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Technical Specification

3rd Generation Partnership Project;
Technical Specification Group Radio Access Network;
NR;
User Equipment (UE) radio transmission and reception;
Part 4: Performance requirements
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3GPP

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Contents

Foreword

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

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

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where:

- x the first digit:
  - 1 presented to TSG for information;
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  - 3 or greater indicates TSG approved document under change control.
- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
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1 Scope

The present document establishes the minimum performance requirements for NR User Equipment (UE).

2 References

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

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

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

[2] 3GPP TS 38.521-4: "NR; User Equipment (UE) radio transmission and reception; Part 4: Performance requirements".

[3] Recommendation ITU-R M.1545: "Measurement uncertainty as it applies to test limits for the terrestrial component of International Mobile Telecommunications-2000".

[4] 3GPP TS 36.101: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception".

[5] 3GPP TR 38.901: "Study on channel model for frequencies from 0.5 to 100 GHz".

[6] 3GPP TS 38.101-1: "NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone".

[7] 3GPP TS 38.101-2: "NR; User Equipment (UE) radio transmission and reception; Part 2: Range 2 Standalone".

[8] 3GPP TS 38.101-3: "NR; User Equipment (UE) radio transmission and reception; Part 3: Range 1 and Range 2 Interworking operation with other radios".

[9] 3GPP TS 38.211: "NR; Physical channels and modulation".

[10] 3GPP TS 38.212: "NR; Multiplexing and channel coding".

[11] 3GPP TS 38.213: "NR; Physical layer procedures for control ".

[12] 3GPP TS 38.214: "NR; Physical layer procedures for data".

[13] 3GPP TS 37.340: "Evolved Universal Terrestrial Radio Access (E-UTRA) and NR; Multi-connectivity", Stage 2.

[14] 3GPP TS 38.306: "NR; User Equipment (UE) radio access capabilities".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

DL BWP: DL bandwidth part as defined in TS 38.213 [11].

EN-DC: E-UTRA-NR Dual Connectivity as defined in TS 37.340 [13, Section 4.1.2].

FR1: Frequency range 1 as defined in TS 38.101-3 [8, Section 5.1].

FR2: Frequency range 2 as defined in TS 38.101-3 [8, Section 5.1].

SSB: SS/PBCH block as defined in TS 38.211 [9, Section 7.8.3].

3.2 Symbols

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

μ Subcarrier spacing configuration as defined in TS 38.211 [9, Section 4.2]

N_{oc} The power spectral density of a white noise source with average power per RE normalized to the subcarrier spacing as defined in Section 4.4.3 for conducted requirements and Section 4.5.3 for radiated requirements

3.3 Abbreviations

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

CA	Carrier Aggregation
CC	Component Carrier
CCE	Control Channel Element
CORESET	Control Resource Set
CP	Cyclic Prefix
CSI	Channel-State Information
CSI-IM	CSI Interference Measurement
CSI-RS	CSI Reference Signal
CW	Codeword
CQI	Channel Quality Indicator
CRC	Cyclic Redundancy Check
CRI	CSI-RS Resource Indicator
DC	Dual Connectivity
DCI	Downlink Control Information
DL	Downlink
DMRS	Demodulation Reference Signal
EPRE	Energy Per Resource Element
EN-DC	E-UTRA-NR Dual Connectivity
FR	Frequency Range
FRC	Fixed Reference Channel
HARQ	Hybrid Automatic Repeat Request
LI	Layer Indicator
MAC	Medium Access Control
MCS	Modulation and Coding Scheme
MIB	Master Information Block
NR	New Radio
NSA	Non-Standalone Operation Mode
OCNG	OFDMA Channel Noise Generator
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
PBCH	Physical Broadcast Channel
Pcell	Primary Cell
PDCCH	Physical Downlink Control Channel
PDSCH	Physical Downlink Shared Channel

