500
10	2.875
11	3.125
12	3.500
13	4.000
14	5.000
15	6.250

8.7 UE transmit antenna selection

UE transmit antenna selection is configured by higher layers via parameter *ue-TransmitAntennaSelection*.

A UE configured with transmit antenna selection for a serving cell is not expected to

- be configured with more than one antenna port for any uplink physical channel or signal for any configured serving cell, or
- be configured with trigger type 1 SRS transmission on any configured serving cell, or
- be configured with simultaneous PUCCH and PUSCH transmission, or
- be configured with demodulation reference signal for PUSCH with OCC for any configured serving cell (see [3], Subclause 5.5.2.1.1), or
- receive DCI Format 0 indicating uplink resource allocation type 1 for any serving cell, or
- be configured with a SCG.

If UE transmit antenna selection is disabled or not supported by the UE, the UE shall transmit from UE port 0.

If closed-loop UE transmit antenna selection is enabled by higher layers the UE shall perform transmit antenna selection for PUSCH in response to the most recent command received via DCI Format 0 in Subclause 5.3.3.2 of [4].
If a UE is configured with more than one serving cell, and for a group of cells belonging to bands that are signalled to be switched together in *txAntennaSwitchUL* the UE may assume the same transmit antenna port value is indicated in each PDCCH/EPDCCH with DCI format 0 in a given subframe.

If open-loop UE transmit antenna selection is enabled by higher layers, the transmit antenna for PUSCH/SRS to be selected by the UE is not specified.

8.8 Transmission timing adjustments

The higher layers indicate the 16-bit UL Grant to the physical layer, as defined in [11]. This is referred to the UL Grant in the physical layer. The content of these 16 bits starting with the MSB and ending with the LSB are as follows:

- Hopping flag – 1 bit, as described in Subclause 6.2
- Fixed size resource block assignment – 10 bits, as described in Subclause 6.2
- Truncated modulation and coding scheme – 4 bits, as described in Subclause 6.2
- CQI request – 1 bit, as described in Subclause 6.2

9 Physical downlink control channel procedures

If the UE is configured with a SCG, the UE shall apply the procedures described in this clause for both MCG and SCG

- When the procedures are applied for MCG, the terms 'secondary cell', 'secondary cells' , 'serving cell', 'serving cells' in this clause refer to secondary cell, secondary cells, serving cell, serving cells belonging to the MCG respectively.
- When the procedures are applied for SCG, the terms 'secondary cell', 'secondary cells', 'serving cell', 'serving cells' in this clause refer to secondary cell, secondary cells (not including PSCell), serving cell, serving cells belonging to the SCG respectively. The term 'primary cell' in this clause refers to the PSCell of the SCG.

If a UE is configured with a LAA Scell, the UE shall apply the procedures described in this clause assuming frame structure type 1 for the LAA Scell unless stated otherwise.

9.1 UE procedure for determining physical downlink control channel assignment

9.1.1 PDCCH assignment procedure

The control region of each serving cell consists of a set of CCEs, numbered from 0 to $N_{\mathrm{CCE},k}-1$ according to Subclause 6.8.1 in [3], where $N_{\mathrm{CCE},k}$ is the total number of CCEs in the control region of subframe k.
The UE shall monitor a set of PDCCH candidates on one or more activated serving cells as configured by higher layer signalling for control information, where monitoring implies attempting to decode each of the PDCCHs in the set according to all the monitored DCI formats.

A BL/CE UE is not required to monitor PDCCH.

A UE is not required to monitor PDCCH in an MBSFN subframe with zero-size non-MBSFN region.

The set of PDCCH candidates to monitor are defined in terms of search spaces, where a search space $S_k^{(L)}$ at aggregation level $L \in \{1,2,4,8\}$ is defined by a set of PDCCH candidates. For each serving cell on which PDCCH is monitored, the CCEs corresponding to PDCCH candidate *m* of the search space $S_k^{(L)}$ are given by

$$L \cdot \left\{ (Y_k + m') \bmod \left\lfloor N_{\mathrm{CCE},k} / L \right\rfloor \right\} + i$$

where Y_k is defined below, $i = 0, \cdots, L-1$. For the common search space $m' = m$. For the PDCCH UE specific search space, for the serving cell on which PDCCH is monitored, if the monitoring UE is configured with carrier indicator field then $m' = m$ for n_{CI} =0 and $m' = m + \sum_{x=0}^{n_{CI}-1} M_x^{(L)}$ for n_{CI} >0 where n_{CI} is the carrier indicator field value and $M_x^{(L)}$ is the reference number of PDCCH candidates for a carrier indicator field value "*x*", else if the monitoring UE is not configured with carrier indicator field then $m' = m$, where $m = 0, \cdots, M^{(L)}-1$. $M^{(L)}$ is the number of PDCCH candidates to monitor in the given search space for the scheduled serving cell. If a carrier indicator field value "*x*" corresponds to a LAA SCell and the monitoring UE is configured with uplink transmission on the LAA SCell, $M_x^{(L)}$ is the maximum number of $M^{(L)}$ over all configured DCI formats for the LAA SCell. Otherwise, $M_x^{(L)}$ is determined according to Table 9.1.1-1 by replacing $M^{(L)}$ with $M_x^{(L)}$.

If a UE is configured with higher layer parameter *cif-InSchedulingCell-r13*, the carrier indicator field value corresponds to *cif-InSchedulingCell-r13*, otherwise, the carrier indicator field value is the same as *ServCellIndex* given in [11].

If a UE is configured with a LAA SCell for UL transmissions, and if the UE is configured with higher layer parameter *cif-InSchedulingCell-r14* for the LAA SCell, the carrier indicator field value in PDCCH scheduling PUSCH corresponds to *cif-InSchedulingCell-r14*, otherwise, the carrier indicator field value is the same as *ServCellIndex* given in [11].

The UE shall monitor one common search space in every non-DRX subframe at each of the aggregation levels 4 and 8 on the primary cell.

A UE shall monitor common search space on a cell to decode the PDCCHs necessary to receive MBMS on that cell when configured by higher layers.

If a UE is not configured for EPDCCH monitoring, and if the UE is not configured with a carrier indicator field, then the UE shall monitor one PDCCH UE-specific search space at each of the aggregation levels 1, 2, 4, 8 on each activated serving cell in every non-DRX subframe.

If a UE is not configured for EPDCCH monitoring, and if the UE is configured with a carrier indicator field, then the UE shall monitor one or more UE-specific search spaces at each of the aggregation levels 1, 2, 4, 8 on one or more activated serving cells as configured by higher layer signalling in every non-DRX subframe.

If a UE is configured for EPDCCH monitoring on a serving cell, and if that serving cell is activated, and if the UE is not configured with a carrier indicator field, then the UE shall monitor one PDCCH UE-specific search space at each of the aggregation levels 1, 2, 4, 8 on that serving cell in all non-DRX subframes where EPDCCH is not monitored on that serving cell.

If a UE is configured for EPDCCH monitoring on a serving cell, and if that serving cell is activated, and if the UE is configured with a carrier indicator field, then the UE shall monitor one or more PDCCH UE-specific search spaces at each of the aggregation levels 1, 2, 4, 8 on that serving cell as configured by higher layer signalling in all non-DRX subframes where EPDCCH is not monitored on that serving cell.

The common and PDCCH UE-specific search spaces on the primary cell may overlap.

A UE configured with the carrier indicator field associated with monitoring PDCCH on serving cell *c* shall monitor PDCCH configured with carrier indicator field and with CRC scrambled by C-RNTI in the PDCCH UE specific search space of serving cell *c*.

A UE configured with the carrier indicator field associated with monitoring PDCCH on the primary cell shall monitor PDCCH configured with carrier indicator field and with CRC scrambled by SPS C-RNTI or UL-SPS-V-RNTI in the PDCCH UE specific search space of the primary cell.

The UE shall monitor the common search space for PDCCH without carrier indicator field.

For the serving cell on which PDCCH is monitored, if the UE is not configured with a carrier indicator field, it shall monitor the PDCCH UE specific search space for PDCCH without carrier indicator field, if the UE is configured with a carrier indicator field it shall monitor the PDCCH UE specific search space for PDCCH with carrier indicator field.

If the UE is not configured with a LAA Scell, the UE is not expected to monitor the PDCCH of a secondary cell if it is configured to monitor PDCCH with carrier indicator field corresponding to that secondary cell in another serving cell.

If the UE is configured with a LAA Scell, the UE is not expected to monitor the PDCCH UE specific space of the LAA SCell if it is configured to monitor PDCCH with carrier indicator field corresponding to that LAA Scell in another serving cell,

- where the UE is not expected to be configured to monitor PDCCH with carrier indicator field in an LAA Scell;
- where the UE is not expected to be scheduled with PDSCH starting in the second slot in a subframe in an LAA Scell if the UE is configured to monitor PDCCH with carrier indicator field corresponding to that LAA Scell in another serving cell.

For the serving cell on which PDCCH is monitored, the UE shall monitor PDCCH candidates at least for the same serving cell.

A UE configured to monitor PDCCH candidates with CRC scrambled by C-RNTI, SPS C-RNTI or UL-SPS-V-RNTI with a common payload size and with the same first CCE index n_{CCE} (as described in Subclause 10.1) but with different sets of DCI information fields as defined in [4] in the

- common search space
- PDCCH UE specific search space

on the primary cell shall assume that for the PDCCH candidates with CRC scrambled by C-RNTI, SPS C-RNTI or UL-SPS-V-RNTI,

if the UE is configured with the carrier indicator field associated with monitoring the PDCCH on the primary cell, only the PDCCH in the common search space is transmitted by the primary cell;

otherwise, only the PDCCH in the UE specific search space is transmitted by the primary cell.

A UE configured to monitor PDCCH candidates in a given serving cell with a given DCI format size with CIF, and CRC scrambled by C- RNTI, where the PDCCH candidates may have one or more possible values of CIF for the given DCI format size, shall assume that a PDCCH candidate with the given DCI format size may be transmitted in the given serving cell in any PDCCH UE specific search space corresponding to any of the possible values of CIF for the given DCI format size.

If a serving cell is a LAA Scell, and if the higher layer parameter *subframeStartPosition* for the Scell indicates 's07',

- The UE monitors PDCCH UE-specific search space candidates on the Scell in both the first and second slots of a subframe, and the aggregation levels defining the search spaces are listed in Table 9.1.1-1A;

otherwise,

- The aggregation levels defining the search spaces are listed in Table 9.1.1-1.

If a serving cell is a LAA Scell, the UE may receive PDCCH with DCI CRC scrambled by CC-RNTI as described in Subclause 13A on the LAA Scell.

The DCI formats that the UE shall monitor depend on the configured transmission mode per each serving cell as defined in Subclause 7.1.