PMI	Precoding Matrix Indicator
PRB	Physical Resource Block
PRG	Physical resource block group
PSS	Primary Synchronization Signal
PTRS	Phase Tracking Reference Signal
PUCCH	Physical Uplink Control Channel
PUSCH	Physical Uplink Shared Channel
QCL	Quasi Co-location
RB	Resource Block
RBG	Resource Block Group
RE	Resource Element
REG	Resource Element Group
RI	Rank Indicator
RRC	Radio Resource Control
SA	Standalone operation mode
SCS	Subcarrier Spacing
SINR	Signal-to-Interference-and-Noise Ratio
SNR	Signal-to-Noise Ratio
SS	Synchronization Signal
SSB	Synchronization Signal Block
SSS	Secondary Synchronization Signal
TCI	Transmission Configuration Indicator
TDM	Time division multiplexing
TTI	Transmission Time Interval
UL	Uplink
VRB	Virtual Resource Block

4 General

4.1 Relationship between minimum requirements and test requirements

The present document is a Single-RAT and interwork specification for NR UE, covering minimum performance requirements of both conducted and radiated requirements. Conformance to the present specification is demonstrated by fulfilling the test requirements specified in the conformance specification TS 38.521-4 [2].

The Minimum Requirements given in this specification make no allowance for measurement uncertainty. The test specification TS 38.521-4 [2] defines test tolerances. These test tolerances are individually calculated for each test. The test tolerances are used to relax the minimum requirements in this specification to create test requirements.

The measurement results returned by the test system are compared – without any modification – against the test requirements as defined by the shared risk principle.

The shared risk principle is defined in Recommendation ITU-R M.1545 [3].

The applicability of each requirement is described under each sub-clause in [5.1, 6.1, 7.1 and 8.1].

4.2 Applicability of minimum requirements

The conducted minimum requirements specified in this specification shall be met in all applicable scenarios for FR1. The radiated minimum requirements specified in this specification shall be met in all applicable scenarios for FR2. The interwork minimum requirement specified in this specification shall be met in all applicable scenarios for NR interworking operation.

All minimum performance requirements defined in Sections 5-8 are applicable to both SA and NSA unless otherwise explicitly stated in Section 9 and 10.

All minimum performance requirements defined in Sections 5-10 are applicable to all UE power classes unless otherwise stated.

4.3 Specification suffix information

Unless stated otherwise the following suffixes are used for indicating at 2nd level subclause, shown in table 4.3-1.

Table 4.3-1: Definition of suffixes

Clause suffix	Variant
None	Single Carrier
A	Carrier Aggregation (CA)
B	Dual-Connectivity (DC)
C	Supplement Uplink (SUL)

A terminal which supports the above features needs to meet the requirement defined in the additional subclause (suffix A, B, C) in clauses 5, 6, 7, 8, 9, 10.

4.4 Conducted requirements

4.4.1 Conducted requirement reference point

The reference point for SNR and Noc of DL signal is the UE antenna connector or connectors.

4.4.2 SNR definition

UE demodulation and CSI requirements define the SNR as:

$$SNR = \frac{\sum_{j=1}^{N_{RX}} \hat{E}_s^{(j)}}{\sum_{j=1}^{N_{RX}} N_{oc}^{(j)}}$$

N_{RX} denotes the number of receiver antenna connectors and the superscript receiver antenna connector j.

The above SNR definition assumes that the REs are not precoded, and does not account for any gain which can be associated to the precoding operation.

E_s denotes the averaged received energy per resource element (EPRE) of the wanted signal. Unless otherwise stated, the SNR refers to the SSS wanted signal. The downlink SSS transmit power is defined as the linear average over the power contributions in [W] of all resource elements that carry the SSS within the operating system bandwidth.

The power ratio of other wanted signals to the SSS is defined in each requirement.

N_{oc} denotes the power spectral density of a white noise source, with average power per RE normalized to the subcarrier spacing.

4.4.3 Noc

Unless otherwise stated, the spectral density of Noc is [-142dBm/Hz].

4.5 Radiated requirements

4.5.1 Radiated requirement reference point

The reference point for SNR and Noc of DL signal from the UE perspective is the input of UE antenna array.

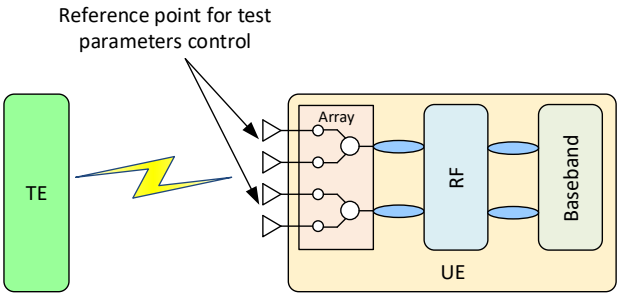

Figure 4.5.1-1: Reference point for radiated Demodulation and CSI requirements

Radiated performance requirements are specified at the Reference point, with signal-to-noise ratio (SNR) $SNR_{RP} = SNR_{BB} + \Delta_{BB}$

where SNR_{BB} is the baseband SNR level specified by the Minimum performance requirement in clause 7, 8, 9 and 10, and Δ_{BB} is specified in clause 4.5.3.2. The noise spectral density for Noc is specified in Table 4.5.3.2-1.

4.5.2 SNR definition

UE demodulation and CSI requirements define the SNR as:

$$SNR_{<signal>} = \frac{\sum_{j=1}^{N_{RX}} \hat{E}_{<signal>}^{(j)}}{\sum_{j=1}^{N_{RX}} N_{oc}^{(j)}}$$

N_{RX} denotes the number of receiver reference points, and the super script receiver reference point j.

The above SNR definition assumes that the REs are not precoded, and does not account for any gain which can be associated to the precoding operation.

$\hat{E}_{<signal>}$ denotes the averaged received energy per resource element (EPRE) of the wanted signal. Unless otherwise stated, the SNR refers to the SSS wanted signal. The downlink SSS transmit power is defined as the linear average over the power contributions in [W] of all resource elements that carry the SSS within the operating system bandwidth.

The power ratio of other wanted signals to the SSS is defined in each requirement.

N_{oc} denotes the power spectral density of a white noise source, with average power per RE normalized to the subcarrier spacing.

4.5.3 Noc

4.5.3.1 Introduction

For radiated testing of demodulation and CSI requirements it is not feasible in practice to use signal levels high enough to make the noise contribution of the UE negligible. Demodulation requirements are therefore specified with the applied noise higher than the UE peak EIS level in TS 38.101-2 [7] by a defined amount, so that the impact of UE noise floor is limited to no greater than a value Δ_{BB} at the specified Noc level. As UEs have EIS levels that are dependent on operating band and power class, Noc level is dependent on operating band and power class.

4.5.3.2 Noc for NR operating bands in FR2

Values for Noc according to operating band and power class for single carrier requirements are specified in Table 4.5.3.2-1 for Δ_{BB} =1dB.

Table 4.5.3.2-1: Noc power level for different UE power classes and frequency bands

Operating band	UE Power class			
	1	2	3	4
n257	-166.8	-163.8	-157.6	-166.3
n258	-166.8	-163.8	-157.6	-166.3
n260	-163.8		-155.0	-164.3
n261	-166.8	-163.8	-157.6	-166.3
Note 1: Noc levels are specified in dBm/Hz				

The handling of Carrier Aggregation is FFS, and the handling of multi-band relaxation is FFS.

4.5.3.3 Derivation of Noc values for NR operating bands in FR2

The Noc values in Table 4.5.3.2-1 are based on Refsens for the Operating band and on the UE Power class, and taking a baseline of UE Power class 3 in Band n260.

$$\text{Spectral density of Noc} = \text{Refsens}_{\text{PC3, n260, 50MHz}} - 10\text{Log}_{10}(\text{SCS}_{\text{Refsens}} \times \text{PRB}_{\text{Refsens}} \times 12) - \text{SNR}_{\text{Refsens}} + \Delta_{\text{thermal}}$$

where:

$\text{Refsens}_{\text{PC3, n260, 50MHz}}$ is the Refsens value in dBm specified for Power Class 3 in Band n260 for 50MHz Channel bandwidth in TS 38.101-2 [7, Table 7.3.2.3-1].

$\text{SCS}_{\text{Refsens}}$ is a subcarrier spacing associated with N_{RB} for 50MHz in TS 38.101-2 [7, Table 5.3.2-1], chosen as 120 kHz.