If a UE is configured with higher layer parameter *skipMonitoringDCI-format0-1A* for a serving cell, the UE is not required to monitor the PDCCH with DCI Format 0/1A in the UE specific search space for that serving cell.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured with higher layer parameter *skipMonitoringDCI-format0A* for the LAA SCell, the UE is not required to monitor the PDCCH with DCI Format 0A in the UE specific search space for the LAA SCell.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured in transmission mode 2 and if the UE is configured with higher layer parameter *skipMonitoringDCI-format4A* for the LAA SCell, the UE is not required to monitor the PDCCH with DCI Format 4A in the UE specific search space for the LAA SCell.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured with higher layer parameter *enableMonitoringDCI-format0B* for the LAA SCell, the UE is required to monitor the PDCCH with DCI Format 0B in the UE specific search space for the LAA SCell.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured in transmission mode 2 and if the UE is configured with higher layer parameter *enableMonitoringDCI-format4B* for the LAA SCell, the UE is required to monitor the PDCCH with DCI Format 4B in the UE specific search space for the LAA SCell.

If a UE is not configured for PUSCH/PUCCH transmission for at least one TDD serving cell, the UE is not expected to monitor PDCCH on serving cell c_1 if the PDCCH overlaps in time with SRS transmission (including any interruption due to uplink or downlink RF retuning time [10]) on TDD serving cell c_2 not configured for PUSCH/PUCCH transmission, and if the UE is not capable of simultaneous reception and transmission on serving cell c_1 and serving cell c_2.

If a UE is configured with higher layer parameter *pdcch-candidateReductions* for a UE specific search space at aggregation level *L* for a serving cell, the corresponding number of PDCCH candidates is given by $M^{(L)} = \text{round}\left(a \times M_{full}^{(L)}\right)$, where the value of a is determined according to Table 9.1.1-2 and $M_{full}^{(L)}$ is determined according to Table 9.1.1-1 by replacing $M^{(L)}$ with $M_{full}^{(L)}$.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured with higher layer parameter *pdcch-candidateReductions-Format0A* for a UE specific search space at aggregation level *L* for the LAA SCell, the corresponding number of PDCCH candidates for DCI format 0A is given by $M^{(L)} = \text{round}\left(a \times M_{full}^{(L)}\right)$, where the value of a is determined according to Table 9.1.1-2 and $M_{full}^{(L)}$ is determined according to Table 9.1.1-1 by replacing $M^{(L)}$ with $M_{full}^{(L)}$.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured with higher layer parameter *pdcch-candidateReductions-Format0B-4A-4B-AL1-2* for a UE specific search space of the first and second aggregation level for the LAA SCell, the corresponding number of PDCCH candidates for DCI format 0B/4A/4B is given by $M^{(L)} = \text{round}\left(a \times M_{full}^{(L)}\right)$, where the value of a is determined according to Table 9.1.1-2 and $M_{full}^{(L)}$ is determined according to Table 9.1.1-1 by replacing $M^{(L)}$ with $M_{full}^{(L)}$.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured with higher layer parameter *pdcch-candidateReductions-Format0B-4A-4B-AL3-4* for a UE specific search space of the third and fourth aggregation level for the LAA SCell, the corresponding number of PDCCH candidates for DCI format 0B/4A/4B is given by $M^{(L)} = \text{round}\left(a \times M_{full}^{(L)}\right)$, where the value of a is determined according to Table 9.1.1-3 and $M_{full}^{(L)}$ is determined according to Table 9.1.1-1 by replacing $M^{(L)}$ with $M_{full}^{(L)}$.

Table 9.1.1-1: PDCCH candidates monitored by a UE

Search space $S_k^{(L)}$			Number of PDCCH candidates $M^{(L)}$
Type	Aggregation level L	Size [in CCEs]	
UE-specific	1	6	6
	2	12	6
	4	8	2
	8	16	2
Common	4	16	4
	8	16	2

Note: the Size [in CCEs] is given assuming a =1

Table 9.1.1-1A: PDCCH UE-specific search space candidates monitored by a UE on LAA Scell

Search space $S_k^{(L)}$			Number of PDCCH candidates $M^{(L)}$ in first slot	Number of PDCCH candidates $M^{(L)}$ in second slot
Type	Aggregation level L	Size [in CCEs]		
UE-specific	1	6	6	6
	2	12	6	6
	4	8	2	2
	8	16	2	2

Note: the Size [in CCEs] is given assuming a =1

Table 9.1.1-2: Scaling factor for PDCCH candidates reduction

pdcch-candidateReductions	Value of a
0	0
1	0.33
2	0.66
3	1

Table 9.1.1-3: Scaling factor for PDCCH candidates reduction

pdcch-candidateReductions	Value of a
0	0
1	0.5
2	1
3	1.5

For the common search spaces, Y_k is set to 0 for the two aggregation levels $L=4$ and $L=8$.

For the UE-specific search space $S_k^{(L)}$ at aggregation level L, the variable Y_k is defined by

$$Y_k = \left(A \cdot Y_{k-1}\right) \bmod D$$

where $Y_{-1} = n_{\text{RNTI}} \neq 0$, $A = 39827$, $D = 65537$ and $k = \lfloor n_s/2 \rfloor$, n_s is the slot number within a radio frame.

The RNTI value used for n_{RNTI} is defined in Subclause 7.1 in downlink and Subclause 8 in uplink.

9.1.2 PHICH assignment procedure

If a UE is not configured with multiple TAGs, or if a UE is configured with multiple TAGs and PUSCH transmissions scheduled from serving cell c in subframe n are not scheduled by a Random Access Response Grant corresponding to a random access preamble transmission for a secondary cell

- For PUSCH transmissions scheduled from serving cell c in subframe n, the UE shall determine the corresponding PHICH resource of serving cell c in subframe $n + k_{PHICH}$, where
  - k_{PHICH} is always 4 for FDD.
  - k_{PHICH} is 6 for FDD-TDD and serving cell c frame structure type 2 and the PUSCH transmission is for another serving cell with frame structure type 1.
  - k_{PHICH} is 4 for FDD-TDD and serving cell c frame structure type 1and the PUSCH transmission is for a serving cell with frame structure type 1.
  - k_{PHICH} is given in table 9.1.2-1 for FDD-TDD and serving cell c frame structure type 1 and the PUSCH transmission is for another serving cell with frame structure type 2.
- For TDD, if the UE is not configured with *EIMTA-MainConfigServCell-r12* for any serving cell and, if the UE is configured with one serving cell, or if the UE is configured with more than one serving cell and the TDD UL/DL configuration of all the configured serving cells is the same, for PUSCH transmissions scheduled from serving cell c in subframe n, the UE shall determine the corresponding PHICH resource of serving cell c in subframe $n + k_{PHICH}$, where k_{PHICH} is given in table 9.1.2-1 if the UE is not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, otherwise k_{PHICH} is given in Table 9.1.2-3.
- For TDD, if the UE is configured with more than one serving cell and the TDD UL/DL configuration of at least two configured serving cells is not the same, or if the UE is configured with *EIMTA-MainConfigServCell-r12* for at least one serving cell , or for FDD-TDD and serving cell c frame structure type 2, for PUSCH transmissions scheduled from serving cell c in subframe n, the UE shall determine the corresponding PHICH resource of serving cell c in subframe $n + k_{PHICH}$, where k_{PHICH} is given in table 9.1.2-1 if the UE is not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, otherwise k_{PHICH} is given in Table 9.1.2-3, where the "TDD UL/DL Configuration" in the rest of this Subclause refers to the UL-reference UL/DL configuration (defined in Subclause 8.0) of the serving cell corresponding to the PUSCH transmission.

If a UE is configured with multiple TAGs, for PUSCH transmissions on subframe n for a secondary cell c scheduled by a Random Access Response grant corresponding to a random access preamble transmission for the secondary cell c,

- For TDD, if the UE is configured with more than one serving cell and the TDD UL/DL configuration of at least two configured serving cells is not the same, or if the UE is configured with *EIMTA-MainConfigServCell-r12* for at least one serving cell, or for FDD-TDD and serving cell c frame structure type 2, the "TDD UL/DL Configuration" in the rest of this Subclause refers to the UL-reference UL/DL configuration (defined in Subclause 8.0) of secondary cell c.
- If the UE is not configured to monitor PDCCH/EPDCCH with carrier indicator field corresponding to secondary cell c in another serving cell, the UE shall determine the corresponding PHICH resource on the secondary cell c in subframe $n + k_{PHICH}$, where
  - k_{PHICH} is always 4 for FDD and where k_{PHICH} is given in table 9.1.2-1 if the UE is not configured with higher layer parameter *symPUSCH-UpPts-r14* for the secondary cell c, otherwise k_{PHICH} is given in Table 9.1.2-3 for TDD.
  - k_{PHICH} is 4 for FDD-TDD and secondary cell c frame structure type 1.

- k_{PHICH} is given in table 9.1.2-1 if the UE is not configured with higher layer parameter *symPUSCH-UpPts-r14* for the secondary cell c, otherwise k_{PHICH} is given in Table 9.1.2-3 for FDD-TDD and secondary cell c frame structure type 2

- If the UE is configured to monitor PDCCH/EPDCCH with carrier indicator field corresponding to secondary cell c in another serving cell $c1$, the UE configured with multiple TAGs shall determine the corresponding PHICH resource on the serving cell $c1$ in subframe $n+k_{PHICH}$, where

  - k_{PHICH} is always 4 for FDD and where k_{PHICH} is given in table 9.1.2-1 if the UE is not configured with higher layer parameter *symPUSCH-UpPts-r14* for the secondary cell c, otherwise k_{PHICH} is given in Table 9.1.2-3 for TDD.

  - k_{PHICH} is 4 for FDD-TDD and primary cell frame structure type 1 and frame structure type 1 for secondary cell c and serving cell $c1$

  - k_{PHICH} is given in table 9.1.2-1 if the UE is not configured with higher layer parameter *symPUSCH-UpPts-r14* for the secondary cell c, otherwise k_{PHICH} is given in Table 9.1.2-3 for FDD-TDD and serving cell *c* frame structure type 2

  - k_{PHICH} is 6 for FDD-TDD and serving cell *c* frame structure type 1 and serving cell $c1$ frame structure type 2

For subframe bundling operation, the corresponding PHICH resource is associated with the last subframe in the bundle.

Table 9.1.2-1: k_{PHICH} for TDD

TDD UL/DL Configuration	subframe index *n*									
	0	1	2	3	4	5	6	7	8	9
0			4	7	6			4	7	6
1			4	6				4	6	
2			6					6		
3			6	6	6					
4			6	6						
5			6							
6			4	6	6			4	7	

Table 9.1.2-3: k_{PHICH} for TDD and UE configured with *symPUSCH-UpPts-r14*

TDD UL/DL Configuration	subframe index *n*									
	0	1	2	3	4	5	6	7	8	9
0		5	4	7	6		5	4	7	6
1		5	4	6			5	4	6	
2		7	6				7	6		
3		7	6	6	6					
4		7	6	6						
5		7	6							
6		4	4	6	6		4	4	7	

The PHICH resource is identified by the index pair $(n_{PHICH}^{group}, n_{PHICH}^{seq})$ where n_{PHICH}^{group} is the PHICH group number and n_{PHICH}^{seq} is the orthogonal sequence index within the group as defined by:

$$n_{PHICH}^{group} = (I_{PRB\_RA} + n_{DMRS}) \bmod N_{PHICH}^{group} + I_{PHICH} N_{PHICH}^{group}$$
$$n_{PHICH}^{seq} = (\lfloor I_{PRB\_RA} / N_{PHICH}^{group} \rfloor + n_{DMRS}) \bmod 2N_{SF}^{PHICH}$$

where

- n_{DMRS} is mapped from the cyclic shift for DMRS field (according to Table 9.1.2-2) in the most recent PDCCH/EPDCCH with uplink DCI format [4] for the transport block(s) associated with the corresponding PUSCH transmission. n_{DMRS} shall be set to zero, if there is no PDCCH/EPDCCH with uplink DCI format for the same transport block, and
  - if the initial PUSCH for the same transport block is semi-persistently scheduled, or
  - if the initial PUSCH for the same transport block is scheduled by the random access response grant .
- N_{SF}^{PHICH} is the spreading factor size used for PHICH modulation as described in Subclause 6.9.1 in [3].
- $I_{PRB\_RA} = \begin{cases} I_{PRB\_RA}^{lowest\_index} & \text{for the first TB of a PUSCH with associated PDCCH/EPDCCH or for the case of no associated PDCCH/EPDCCH when the number of negatively acknowledged TBs is not equal to the number of TBs indicated in the most recent PDCCH/EPDCCH associated with the corresponding PUSCH} \\ I_{PRB\_RA}^{lowest\_index} + 1 & \text{for a second TB of a PUSCH with associated PDCCH/EPDCCH} \end{cases}$

  where $I_{PRB\_RA}^{lowest\_index}$ is the lowest PRB index in the first slot of the corresponding PUSCH transmission
- N_{PHICH}^{group} is the number of PHICH groups configured by higher layers as described in Subclause 6.9 of [3],
- $I_{PHICH} = \begin{cases} 1 & \text{for TDD UL/DL configuration 0 with PUSCH transmission in subframe } n = 4 \text{ or } 9 \\ 0 & \text{otherwise} \end{cases}$

Table 9.1.2-2: Mapping between n_{DMRS} and the cyclic shift for DMRS field in PDCCH/EPDCCH with uplink DCI format in [4]

Cyclic Shift for DMRS Field in PDCCH/EPDCCH with uplink DCI format in [4]	n_{DMRS}
000	0
001	1
010	2
011	3
100	4
101	5
110	6
111	7

9.1.3 Control Format Indicator (CFI) assignment procedure

PHICH duration is signalled by higher layers according to Table 6.9.3-1 in [3]. The duration signalled puts a lower limit on the size of the control region determined from the control format indicator (CFI). When $N_{\mathrm{RB}}^{\mathrm{DL}} > 10$, if extended PHICH duration is indicated by higher layers then the UE shall assume that CFI is equal to PHICH duration.

In subframes indicated by higher layers to decode PMCH, when $N_{\mathrm{RB}}^{\mathrm{DL}} > 10$, a UE may assume that CFI is equal to the value of the higher layer parameter *non-MBSFNregionLength* [11].

9.1.4 EPDCCH assignment procedure

For each serving cell, higher layer signalling can configure a UE with one or two EPDCCH-PRB-sets for EPDCCH monitoring. The PRB-pairs corresponding to an EPDCCH-PRB-set are indicated by higher layers as described in

Subclause 9.1.4.4. Each EPDCCH-PRB-set consists of set of ECCEs numbered from 0 to $N_{\mathrm{ECCE},p,k}-1$ where $N_{\mathrm{ECCE},p,k}$ is the number of ECCEs in EPDCCH-PRB-set p of subframe k. Each EPDCCH-PRB-set can be configured for either localized EPDCCH transmission or distributed EPDCCH transmission.

The UE shall monitor a set of EPDCCH candidates on one or more activated serving cells as configured by higher layer signalling for control information, where monitoring implies attempting to decode each of the EPDCCHs in the set according to the monitored DCI formats.

A BL/CE UE is not required to monitor EPDCCH.

A UE is not required to monitor EPDCCH in an MBSFN subframe with zero-size non-MBSFN region.

The set of EPDCCH candidates to monitor are defined in terms of EPDCCH UE-specific search spaces.

For each serving cell, the subframes in which the UE monitors EPDCCH UE-specific search spaces are configured by higher layers.

The UE shall not monitor EPDCCH

- For TDD and normal downlink CP, in special subframes for the special subframe configurations 0 and 5, or for frame structure type 3, in the subframe with the same duration as the DwPTS duration of the special subframe configurations 0 and 5, shown in Table 4.2-1 of [3], or for the special subframe configuration 10 with the higher layer parameter *crs-LessDwPTS-r14* set as *true*.
- For TDD and extended downlink CP, in special subframes for the special subframe configurations 0, 4 and 7 shown in Table 4.2-1 of [3].
- In subframes indicated by higher layers to decode PMCH.
- For TDD and if the UE is configured with different UL/DL configurations for the primary and a secondary cell, in a downlink subframe on the secondary cell when the same subframe on the primary cell is a special subframe and the UE is not capable of simultaneous reception and transmission on the primary and secondary cells.

An EPDCCH UE-specific search space $ES_k^{(L)}$ at aggregation level $L \in \{1,2,4,8,16,32\}$ is defined by a set of EPDCCH candidates.

For an EPDCCH-PRB-set p, the ECCEs corresponding to EPDCCH candidate *m* of the search space $ES_k^{(L)}$ are given by

$$L\left\{\left(Y_{p,k}+\left\lfloor\frac{m\cdot N_{\mathrm{ECCE},p,k}}{L\cdot M_{p,full}^{(L)}}\right\rfloor+b\right)\bmod\left\lfloor N_{\mathrm{ECCE},p,k}/L\right\rfloor\right\}+i$$

where

$Y_{p,k}$ is defined below,

$i=0,\cdots,L-1$

$b=n_{CI}$ if the UE is configured with a carrier indicator field for the serving cell on which EPDCCH is monitored, otherwise $b=0$

n_{CI} is the carrier indicator field value,

$M_{p,full}^{(L)}$ is the maximum number of EPDCCH candidates among all the configured DCI formats over all the configured carrier indicator field values for an aggregation level *L* in EPDCCH-PRB-set *p* if the UE is configured with uplink transmission on a LAA SCell, otherwise, $M_{p,full}^{(L)}$ is the nominal number of EPDCCH candidates at

aggregation level *L* in EPDCCH-PRB-set *p* determined according to Tables 9.1.4-1a to 9.1.4-5b by replacing $M_p^{(L)}$ with $M_{p,full}^{(L)}$,

$m = 0,1,\ldots M_p^{(L)} - 1.$

If the UE is not configured with a carrier indicator field for the serving cell on which EPDCCH is monitored, $M_p^{(L)}$ is the number of EPDCCH candidates to monitor at aggregation level L in EPDCCH-PRB-set p for the serving cell on which EPDCCH is monitored, as given in Tables 9.1.4-1a, 9.1.4-1b, 9.1.4-2a, 9.1.4-2b, 9.1.4-3a, 9.1.4-3b, 9.1.4-4a, 9.4.4-4b, 9.1.4-5a, 9.1.4-5b below; otherwise, $M_p^{(L)}$ is the number of EPDCCH candidates to monitor at aggregation level L in EPDCCH-PRB-set p for the serving cell indicated by n_{CI}.

If a UE is configured with higher layer parameter *pdcch-candidateReductions* for a specific search space at aggregation level *L* in EPDCCH-PRB-set p for a serving cell, the corresponding number of EPDCCH candidates is given by $M_p^{(L)} = \text{round}\left(a \times M_{p,full}^{(L)}\right)$, where the value of a is determined according to Table 9.1.1-2 and $M_{p,full}^{(L)}$ is determined according to Tables 9.1.4-1a to 9.1.4-5b by replacing $M_p^{(L)}$ with $M_{p,full}^{(L)}$.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured with higher layer parameter *pdcch-candidateReductions-Format0A* for a UE specific search space at aggregation level *L* in EPDCCH-PRB-set p for the LAA SCell, the corresponding number of EPDCCH candidates for DCI format 0A is given by $M_p^{(L)} = \text{round}\left(a \times M_{p,full}^{(L)}\right)$, where the value of a is determined according to Table 9.1.1-2 and $M_{p,full}^{(L)}$ is determined according to Tables 9.1.4-1a to 9.1.4-5b by replacing $M_p^{(L)}$ with $M_{p,full}^{(L)}$.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured with higher layer parameter *pdcch-candidateReductions-Format0B-4A-4B-AL1-2* for a UE specific search space of the first and second aggregation level in EPDCCH-PRB-set p for the LAA SCell, the corresponding number of EPDCCH candidates for DCI format 0B/4A/4B is given by $M_p^{(L)} = \text{round}\left(a \times M_{p,full}^{(L)}\right)$, where the value of a is determined according to Table 9.1.1-2 and $M_{p,full}^{(L)}$ is determined according to Tables 9.1.4-1a to 9.1.4-5b by replacing $M_p^{(L)}$ with $M_{p,full}^{(L)}$.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured with higher layer parameter *pdcch-candidateReductions-Format0B-4A-4B-AL3-5* for a UE specific search space of the third, fourth, and fifth aggregation level in EPDCCH-PRB-set p for the LAA SCell, the corresponding number of EPDCCH candidates for DCI format 0B/4A/4B is given by $M_p^{(L)} = \text{round}\left(a \times M_{p,full}^{(L)}\right)$, where the value of a is determined according to Table 9.1.1-3 and $M_{p,full}^{(L)}$ is determined according to Tables 9.1.4-1a to 9.1.4-5b by replacing $M_p^{(L)}$ with $M_{p,full}^{(L)}$.

If a UE is configured with higher layer parameter *cif-InSchedulingCell-r13*, the carrier indicator field value corresponds to *cif-InSchedulingCell-r13*, otherwise the carrier indicator field value is the same as *ServCellIndex* given in [11].