$\text{PRB}_{\text{Refsens}}$ is N_{RB} associated with subcarrier spacing 120 kHz for 50MHz in TS 38.101-2 [7, Table 5.3.2-1] and is 32.

12 is the number of subcarriers in a PRB

$\text{SNR}_{\text{Refsens}}$ is the SNR used for simulation of Refsens, and is -1dB

Δ_{thermal} is the amount of dB that the wanted noise is set above UE thermal noise, giving a rise in total noise of Δ_{BB}. Δ_{thermal} is chosen as 6dB, giving a rise in total noise of 1dB.

The calculated Noc value for the baseline of UE Power class 3 in Band n260 is rounded to -155 dBm/Hz.

The following methodology to define the Noc level for power class X (PC_X) and operating band Y (Band_Y) is used for the single carrier case:

$$\text{Noc(PC\_X, Band\_Y)} = -155 \text{ dBm/Hz} + \text{Refsens}_{\text{PC\_X, Band\_Y, 50MHz}} - \text{Refsens}_{\text{PC3, n260, 50MHz}} + \Sigma MB_P$$

where Refsens and ΣMB_P values are specified in TS 38.101-2 [7].

4.5.4 Angle of arrival

Unless otherwise stated, the downlink signal and noise are aligned to arrive in the UE Rx beam peak direction as defined in TS 38.101-2 [7].

5 Demodulation performance requirements (Conducted requirements)

5.1 General

5.1.1 Applicability of requirements

5.1.1.1 General

The minimum performance requirements are applicable to all FR1 operating bands defined in [TS 38.101-1].

The minimum performance requirements in Clause 5 are mandatary for UE supporting NR operation, except test cases listed in Clause 5.1.1.3.

5.1.1.2 Applicability of requirements for different number of RX antenna ports

The number of RX antenna ports for different RF operating bands is up to UE declaration.

The UE shall support 2 or 4 RX antenna ports for different RF operating bands. The operating bands, where 4 RX antenna ports shall be the baseline, are defined in Clause 7.4 of TS 38.101-1 [6]. The UE requirements applicability for UEs with different number of RX antenna ports is defined in Table 5.1.1.2-1.

Table 5.1.1.2-1: Requirements applicability

Supported RX antenna ports	Test type	Test list
UE supports only 2RX	PDSCH	All tests in Clause 5.2.2
	PDCCH	All tests in Clause 5.3.2
	PBCH	All tests in Clause 5.4.2
UE supports only 4RX or both 2RX and 4RX	PDSCH	All tests in Clause 5.2.3
	PDCCH	All tests in Clause 5.3.3
	PBCH	All tests in Clause 5.4.3

5.1.1.3 Applicability of requirements for optional UE capabilities

For UE which supports optional UE capabilities the additional performance requirements from Table 5.1.1.3-1 should be applied.

Table 5.1.1.3-1: Requirements applicability for optional UE capabilities

UE feature/capability	Test type		Test list	Applicability notes
[Enhanced Type X receiver]	FR1 FDD	PDSCH	5.2.2.1.1 Minimum requirements for PDSCH Mapping Type A (Test 3-1) 5.2.3.1.1 Minimum requirements for PDSCH Mapping Type A (Test 5-1)	
	FR1 TDD	PDSCH	5.2.2.2.1 Minimum requirements for PDSCH Mapping Type A (Test 3-1) 5.2.3.2.1 Minimum requirements for PDSCH Mapping Type A (Test 5-1)	
[Support alternative additional DMRS position for co-existence with LTE CRS]	FR1 FDD	PDSCH	5.2.2.1.4 Minimum requirements for PDSCH Mapping Type A and LTE-NR coexistence (Test 1-2) 5.2.3.1.4 Minimum requirements for PDSCH Mapping Type A and LTE-NR coexistence (Test 1-2)	

5.2 PDSCH demodulation requirements

The parameters specified in Table 5.2-1 are valid for all PDSCH tests unless otherwise stated.