If a UE is configured with a LAA SCell for UL transmissions, and if the UE is configured with higher layer parameter *cif-InSchedulingCell-r14* for the LAS SCell, the carrier indicator field value in EPDCCH scheduling PUSCH corresponds to *cif-InSchedulingCell-r14*, otherwise, the carrier indicator field value is the same as *ServCellIndex* given in [11].

A UE is not expected to monitor an EPDCCH candidate, if an ECCE corresponding to that EPDCCH candidate is mapped to a PRB pair that overlaps in frequency with a transmission of either PBCH or primary or secondary synchronization signals in the same subframe.

If a UE is configured with two EPDCCH-PRB-sets with the same $n_{\text{ID},i}^{\text{EPDCCH}}$ value (where $n_{\text{ID},i}^{\text{EPDCCH}}$ is defined in Subclause 6.10.3A.1 in [3]), if the UE receives an EPDCCH candidate with a given DCI payload size corresponding to one of the EPDCCH-PRB-sets and mapped only to a given set of REs (as described in Subclause 6.8A.5 in [3]), and if the UE is also configured to monitor an EPDCCH candidate with the same DCI payload size and corresponding to the other EPDCCH-PRB-set and which is mapped only to the same set of REs, and if the number of the first ECCE of the received EPDCCH candidate is used for determining PUCCH resource for HARQ-ACK transmission (as described in

Subclause 10.1.2 and Subclause 10.1.3), the number of the first ECCE shall be determined based on EPDCCH-PRB-set $p = 0$.

The variable $Y_{p,k}$ is defined by

$$Y_{p,k} = \left(A_p \cdot Y_{p,k-1}\right) \bmod D$$

where $Y_{p,-1} = n_{\text{RNTI}} \neq 0$, $A_0 = 39827$, $A_1 = 39829$, $D = 65537$ and $k = \lfloor n_s/2 \rfloor$, n_s is the slot number within a radio frame. The RNTI value used for n_{RNTI} is defined in Subclause 7.1 in downlink and Subclause 8 in uplink. The DCI formats that the UE shall monitor depend on the configured transmission mode per each serving cell as defined in Subclause 7.1.

If a UE is configured with higher layer parameter *skipMonitoringDCI-format0-1A* for a serving cell, the UE is not required to monitor the EPDCCH with DCI Format 0/1A in the UE specific search space for that serving cell.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured with higher layer parameter *skipMonitoringDCI-format0A* for the LAA SCell, the UE is not required to monitor the EPDCCH with DCI Format 0A in the UE specific search space for the LAA SCell.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured in transmission mode 2 and if the UE is configured with higher layer parameter *skipMonitoringDCI-format4A* for the LAA SCell, the UE is not required to monitor the EPDCCH with DCI Format 4A in the UE specific search space for the LAA SCell.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured with higher layer parameter *enableMonitoringDCI-format0B* for the LAA SCell, the UE is required to monitor the EPDCCH with DCI Format 0B in the UE specific search space for the LAA SCell.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured in transmission mode 2 and if the UE is configured with higher layer parameter *enableMonitoringDCI-format4B* for the LAA SCell, the UE is required to monitor the EPDCCH with DCI Format 4B in the UE specific search space for the LAA SCell.

If a serving cell is a LAA Scell, and if the higher layer parameter *subframeStartPosition* for the Scell indicates 's07'

- the UE monitors EPDCCH UE-specific search space candidates on the Scell assuming they start in both the first slot and the second slot of a subframe.

The aggregation levels defining the search spaces and the number of monitored EPDCCH candidates is given as follows

- For a UE configured with only one EPDCCH-PRB-set for distributed transmission, the aggregation levels defining the search spaces and the number of monitored EPDCCH candidates are listed in Table 9.1.4-1a, Table 9.1.4-1b.
- For a UE configured with only one EPDCCH-PRB-set for localized transmission, the aggregation levels defining the search spaces and the number of monitored EPDCCH candidates are listed in Table 9.1.4-2a, Table 9.1.4-2b.
- For a UE configured with two EPDCCH-PRB-sets for distributed transmission, the aggregation levels defining the search spaces and the number of monitored EPDCCH candidates are listed in Table 9.1.4-3a, 9.1.4-3b.
- For a UE configured with two EPDCCH-PRB-sets for localized transmission, the aggregation levels defining the search spaces and the number of monitored EPDCCH candidates are listed in Table 9.1.4-4a, 9.4.4-4b.
- For a UE configured with one EPDCCH-PRB-set for distributed transmission, and one EPDCCH-PRB-set for localized transmission, the aggregation levels defining the search spaces and the number of monitored EPDCCH candidates are listed in Table 9.1.4-5a, 9.1.4-5b.

If the UE is not configured with a carrier indicator field for the serving cell on which EPDCCH is monitored, $\hat{N}_{\text{RB}}^{\text{DL}} = N_{\text{RB}}^{\text{DL}}$ of the serving cell on which EPDCCH is monitored. If the UE is configured with a carrier indicator field for the serving cell on which EPDCCH is monitored, $\hat{N}_{\text{RB}}^{\text{DL}} = N_{\text{RB}}^{\text{DL}}$ of the serving cell indicated by n_{CI}.

For Tables 9.1.4-1a, 9.1.4-1b, 9.1.4-2a, 9.1.4-2b, 9.1.4-3a, 9.1.4-3b, 9.1.4-4a, 9.4.4-4b, 9.1.4-5a, 9.1.4-5b

- Case 1 applies

- for normal subframes and normal downlink CP when DCI formats 2/2A/2B/2C/2D are monitored and $\hat{N}_{\mathrm{RB}}^{\mathrm{DL}} \geq 25$, or
- for frame structure type 3, for downlink subframes with PDSCH transmissions starting in the second slot,
- for special subframes with special subframe configuration 3,4,8 for frame structure type 2 or the subframes with the same duration as the DwPTS duration of a special subframe configuration 3,4,8 for frame structure type 3, and normal downlink CP when DCI formats 2/2A/2B/2C/2D are monitored and $\hat{N}_{\mathrm{RB}}^{\mathrm{DL}} \geq 25$, or
- for normal subframes and normal downlink CP when DCI formats 1A/1B/1D/1/2/2A/2B/2C/2D/0/0A/0B/4/4A/4B/5/6-0A/6-0B/6-1A/6-1B are monitored, and when $n_{\mathrm{EPDCCH}} < 104$ (n_{EPDCCH} defined in Subclause 6.8A.1 in [3]), or
- for special subframes with special subframe configuration 3, 4, 8 for frame structure type 2 or the subframes with the same duration as the DwPTS duration of a special subframe configuration 3,4,8 for frame structure type 3, and normal downlink CP when DCI formats 1A/1B/1D/1/2A/2/2B/2C/2D/0/0A/0B/4/4A/4B/5/6-0A/6-0B/6-1A/6-1B are monitored, and when $n_{\mathrm{EPDCCH}} < 104$ (n_{EPDCCH} defined in Subclause 6.8A.1 in [3]);

- Case 2 applies
  - for normal subframes and extended downlink CP when DCI formats 1A/1B/1D/1/2A/2/2B/2C/2D/0/0A/0B/4/4A/4B/5/6-0A/6-0B/6-1A/6-1B are monitored or,
  - for special subframes with special subframe configuration 1, 2, 6, 7, 9, 10 for frame structure type 2 or the subframes with the same duration as the DwPTS duration of a special subframe configuration 1, 2, 6, 7, 9, 10 for frame structure type 3, and normal downlink CP when DCI formats 1A/1B/1D/1/2A/2/2B/2C/2D/0/0A/0B/4/4A/4B/5/6-0A/6-0B/6-1A/6-1B are monitored, or
  - for special subframes with special subframe configuration 1,2,3,5,6 and extended downlink CP when DCI formats 1A/1B/1D/1/2A/2/2B/2C/2D/0/0A/0B/4/4A/4B/5/6-0A/6-0B/6-1A/6-1B are monitored;
- otherwise
  - Case 3 is applied.

$N_{\mathrm{RB}}^{X_p}$ is the number of PRB-pairs constituting EPDCCH-PRB-set p .

Table 9.1.4-1a: EPDCCH candidates monitored by a UE (One Distributed EPDCCH-PRB-set - Case1, Case 2)

$N_{\mathrm{RB}}^{X_p}$	Number of EPDCCH candidates $M_p^{(L)}$ for Case 1					Number of EPDCCH candidates $M_p^{(L)}$ for Case 2				
	L=2	L=4	L=8	L=16	L=32	L=1	L=2	L=4	L=8	L=16
2	4	2	1	0	0	4	2	1	0	0
4	8	4	2	1	0	8	4	2	1	0
8	6	4	3	2	1	6	4	3	2	1

Table 9.1.4-1b: EPDCCH candidates monitored by a UE (One Distributed EPDCCH-PRB-set – Case 3)

$N_{\mathrm{RB}}^{X_p}$	Number of EPDCCH candidates $M_p^{(L)}$ for Case 3				
	L=1	L=2	L=4	L=8	L=16
2	8	4	2	1	0
4	4	5	4	2	1
8	4	4	4	2	2

Table 9.1.4-2a: EPDCCH candidates monitored by a UE (One Localized EPDCCH-PRB-set - Case1, Case 2)

$N_{\mathrm{RB}}^{X_p}$	Number of EPDCCH candidates $M_p^{(L)}$ for Case 1				Number of EPDCCH candidates $M_p^{(L)}$ for Case 2			
	L=2	L=4	L=8	L=16	L=1	L=2	L=4	L=8
2	4	2	1	0	4	2	1	0
4	8	4	2	1	8	4	2	1
8	6	6	2	2	6	6	2	2

Table 9.1.4-2b: EPDCCH candidates monitored by a UE (One Localized EPDCCH-PRB-set – Case 3)

$N_{\mathrm{RB}}^{X_p}$	Number of EPDCCH candidates $M_p^{(L)}$ for Case 3			
	L=1	L=2	L=4	L=8
2	8	4	2	1
4	6	6	2	2
8	6	6	2	2

.

Table 9.1.4-3a: EPDCCH candidates monitored by a UE (Two Distributed EPDCCH-PRB-sets - Case1, Case 2)

$N_{\mathrm{RB}}^{Xp_1}$	$N_{\mathrm{RB}}^{Xp_2}$	Number of EPDCCH candidates $\left[M_{p1}^{(L)}, M_{p2}^{(L)}\right]$ for Case 1					Number of EPDCCH candidates $\left[M_{p1}^{(L)}, M_{p2}^{(L)}\right]$ for Case 2				
		L=2	L=4	L=8	L=16	L=32	L=1	L=2	L=4	L=8	L=16
2	2	4,4	2,2	1,1	0,0	0,0	4,4	2,2	1,1	0,0	0,0
4	4	3,3	3,3	1,1	1,1	0,0	3,3	3,3	1,1	1,1	0,0
8	8	3,3	2,2	1,1	1,1	1,1	3,3	2,2	1,1	1,1	1,1
4	2	5,3	3,2	1,1	1,0	0,0	5,3	3,2	1,1	1,0	0,0
8	2	4,2	4,2	1,1	1,0	1,0	4,2	4,2	1,1	1,0	1,0
8	4	3,3	2,2	2,1	1,1	1,0	3,3	2,2	2,1	1,1	1,0

Table 9.1.4-3b: EPDCCH candidates monitored by a UE (Two Distributed EPDCCH-PRB-sets – Case 3)

$N_{\mathrm{RB}}^{Xp_1}$	$N_{\mathrm{RB}}^{Xp_2}$	Number of EPDCCH candidates $\left[M_{p1}^{(L)}, M_{p2}^{(L)}\right]$ for Case 3				
		L=1	L=2	L=4	L=8	L=16
2	2	2,2	3,3	2,2	1,1	0,0
4	4	2,2	2,2	2,2	1,1	1,1
8	8	2,2	2,2	2,2	1,1	1,1
4	2	3,1	3,2	3,1	1,1	1,0
8	2	3,1	4,1	3,1	1,1	1,0
8	4	2,2	2,2	2,2	1,1	1,1

Table 9.1.4-4a: EPDCCH candidates monitored by a UE (Two Localized EPDCCH-PRB-sets - Case1, Case 2)

$N_{\mathrm{RB}}^{Xp_1}$	$N_{\mathrm{RB}}^{Xp_2}$	Number of EPDCCH candidates $\left[M_{p1}^{(L)}, M_{p2}^{(L)}\right]$ for Case 1				Number of EPDCCH candidates $\left[M_{p1}^{(L)}, M_{p2}^{(L)}\right]$ for Case 2			
		L=2	L=4	L=8	L=16	L=1	L=2	L=4	L=8
2	2	4,4	2,2	1,1	0,0	4,4	2,2	1,1	0,0
4	4	3,3	3,3	1,1	1,1	3,3	3,3	1,1	1,1
8	8	3,3	3,3	1,1	1,1	3,3	3,3	1,1	1,1
4	2	4,3	4,2	1,1	1,0	4,3	4,2	1,1	1,0
8	2	5,2	4,2	1,1	1,0	5,2	4,2	1,1	1,0
8	4	3,3	3,3	1,1	1,1	3,3	3,3	1,1	1,1

Table 9.1.4-4b: EPDCCH candidates monitored by a UE (Two Localized EPDCCH-PRB-sets – Case 3)

$N_{RB}^{Xp_1}$	$N_{RB}^{Xp_2}$	Number of EPDCCH candidates $\left[M_{p1}^{(L)}, M_{p2}^{(L)}\right]$ for Case 3			
		L=1	L=2	L=4	L=8
2	2	3,3	3,3	1,1	1,1
4	4	3,3	3,3	1,1	1,1
8	8	3,3	3,3	1,1	1,1
4	2	4,2	4,2	1,1	1,1
8	2	4,2	4,2	1,1	1,1
8	4	3,3	3,3	1,1	1,1

Table 9.1.4-5a: EPDCCH candidates monitored by a UE (NOTE)

$N_{RB}^{Xp_1}$	$N_{RB}^{Xp_2}$	Number of EPDCCH candidates $\left[M_{p1}^{(L)}, M_{p2}^{(L)}\right]$ for Case 1					Number of EPDCCH candidates $\left[M_{p1}^{(L)}, M_{p2}^{(L)}\right]$ for Case 2				
		L=2	L=4	L=8	L=16	L=32	L=1	L=2	L=4	L=8	L=16
2	2	4,4	2,2	1,1	0,0	0,0	4,4	2,2	1,1	0,0	0,0
4	4	4,2	4,3	0,2	0,1	0,0	4,2	4,3	0,2	0,1	0,0
8	8	4,1	4,2	0,2	0,2	0,1	4,1	4,2	0,2	0,2	0,1
2	4	4,3	2,4	0,2	0,1	0,0	4,3	2,4	0,2	0,1	0,0
2	8	4,1	2,2	0,4	0,2	0,1	4,1	2,2	0,4	0,2	0,1
4	2	5,2	4,2	1,1	1,0	0,0	5,2	4,2	1,1	1,0	0,0
4	8	4,1	4,2	0,2	0,2	0,1	4,1	4,2	0,2	0,2	0,1
8	2	5,1	4,2	2,1	1,0	0,0	5,1	4,2	2,1	1,0	0,0
8	4	6,1	4,2	0,2	0,1	0,0	6,1	4,2	0,2	0,1	0,0

NOTE: One localized EPDCCH-PRB-set and one distributed EPDCCH-PRB-set, - Case1, Case 2;
p_1 is the identity of the localized EPDCCH-PRB-set,
p_2 is the identity of the distributed EPDCCH-PRB-set

Table 9.1.4-5b: EPDCCH candidates monitored by a UE (NOTE)

$N_{RB}^{Xp_1}$	$N_{RB}^{Xp_2}$	Number of EPDCCH candidates $\left[M_{p1}^{(L)}, M_{p2}^{(L)}\right]$ for Case 3				
		L=1	L=2	L=4	L=8	L=16
2	2	4,1	4,2	2,2	0,1	0,0
4	4	4,1	4,1	2,2	0,1	0,1
8	8	4,1	4,1	2,2	0,1	0,1
2	4	4,1	4,1	2,2	0,1	0,1
2	8	4,1	4,1	2,2	0,1	0,1
4	2	4,1	4,1	2,2	1,1	0,0
4	8	4,1	4,1	2,2	0,1	0,1
8	2	4,1	4,1	4,1	0,1	0,0
8	4	4,1	4,1	2,2	0,1	0,1

NOTE: One localized EPDCCH-PRB-set and one distributed EPDCCH-PRB-set - Case 3);
p_1 is the identity of the localized EPDCCH-PRB-set,
p_2 is the identity of the distributed EPDCCH-PRB-set)

If the UE is not configured with a carrier indicator field, then the UE shall monitor one EPDCCH UE-specific search space at each of the aggregation levels given by Tables 9.1.4-1a to 9.1.4-5b on each activated serving cell for which it is configured to monitor EPDCCH.

If a UE is configured for EPDCCH monitoring, and if the UE is configured with a carrier indicator field, then the UE shall monitor one or more EPDCCH UE-specific search spaces at each of the aggregation levels given by Tables 9.1.4-1a to 9.1.4-5b on one or more activated serving cells as configured by higher layer signalling.

A UE configured with the carrier indicator field associated with monitoring EPDCCH on serving cell *c* shall monitor EPDCCH configured with carrier indicator field and with CRC scrambled by C-RNTI in the EPDCCH UE specific search space of serving cell *c*.

A UE configured with the carrier indicator field associated with monitoring EPDCCH on the primary cell shall monitor EPDCCH configured with carrier indicator field and with CRC scrambled by SPS C-RNTI or UL-SPS-V-RNTI in the EPDCCH UE specific search space of the primary cell.

A UE is not expected to be configured to monitor EPDCCH with carrier indicator field in an LAA Scell

A UE is not expected to be scheduled with PDSCH starting in the second slot in a subframe in an LAA Scell if the UE is configured to monitor EPDCCH with carrier indicator field corresponding to that LAA Scell in another serving cell

For the serving cell on which EPDCCH is monitored, if the UE is not configured with a carrier indicator field, it shall monitor the EPDCCH UE specific search space for EPDCCH without carrier indicator field, if the UE is configured with a carrier indicator field it shall monitor the EPDCCH UE specific search space for EPDCCH with carrier indicator field.

A UE is not expected to monitor the EPDCCH of a secondary cell if it is configured to monitor EPDCCH with carrier indicator field corresponding to that secondary cell in another serving cell. For the serving cell on which EPDCCH is monitored, the UE shall monitor EPDCCH candidates at least for the same serving cell.

A UE configured to monitor EPDCCH candidates in a given serving cell with a given DCI format size with CIF, and CRC scrambled by C- RNTI, where the EPDCCH candidates may have one or more possible values of CIF for the given DCI format size, shall assume that an EPDCCH candidate with the given DCI format size may be transmitted in the given serving cell in any EPDCCH UE specific search space corresponding to any of the possible values of CIF for the given DCI format size.

For the serving cell on which EPDCCH is monitored, a UE is not required to monitor the EPDCCH in a subframe which is configured by higher layers to be part of a positioning reference signal occasion if the positioning reference signal occasion is only configured within MBSFN subframes and the cyclic prefix length used in subframe #0 is normal cyclic prefix.

A UE may assume the same c_{init} value (described in Subclause 6.10.3A.1 of [3]) is used for antenna ports 107,108 while monitoring an EPDCCH candidate associated with either antenna port 107 or antenna port 108.
A UE may assume the same c_{init} value (described in Subclause 6.10.3A.1 of [3]) is used for antenna ports 109,110 while monitoring an EPDCCH candidate associated with either antenna port 109 or antenna port 110.

9.1.4.1 EPDCCH starting position

For a given serving cell, if the UE is configured via higher layer signalling to receive PDSCH data transmissions according to transmission modes 1-9,

- if the UE is configured with a higher layer parameter *epdcch-StartSymbol-r11*,
  - the starting OFDM symbol for EPDCCH given by index $l_{\text{EPDCCHStart}}$ is determined from the higher layer parameter,
- otherwise
  - the starting OFDM symbol for EPDCCH given by index $l_{\text{EPDCCHStart}}$ is given by the CFI value in the subframe of the given serving cell when $N_{\text{RB}}^{\text{DL}} > 10$, and $l_{\text{EPDCCHStart}}$ is given by the CFI value+1 in the subframe of the given serving cell when $N_{\text{RB}}^{\text{DL}} \le 10$

For a given serving cell, if the UE is configured via higher layer signalling to receive PDSCH data transmissions according to transmission mode 10, for each EPDCCH-PRB-set, the starting OFDM symbol for monitoring EPDCCH in subframe k is determined from the higher layer parameter *pdsch-Start-r11* (defined in Subclause 9.1.4.3) as follows

- if the value of the parameter *pdsch-Start-r11* belongs to {1,2,3,4},

- $l'_{EPDCCHStart}$ is given by the higher layer parameter *pdsch-Start-r11*

- otherwise

  - $l'_{EPDCCHStart}$ is given by the CFI value in subframe k of the given serving cell when $N_{RB}^{DL} > 10$, and $l'_{EPDCCHStart}$ is given by the CFI value+1 in subframe k of the given serving cell when $N_{RB}^{DL} \leq 10$

- if subframe k is indicated by the higher layer parameter *mbsfn-SubframeConfigList-r11* (defined in Subclause 9.1.4.3), or if subframe k is subframe 1 or 6 for frame structure type 2,

  - $l_{EPDCCHStart} = \min(2, l'_{EPDCCHStart})$,

- otherwise

  - $l_{EPDCCHStart} = l'_{EPDCCHStart}$.