Table 5.2-1: Common test parameters

Parameter		Unit	Value
PDSCH transmission scheme			Transmission scheme 1
EPRE ratio of PTRS to PDSCH		dB	N/A
DL BWP configuration #1	Cyclic prefix		Normal
Common serving cell parameters	Physical Cell ID		0
	SSB position in burst		First SSB in Slot #0
	SSB periodicity	ms	20
	First DMRS position for Type A PDSCH mapping		2
PDCCH configuration	Slots for PDCCH monitoring		Each slot
	Symbols with PDCCH	Symbols	0, 1
	Number of PDCCH candidates and aggregation levels		1/[AL8]
	DCI format		1_1
	TCI state		TCI state #1
Cross carrier scheduling			Not configured
CSI-RS for tracking	First subcarrier index in the PRB used for CSI-RS		k_0=0 for CSI-RS resource 1,2,3,4
	First OFDM symbol in the PRB used for CSI-RS		l_0 = 6 for CSI-RS resource 1 and 3 l_0 = 10 for CSI-RS resource 2 and 4
	Number of CSI-RS ports (X)		1 for CSI-RS resource 1,2,3,4
	CDM Type		'No CDM' for CSI-RS resource 1,2,3,4
	Density (ρ)		3 for CSI-RS resource 1,2,3,4
	CSI-RS periodicity	Slots	15 kHz SCS: 20 for CSI-RS resource 1,2,3,4 30 kHz SCS: 40 for CSI-RS resource 1,2,3,4
	CSI-RS offset	Slots	15 kHz SCS: 10 for CSI-RS resource 1 and 2 11 for CSI-RS resource 3 and 4 30 kHz SCS: 20 for CSI-RS resource 1 and 2 21 for CSI-RS resource 3 and 4
	Frequency Occupation		Start PRB 0 Number of PRB = BWP size
	QCL info		TCI state #0
NZP CSI-RS for CSI acquisition	First subcarrier index in the PRB used for CSI-RS		k_0 = 0
	First OFDM symbol in the PRB used for CSI-RS		l_0 = 12
	Number of CSI-RS ports (X)		Same as number of transmit antenna
	CDM Type		'FD-CDM2'
	Density (ρ)		1
	CSI-RS periodicity	Slots	15 kHz SCS: 20 30 kHz SCS: 40
	CSI-RS offset	Slots	0
	Frequency Occupation		Start PRB 0 Number of PRB = BWP size
	QCL info		TCI state #1
ZP CSI-RS for CSI acquisition	First subcarrier index in the PRB used for CSI-RS		k_0 = 4
	First OFDM symbol in the PRB used for CSI-RS		l_0 = 12
	Number of CSI-RS ports (X)		4
	CDM Type		'FD-CDM2'
	Density (ρ)		1
	CSI-RS periodicity	Slots	15 kHz SCS: 20 30 kHz SCS: 40
	CSI-RS offset	Slots	0
	Frequency Occupation		Start PRB 0 Number of PRB = BWP size
PDSCH DMRS configuration	Antenna ports indexes		{1000} for Rank 1 tests {1000, 1001} for Rank 2 tests

				{1000-1002} for Rank 3 tests {1000-1003} for Rank 4 tests
	Number of PDSCH DMRS CDM group(s) without data			1 for Rank 1 and Rank 2 tests 2 for Rank 3 and Rank 4 tests
TCI state #0	Type 1 QCL information	SSB index		SSB #0
		QCL Type		Type C
	Type 2 QCL information	SSB index		N/A
		QCL Type		N/A
TCI state #1	Type 1 QCL information	CSI-RS resource		CSI-RS resource 1 from 'CSI-RS for tracking' configuration
		QCL Type		Type A
	Type 2 QCL information	CSI-RS resource		N/A
		QCL Type		N/A
PTRS configuration				PTRS is not configured
Maximum number of code block groups for ACK/NACK feedback				1
Maximum number of HARQ transmission				4
HARQ ACK/NACK bundling				Multiplexed
Redundancy version coding sequence				{0,2,3,1}
Precoding configuration				SP Type I, Random per slot with PRB bundling granularity
Symbols for all unused REs				OCNG Annex A.5
Note 1: UE assumes that the TCI state for the PDSCH is identical to the TCI state applied for the PDCCH transmission.				