If a serving cell is a LAA Scell, and if the higher layer parameter *subframeStartPosition* for the Scell indicates 's07'

- for monitoring EPDCCH candidates starting in the first slot of the subframe, the starting OFDM symbol for EPDCCH is given by index $l_{EPDCCHStart}$ in the first slot in a subframe;

- for monitoring EPDCCH candidates starting in the second slot of the subframe, the starting OFDM symbol for EPDCCH is given by index $l_{EPDCCHStart}$ in the second slot in a subframe;

otherwise

- the starting OFDM symbol for EPDCCH is given by index $l_{EPDCCHStart}$ in the first slot in a subframe.

9.1.4.2 Antenna ports quasi co-location for EPDCCH

For a given serving cell, if the UE is configured via higher layer signalling to receive PDSCH data transmissions according to transmission modes 1-9, and if the UE is configured to monitor EPDCCH,

- the UE may assume the antenna ports 0 – 3, 107 – 110 of the serving cell are quasi co-located (as defined in [3]) with respect to Doppler shift, Doppler spread, average delay, and delay spread.

For a given serving cell, if the UE is configured via higher layer signalling to receive PDSCH data transmissions according to transmission mode 10, and if the UE is configured to monitor EPDCCH, for each EPDCCH-PRB-set,

- if the UE is configured by higher layers to decode PDSCH according to quasi co-location Type-A as described in Subclause 7.1.10

  - the UE may assume the antenna ports 0 – 3, 107 – 110 of the serving cell are quasi co-located (as defined in [3]) with respect to Doppler shift, Doppler spread, average delay, and delay spread.

- if the UE is configured by higher layers to decode PDSCH according to quasi co-location Type-B as described in Subclause 7.1.10

  - the UE may assume antenna ports 15 – 22 corresponding to the higher layer parameter *qcl-CSI-RS-ConfigNZPId-r11* (defined in Subclause 9.1.4.3) and antenna ports 107-110 are quasi co-located (as defined in [3]) with respect to Doppler shift, Doppler spread, average delay, and delay spread.

9.1.4.3 Resource mapping parameters for EPDCCH

For a given serving cell, if the UE is configured via higher layer signalling to receive PDSCH data transmissions according to transmission mode 10, and if the UE is configured to monitor EPDCCH, for each EPDCCH-PRB-set, the UE shall use the parameter set indicated by the higher layer parameter *re-MappingQCL-ConfigId-r11* for determining the EPDCCH RE mapping (defined in Subclause 6.8A.5 of [3]) and EPDCCH antenna port quasi co-location. The following parameters for determining EPDCCH RE mapping (as described in Subclause 6.8A.5 of [3]) and EPDCCH antenna port quasi co-location are included in the parameter set:

- *crs-PortsCount-r11*.

- *crs-FreqShift-r11*.
- *mbsfn-SubframeConfigList-r11*.
- *csi-RS-ConfigZPId-r11*.
- *pdsch-Start-r11*.
- *qcl-CSI-RS-ConfigNZPId-r11*.
- *csi-RS-ConfigZPId2-r12* if the UE is configured with CSI subframe sets $C_{\mathrm{CSI},0}$ and $C_{\mathrm{CSI},1}$ by the higher layer parameter *csi-SubframePatternConfig-r12* for the serving cell or the UE is configured with higher layer parameter *eMIMO-Type* for TDD serving cell.

9.1.4.4 PRB-pair indication for EPDCCH

For BL/CE UEs and USS, following is applied in the rest of this Subclause.

- $N'^{X_p}_{\mathrm{RB}}$ is used in place of $N^{X_p}_{\mathrm{RB}}$.
- If $N'^{X_p}_{\mathrm{RB}}$=2+4, PRB-pairs of the 2 PRB set is obtained using *resourceBlockAssignment-r11* and the procedure described in the rest of this Subclause. PRB-pairs of the 4 PRB set is the remaining 4 PRB-pairs in PRB-pairs in MPDCCH-PRB-set p. If $N'^{X_p}_{\mathrm{RB}}$=2, PRB-pairs of the 2 PRB set is obtained using *resourceBlockAssignment-r11* and the procedure described in the rest of this Subclause. If $N'^{X_p}_{\mathrm{RB}}$=4, PRB-pairs of the 4 PRB set is obtained using *resourceBlockAssignment-r11* and the procedure described in the rest of this Subclause.
- N^{DL}_{RB} is set to 6.

For a given serving cell, for each EPDCCH-PRB-pair set/MPDCCH-PRB-pair set p, the UE is configured with a higher layer parameter *resourceBlockAssignment-r11* indicating a combinatorial index r corresponding to the PRB index $\{k_i\}_{i=0}^{N^{X_p}_{RB}-1}$, ($1 \le k_i \le N^{DL}_{RB}$, $k_i < k_{i+1}$) and given by equation $r = \sum_{i=0}^{N^{X_p}_{RB}-1} \left\langle \begin{matrix} N^{DL}_{RB} - k_i \\ N^{X_p}_{RB} - i \end{matrix} \right\rangle$, where N^{DL}_{RB} is the number of PRB pairs associated with the downlink bandwidth, $N^{X_p}_{\mathrm{RB}}$ is the number of PRB-pairs constituting EPDCCH-PRB-set/MPDCCH-PRB-pair set p, and is configured by the higher layer parameter *numberPRBPairs-r11*, and $\left\langle \begin{matrix} x \\ y \end{matrix} \right\rangle = \begin{cases} \binom{x}{y} & x \ge y \\ 0 & x < y \end{cases}$ is the extended binomial coefficient, resulting in unique label $r \in \left\{0,\ldots,\binom{N^{DL}_{RB}}{N^{X_p}_{RB}} - 1\right\}$.

9.1.5 MPDCCH assignment procedure

A BL/CE UE shall monitor a set of MPDCCH candidates on one or more Narrowbands (described in Subclause 6.2.7 of [3]) as configured by higher layer signalling for control information, where monitoring implies attempting to decode each of the MPDCCHs in the set according to all the monitored DCI formats. The Narrowband in a subframe used for MPDCCH monitoring is determined as described in [3].

A UE that is not a BL/CE UE is not required to monitor MPDCCH.

A BL/CE UE can derive the configuration of one or two MPDCCH-PRB-sets for MPDCCH monitoring from higher layer signalling. The PRB-pairs corresponding to MPDCCH-PRB-set $p = 0$ are indicated by higher layers. Each MPDCCH-PRB-set consists of set of ECCEs numbered from 0 to $N'_{ECCE,p,k} - 1$ where $N'_{ECCE,p,k}$ is the number of ECCEs in MPDCCH-PRB-set p of subframe k.

The MPDCCH-PRB-set(s) can be configured by higher layers for either localized MPDCCH transmission or distributed MPDCCH transmission.

The set of MPDCCH candidates to monitor are defined in terms of MPDCCH search spaces.

The BL/CE UE shall monitor one or more of the following search spaces

- a Type0-MPDCCH common search space if configured with CEmodeA,
- a Type1-MPDCCH common search space,
- a Type1A-MPDCCH common search space,
- a Type2-MPDCCH common search space,
- a Type2A-MPDCCH common search space, and
- a MPDCCH UE-specific search space.

A BL/CE UE configured with CEModeB is not required to monitor Type0-MPDCCH common search space.

The BL/CE UE is not required to simultaneously monitor MPDCCH UE-specific search space and Type1-MPDCCH common search space.

The BL/CE UE is not required to simultaneously monitor MPDCCH UE-specific search space and Type2-MPDCCH common search space.

The BL/CE UE is not required to monitor Type1A-MPDCCH common search space or Type2A-MPDCCH common search space if the set of subframes comprising the search space include any subframes in which it monitors Type1-MPDCCH common search space or any subframes in which the UE receives PDSCH assigned by PDCCH with DCI CRC scrambled by P-RNTI.

The BL/CE UE is not required to monitor Type2A-MPDCCH common search space if the set of subframes comprising the search space include any subframes in which it monitors Type1A-MPDCCH common search space or any subframes in which the UE receives PDSCH assigned by MPDCCH with DCI CRC scrambled by SC-RNTI.

A BL/CE UE is not expected to monitor an MPDCCH candidate, if an ECCE corresponding to that MPDCCH candidate is mapped to a PRB pair that overlaps with a transmission of PDSCH scheduled previously in the same subframe.

For aggregation level $L'=24$ or $L'=12$ ECCEs, the number of ECCEs refers to the MPDCCH mapping to the REs of the 2+4 PRB set as defined in [3]. An MPDCCH search space $MS_k^{(L',R)}$ at aggregation level $L' \in \{1,2,4,8,16,12,24\}$ and repetition level $R \in \{1,2,4,8,16,32,64,128,256\}$ is defined by a set of MPDCCH candidates where each candidate is repeated in a set of R consecutive BL/CE downlink subframes starting with subframe k. For an MPDCCH-PRB-set p, the ECCEs corresponding to MPDCCH candidate *m* of the search space $MS_k^{(L',R)}$ are given by

$$L'\left\{ (Y_{p,k} + \left\lfloor \frac{m \cdot N'_{ECCE,p,k}}{L' \cdot M'^{(L')}_p} \right\rfloor) \bmod \left\lfloor N'_{\mathrm{ECCE},p,k} / L' \right\rfloor \right\} + i$$

where

$i = 0,\ldots,L'-1$

$m = 0,1,\ldots M'^{(L')}_p - 1,$

$M'^{(L')}_p$ is the number of MPDCCH candidates to monitor at aggregation level L' in MPDCCH-PRB-set p in each subframe in the set of R consecutive subframes.

$Y_{p,k}$ for MPDCCH UE-specific search space is determined as described in Subclause 9.1.4, and $Y_{p,k} = 0$ for Type0-MPDCCH common search space, Type1-MPDCCH common search space and Type2-MPDCCH common search space.

For $R > 1$, if subframe k is a special subframe that does not support MPDCCH according to table 6.8B.1-1 in [3], the UE shall calculate $N'_{ECCE,p,k}$ by assuming $N_{\text{EREG}}^{\text{ECCE}} = 4$ for normal cyclic prefix and $N_{\text{EREG}}^{\text{ECCE}} = 8$ for extended cyclic prefix.

A BL/CE UE is not expected to monitor MPDCCH in subframes that are not BL/CE DL subframes.

Until BL/CE UE receives higher layer configuration of MPDCCH UE-specific search space, the BL/CE UE monitors MPDCCH according to the same configuration of MPDCCH search space and Narrowband as that for MPDCCH scheduling Msg4.

The aggregation and repetition levels defining the MPDCCH search spaces and the number of monitored MPDCCH candidates are given as follows:

For MPDCCH UE-specific search space

- if the BL/CE UE is configured with $N'^{X_p}_{\text{RB}}$=2 or $N'^{X_p}_{\text{RB}}$=4 PRB-pairs, and *mPDCCH-NumRepetition*=1, and
  - if the MPDCCH-PRB-set is configured for distributed transmission, the aggregation levels defining the search spaces and the number of monitored MPDCCH candidates are listed in Table 9.1.4-1a and Table 9.1.4-1b, where L is substituted with L' for $L \leq 24$, and $N_{\text{RB}}^{X_p}$ is substituted with $N'^{X_p}_{\text{RB}}$.
  - if the MPDCCH-PRB-set is configured for localized transmission, the aggregation levels defining the search spaces and the number of monitored MPDCCH candidates are listed in Table 9.1.4-2a and Table 9.1.4-2b, where L is substituted with L' and $N_{\text{RB}}^{X_p}$ is substituted with $N'^{X_p}_{\text{RB}}$.
- otherwise
  - if the UE is configured with CEModeA, and $N'^{X_p}_{\text{RB}}$=2 or $N'^{X_p}_{\text{RB}}$=4, the aggregation and repetition levels defining the search spaces and the number of monitored MPDCCH candidates are listed in Table 9.1.5-1a
  - if the UE is configured with CEModeA, and $N'^{X_p}_{\text{RB}}$=2+4 , the aggregation and repetition levels defining the search spaces and the number of monitored MPDCCH candidates are listed in Table 9.1.5-1b
  - if the UE is configured with CEModeB, and $N'^{X_p}_{\text{RB}}$=2 or $N'^{X_p}_{\text{RB}}$=4, the aggregation and repetition levels defining the search spaces and the number of monitored MPDCCH candidates are listed in Table 9.1.5-2a
  - if the UE is configured with CEModeB, and $N'^{X_p}_{\text{RB}}$=2+4 , the aggregation and repetition levels defining the search spaces and the number of monitored MPDCCH candidates are listed in Table 9.1.5-2b

$N'^{X_p}_{\text{RB}}$ is the number of PRB-pairs configured for MPDCCH UE-specific search space. When $N'^{X_p}_{\text{RB}}$=2+4, it is given by the higher layer parameter *numberPRB-Pairs-r13*, and when $N'^{X_p}_{\text{RB}}$=2 or $N'^{X_p}_{\text{RB}}$=4, it is given by the higher layer parameter *numberPRB-Pairs-r11*.

$r1$, $r2$, $r3$, $r4$ are determined from Table 9.1.5-3 by substituting the value of $r_{\max}$ with the value of higher layer parameter *mPDCCH-NumRepetition*.

The PRB-pairs within a Narrowband corresponding to an MPDCCH-PRB-set are indicated by higher layers and are determined using the description given in Subclause 9.1.4.4.

If higher layer configuration *numberPRB-Pairs-r13* for MPDCCH-PRB-set p is 6, $N'^{X_p}_{\text{RB}}$=2+4, and the number of PRB-pairs in an MPDCCH-PRB-set p = 2+4.

If Type2-MPDCCH common search space or Type2A-MPDCCH common search space,

- PRB-pairs of the 2 PRB set in the 2+4 PRB set correspond to PRB-pairs with the largest two PRB indices in MPDCCH-PRB-set p.

- PRB-pairs of the4 PRB set in the 2+4 PRB set correspond to PRB-pairs with the smallest 4 PRB indices in MPDCCH-PRB-set p.

- PRB-pairs of the 2+4 PRB set in the 2+4 PRB set correspond to all PRB-pairs in MPDCCH-PRB-set p

Table 9.1.5-1a: MPDCCH candidates monitored by a BL/CE UE (CEModeA, MPDCCH-PRB-set size – 2PRBs or 4PRBs)

$N'^{X_p}_{RB}$	R	$M'^{(L')}_p$				
		L'=2	L'=4	L'=8	L'=16	L'=24
2	r1	2	1	1	0	0
4		1	1	1	1	0
2	r2	2	1	1	0	0
4		1	1	1	1	0
2	r3	2	1	1	0	0
4		1	1	1	1	0
2	r4	2	1	1	0	0
4		1	1	1	1	0

Table 9.1.5-1b: MPDCCH candidates monitored by a BL/CE UE (CEModeA, MPDCCH-PRB-set size – 2+4PRBs)

MPDCCH PRB set	R	$M'^{(L')}_p$				
		L'=2	L'=4	L'=8	L'=16	L'=24
2 PRB set in 2+4 PRB set	r1	1	1	0	0	0
4 PRB set in 2+4 PRB set		0	0	2	1	0
Both PRB sets in 2+4 PRB set		0	0	0	0	1
2 PRB set in 2+4 PRB set	r2	0	1	1	0	0
4 PRB set in 2+4 PRB set		0	0	2	1	0
Both PRB sets in 2+4 PRB set		0	0	0	0	1
2 PRB set in 2+4 PRB set	r3	0	0	0	0	0
4 PRB set in 2+4 PRB set		0	0	1	1	0
Both PRB sets in 2+4 PRB set		0	0	0	0	1
2 PRB set in 2+4 PRB set	r4	0	0	0	0	0
4 PRB set in 2+4 PRB set		0	0	0	0	0
Both PRB sets in 2+4 PRB set		0	0	0	0	1

Table 9.1.5-2a: MPDCCH candidates monitored by a BL/CE UE (CEModeB, MPDCCH-PRB-set size – 2PRBs or 4PRBs)

$N'^{X_p}_{RB}$	R	$M'^{(L')}_p$				
		L'=2	L'=4	L'=8	L'=16	L'=24
2	r1	0	0	1	0	0
4		0	0	1	1	0
2	r2	0	0	1	0	0
4		0	0	1	1	0
2	r3	0	0	1	0	0
4		0	0	1	1	0
2	r4	0	0	1	0	0
4		0	0	1	1	0

Table 9.1.5-2b: MPDCCH candidates monitored by a BL/CE UE (CEModeB, MPDCCH-PRB-set size – 2+4PRBs)

MPDCCH PRB set	R	$M_p^{'(L')}$				
		L'=2	L'=4	L'=8	L'=16	L'=24
2 PRB set in 2+4 PRB set	r1	0	0	1	0	0
4 PRB set in 2+4 PRB set		0	0	0	1	0
Both PRB sets in 2+4 PRB set		0	0	0	0	1
2 PRB set in 2+4 PRB set	r2	0	0	1	0	0
4 PRB set in 2+4 PRB set		0	0	0	1	0
Both PRB sets in 2+4 PRB set		0	0	0	0	1
2 PRB set in 2+4 PRB set	r3	0	0	1	0	0
4 PRB set in 2+4 PRB set		0	0	0	1	0
Both PRB sets in 2+4 PRB set		0	0	0	0	1
2 PRB set in 2+4 PRB set	r4	0	0	1	0	0
4 PRB set in 2+4 PRB set		0	0	0	1	0
Both PRB sets in 2+4 PRB set		0	0	0	0	1

Table 9.1.5-3: Determination of repetition levels

r_{max}	$r1$	$r2$	$r3$	$r4$
1	1	-	-	-
2	1	2	-	-
4	1	2	4	-
>=8	$r_{max}/8$	$r_{max}/4$	$r_{max}/2$	r_{max}

Table 9.1.5-4: Repetition levels for Type1/1A-MPDCCH common search space

r_{max}	$r1$	$r2$	$r3$	$r4$
256	2	16	64	256
128	2	16	64	128
64	2	8	32	64
32	1	4	16	32
16	1	4	8	16
8	1	2	4	8
4	1	2	4	-
2	1	2	-	-
1	1	-	-	-

For Type0-MPDCCH common search space, the narrowband location and the MPDCCH-PRB-set p are the same as for MPDCCH UE-specific search space, and

- if $N_{RB}^{'X_p}$=2,
  - $M_p^{'(L')}$=1 for L'=8 and repetition levels $r1, r2, r3, r4$ given in Table 9.1.5.-3. For all other cases, $M_p^{'(L')}$=0
- if $N_{RB}^{'X_p}$=4,
  - $M_p^{'(L')}$=1 for L'=16 and repetition levels $r1, r2, r3, r4$ given in Table 9.1.5.-3. For all other cases, $M_p^{'(L')}$=0
- if $N_{RB}^{'X_p}$=2+4,

- $M_p^{'(L')}$=1 for L'=24 and repetition levels $r1, r2, r3, r4$ given in Table 9.1.5.-3. For all other cases, $M_p^{'(L')}$=0

where $r1, r2, r3, r4$ are determined from Table 9.1.5-3 by substituting the value of r_{max} with the value of higher layer parameter *mPDCCH-NumRepetition*.

For Type1-MPDCCH common search space and Type1A-MPDCCH common search space, the number of PRB-pairs in MPDCCH-PRB-set p is 2+4 PRB-pairs, and

- $M_p^{'(L')}$=1 for L'=24 and repetition levels $r1, r2, r3, r4$ where the repetition levels are determined from Table 9.1.5-4 by substituting the value of r_{max}
  - with higher layer parameter *mPDCCH-NumRepetition-Paging* for Type1-MPDCCH common search space, and
  - with higher layer parameter *mpdcch-NumRepetitions-SC-MCCH* for Type1A-MPDCCH common search space.
- For all other cases, $M_p^{'(L')}$=0

For Type2-MPDCCH common search space, the number of PRB-pairs in MPDCCH-PRB-set p is 2+4 PRB-pairs, and

- If the most recent coverage enhancement level used for PRACH is coverage enhancement level 0 and 1, the aggregation and repetition levels defining the search spaces and the number of monitored MPDCCH candidates are determined from Table 9.1.5-1b, by assuming that the number of candidates for L'<8 as zero.
- If the most recent coverage enhancement level used for PRACH is coverage enhancement level 2 and 3, the aggregation and repetition levels defining the search spaces and the number of monitored MPDCCH candidates are determined from Table 9.1.5-2b.

where $r1, r2, r3, r4$ are determined from Table 9.1.5-3 by substituting the value of r_{max} with the value of higher layer parameter *mPDCCH-NumRepetition-RA*.

For Type2A-MPDCCH common search space, the number of PRB-pairs in MPDCCH-PRB-set p is 2+4 PRB-pairs, and

- for CEModeA, the aggregation and repetition levels defining the search spaces and the number of monitored MPDCCH candidates are determined from Table 9.1.5-1b, by assuming that the number of candidates for L'<8 as zero,
- for CEModeB, the aggregation and repetition levels defining the search spaces and the number of monitored MPDCCH candidates are determined from Table 9.1.5-2b,

where $r1, r2, r3, r4$ are determined from Table 9.1.5-3 by substituting the value of r_{max} with the value of higher layer parameter *mpdcch-NumRepetitions-SC-MTCH*.

In tables 9.1.5-1a, 9.1.5-1b, 9.1.5-2a, 9.1.5-2b, and for Type0, Type1, Type1A, Type2, Type2A MPDCCH common search space, L' is applied for $N_{\text{EREG}}^{\text{ECCE}}$=4, and L'' is applied for $N_{\text{EREG}}^{\text{ECCE}}$=8 wherein $L''=L'/2$ substituting the values of L'.

For Type1-MPDCCH common search space, Type1A-MPDCCH common search space, Type2-MPDCCH common search space and Type2A-MPDCCH common search space, distributed MPDCCH transmission is used.

For MPDCCH UE-specific search space, Type0-MPDCCH common search space, Type1A-MPDCCH common search space, Type2-MPDCCH common search space and Type2A-MPDCCH common search space locations of starting

subframe k are given by $k = k_b$ where k_b is the b^{th} consecutive BL/CE DL subframe from subframe $k0$, and $b = u \cdot rj$, and $u = 0,1,\ldots \frac{r_{\max}}{rj} - 1$, and $j \in \{1,2,3,4\}$, where

- subframe $k0$ is a subframe satisfying the condition $(10n_{\text{f}} + \lfloor n_{\text{s}}/2 \rfloor) \bmod T = \lfloor \alpha_{offset} \cdot T \rfloor$, where $T = r_{\max} \cdot G$
  - For MPDCCH UE-specific search space, and Type0-MPDCCH common search space, G is given by the higher layer parameter *mPDCCH-startSF-UESS*,
  - For Type1A-MPDCCH common search space, G is given by the higher layer parameter *mpdcch-startSF-SC-MCCH*
  - For Type2-MPDCCH common search space, G is given by the higher layer parameter *mPDCCH-startSF-CSS-RA-r13*
  - For Type2A-MPDCCH common search space, G is given by the higher layer parameter *mpdcch-startSF-SC-MTCH*
- α_{offset} is given by higher layer parameter *mpdcch-Offset-SC-MTCH* for Type2A-MPDCCH common search space, and $\alpha_{offset} = 0$ otherwise; and
- $r_{\max}$ is given by higher layer parameter *mPDCCH-NumRepetition* for MPDCCH UE-specific search space and Type0-MPDCCH common search space, and *mPDCCH-NumRepetition-RA* for Type2-MPDCCH common search space, and *mpdcch-NumRepetitions-SC-MCCH* for Type1A-MPDCCH common search space, and *mpdcch-NumRepetitions-SC-MTCH* for Type2A-MPDCCH common search space and
- $r1$, $r2$, $r3$, $r4$ are given in Table 9.1.5-3.

A BL/CE UE is not expected to be configured with values of $r_{\max}$ and G that result in non-integer values of T.

For Type1-MPDCCH common search space, $k = k0$ and is determined from locations of paging opportunity subframes,

If *SystemInformationBlockType1-BR* or SI message is transmitted in one narrowband in subframe k, a BL/CE UE shall assume MPDCCH in the same narrowband in the subframe k is dropped.

The BL/CE UE is not required to monitor an MPDCCH search space if any ECCEs corresponding to any of its MPDCCH candidates occur within a frame before $n_f = 0$ and also occur within frame $n_f \geq 0$.

The BL/CE UE is not expected to be configured with overlapping MPDCCH search spaces.

For MPDCCH UE-specific search space or for Type0-MPDCCH common search space if the higher layer parameter *mPDCCH-NumRepetition* is set to 1; or for Type2-MPDCCH common search space if the higher layer parameter *mPDCCH-NumRepetition-RA* is set to 1; or for Type2A-MPDCCH common search space if the higher layer parameter *mpdcch-NumRepetitions-SC-MTCH* is set to 1;

- The BL/CE UE is not required to monitor MPDCCH
  - For TDD and normal downlink CP, in special subframes for the special subframe configurations 0 and 5 shown in Table 4.2-1 of [3]
  - For TDD and extended downlink CP, in special subframes for the special subframe configurations 0, 4 and 7 shown in Table 4.2-1 of [3];

otherwise

- The BL/CE UE is not required to monitor MPDCCH
  - For TDD, in special subframes, if the BL/CE UE is configured with CEModeB

- For TDD and normal downlink CP, in special subframes for the special subframe configurations 0, 1, 2, 5, 6, 7, 9 and 10 shown in Table 4.2-1 of [3], if the BL/CE UE is configured with CEModeA
- For TDD and extended downlink CP, in special subframes for the special subframe configurations 0, 4, 7, 8, 9 and 10 shown in Table 4.2-1 of [3], if the BL/CE UE is configured with CEModeA.
- For TDD, in special subframes, for MPDCCH in Type1/1A-MPDCCH common search space.

The number of MPDCCH repetitions is indicated in the 'DCI subframe repetition number' field in the DCI according to the mapping in Table 9.1.5-5.

Table 9.1.5-5: Mapping for DCI subframe repetition number

R	DCI subframe repetition number
$r1$	00
$r2$	01
$r3$	10
$r4$	11

9.1.5.1 MPDCCH starting position

The starting OFDM symbol for MPDCCH given by index $l_{MPDCCHStart}$ in the first slot in a subframe k and is determined as follows

- $l'_{MPDCCHStart}$ is given by the higher layer parameter *startSymbolBR*
- if subframe k is a special subframe or configured as an MBSFN subframe, and if the BL/CE UE is configured in CEModeA
  - $l_{MPDCCHStart} = \min\left(2, l'_{MPDCCHStart}\right)$
- else
  - $l_{MPDCCHStart} = l'_{MPDCCHStart}$.

9.1.5.2 Antenna ports quasi co-location for MPDCCH

Regardless of transmission modes configuration of PDSCH data transmissions, the BL/CE UE may assume the antenna ports 0 – 3, 107 – 110 of the serving cell are quasi co-located (as defined in [3]) with respect to Doppler shift, Doppler spread, average delay, and delay spread.

9.2 PDCCH/EPDCCH/MPDCCH validation for semi-persistent scheduling

A UE shall validate a Semi-Persistent Scheduling assignment PDCCH only if all the following conditions are met:

- the CRC parity bits obtained for the PDCCH payload are scrambled with the Semi-Persistent Scheduling C-RNTI or UL-SPS-V-RNTI
- the new data indicator field is set to '0'. In case of DCI formats 2, 2A, 2B, 2C and 2D, the new data indicator field refers to the one for the enabled transport block.

A UE shall validate a Semi-Persistent Scheduling assignment EPDCCH only if all the following conditions are met:

- the CRC parity bits obtained for the EPDCCH payload are scrambled with the Semi-Persistent Scheduling C-RNTI or UL-SPS-V-RNTI
- the new data indicator field is set to '0'. In case of DCI formats 2, 2A, 2B, 2C and 2D, the new data indicator field refers to the one for the enabled transport block.

A UE shall validate a Semi-Persistent Scheduling assignment MPDCCH only if all the following conditions are met:

- the CRC parity bits obtained for the MPDCCH payload are scrambled with the Semi-Persistent Scheduling C-RNTI
- the new data indicator field is set to '0'.

Validation is achieved if all the fields for the respective used DCI format are set according to Table 9.2-1 or Table 9.2-1A, 9.2-1B, 9.2-1C.

If validation is achieved, the UE shall consider the received DCI information accordingly as a valid semi-persistent activation or release. If the valid DCI format 0 is scrambled with UL-SPS-V-RNTI, the UE shall consider the received DCI information as a valid semi-persistent activation or release only for the SPS configuration indicated by the UL SPS configuration index field.

If validation is not achieved, the received DCI format shall be considered by the UE as having been received with a non-matching CRC.

Table 9.2-1: Special fields for Semi-Persistent Scheduling Activation PDCCH/EPDCCH Validation

	DCI format 0	DCI format 1/1A	DCI format 2/2A/2B/2C/2D
TPC command for scheduled PUSCH	set to '00'	N/A	N/A
Cyclic shift DM RS	set to '000' if present	N/A	N/A
Modulation and coding scheme and redundancy version	MSB is set to '0'	N/A	N/A
HARQ process number	N/A	FDD: set to '000' TDD: set to '0000'	FDD: set to '000' TDD: set to '0000'
Modulation and coding scheme	N/A	MSB is set to '0'	For the enabled transport block: MSB is set to '0'
Redundancy version	N/A	set to '00'	For the enabled transport block: set to '00'

Table 9.2-1A: Special fields for Semi-Persistent Scheduling Release PDCCH/EPDCCH Validation

	DCI format 0	DCI format 1A
TPC command for scheduled PUSCH	set to '00'	N/A
Cyclic shift DM RS	set to '000' if present	N/A
Modulation and coding scheme and redundancy version	set to '11111'	N/A
Resource block assignment and hopping resource allocation	Set to all '1's	N/A
HARQ process number	N/A	FDD: set to '000' TDD: set to '0000'
Modulation and coding scheme	N/A	set to '11111'
Redundancy version	N/A	set to '00'
Resource block assignment	N/A	Set to all '1's

Table 9.2-1B: Special fields for Semi-Persistent Scheduling Activation MPDCCH Validation

	DCI format 6-0A	DCI format 6-1A
HARQ process number	set to '000'	FDD: set to '000' TDD: set to '0000
Redundancy version	set to '00'	set to '00'
TPC command for scheduled PUSCH	set to '00'	N/A
TPC command for scheduled PUCCH	N/A	set to '00'

Table 9.2-1C: Special fields for Semi-Persistent Scheduling Release MPDCCH Validation

	DCI format 6-0A	DCI format 6-1A
HARQ process number	set to '000'	FDD: set to '000' TDD: set to '0000
Redundancy version	set to '00'	set to '00'
Repetition number	set to '00'	set to '00'
Modulation and coding scheme	set to '1111'	set to '1111'
TPC command for scheduled PUSCH	set to '00'	N/A
Resource block assignment	Set to all '1's	Set to all '1's

For the case that the DCI format indicates a semi-persistent downlink scheduling activation, the TPC command for PUCCH field shall be used as an index to one of the four PUCCH resource values configured by higher layers, with the mapping defined in Table 9.2-2

Table 9.2-2: PUCCH resource value for downlink semi-persistent scheduling

Value of 'TPC command for PUCCH'	$n_{\mathrm{PUCCH}}^{(1,p)}$
'00'	The first PUCCH resource value configured by the higher layers
'01'	The second PUCCH resource value configured by the higher layers
'10'	The third PUCCH resource value configured by the higher layers
'11'	The fourth PUCCH resource value configured by the higher layers

9.3 PDCCH/EPDCCH/MPDCCH control information procedure

A UE shall discard the PDCCH/EPDCCH/MPDCCH if consistent control information is not detected.