5.2.1 1RX requirements

(Void)

5.2.2 2RX requirements

5.2.2.1 FDD

5.2.2.1.1 Minimum requirements for PDSCH Mapping Type A

The performance requirements are specified in Table 5.2.2.1.1-3 and Table 5.2.2.1.1-4, with the addition of test parameters in table 5.2.2.1.1-2 and the downlink physical channel setup according to Annex C.3.1.

The test purposes are specified in Table 5.2.2.1.1-1.

Table 5.2.2.1.1-1: Tests purpose

Purpose	Test index
Verify the PDSCH mapping Type A normal performance under 2 receive antenna conditions and with different channel models, MCSs and number of MIMO layers	1-1, 1-2, 1-3, 2-1, 2-2
Verify the PDSCH mapping Type A HARQ soft combining performance under 2 receive antenna conditions.	1-4
Verify the PDSCH mapping Type A enhanced performance requirement Type X under 2 receive antenna conditions and with 2 MIMO layers.	3-1

Table 5.2.2.1.1-2: Test parameters

Parameter		Unit	Value
Channel bandwidth		MHz	20 for Test 2-3 10 for other tests
Duplex mode			FDD
Active DL BWP index			1
DL BWP configuration #1	First PRB		0
	Number of contiguous PRB	PRBs	51 for Test 2-3 52 for other tests
	Subcarrier spacing	kHz	30 for Test 2-3 15 for other tests
PDCCH configuration	Number of PRBs in CORESET	PRBs	48
PDSCH configuration	Mapping type		Type A
	k0		0
	Starting symbol (S)		2
	Length (L)		12
	PDSCH aggregation factor		1
	PRB bundling type		Static
	PRB bundling size		4 for Test 1-1 2 for other tests
	Resource allocation type		Type 0
	VRB-to-PRB mapping type		Non-interleaved
	VRB-to-PRB mapping interleaver bundle size		N/A
PDSCH DMRS configuration	DMRS Type		Type 1
	Number of additional DMRS		2 for Test 1-1 1 for other tests
	Length		Single symbol
Number of HARQ Processes			8 for Tests 1-4, [2-1] 4 for other tests
K1 value (PDSCH-to-HARQ-timing-indicator)			2

Table 5.2.2.1.1-3: Minimum performance for Rank 1

Test num.	Reference channel	Modulation format and code rate	Propagation condition	Correlation matrix and antenna configuration	Reference value	
					Fraction of maximum throughput (%)	SNR (dB)
1-1	R.PDSCH.1-1.1 FDD	QPSK, 0.30	TDLB100-400	2x2, ULA Low	70	[-0.8]
1-2	R.PDSCH.1-1.2 FDD	QPSK, 0.30	TDLC300-100	2x2, ULA Low	70	[0.3]
1-3	R.PDSCH.1-4.1 FDD	256QAM, 0.82	TDLA30-10	2x2, ULA Low	70	[24.6]
1-4	R.PDSCH.1-2.1 FDD	16QAM, 0.48	TDLC300-100	2x2, ULA Low	30	[1.2]

Table 5.2.2.1.1-4: Minimum performance for Rank 2

Test num.	Reference channel	Modulation format and code rate	Propagation condition	Correlation matrix and antenna configuration	Reference value	
					Fraction of maximum throughput (%)	SNR (dB)
2-1	R.PDSCH.1-3.1 FDD	64QAM, 0.51	TDLA30-10	2x2, ULA Low	70	TBD
2-2	R.PDSCH.2-1.1 FDD	64QAM, 0.51	TDLA30-10	2x2, ULA Low	70	[19.7]

Table 5.2.2.1.1-5: Minimum performance for Rank 2 and Enhanced Type X Receiver

Test num.	Reference channel	Modulation format and code rate	Propagation condition	Correlation matrix and antenna configuration	Reference value	
					Fraction of maximum throughput (%)	SNR (dB)
3-1	R.PDSCH.1-2.2 FDD	16QAM, 0.48	TDLA30-10	2x2, ULA Medium	70	[17.6]

5.2.2.1.2 Minimum requirements for PDSCH Mapping Type A and CSI-RS overlapped with PDSCH

The performance requirements are specified in Table 5.2.2.1.2-3, with the addition of test parameters in table 5.2.2.1.2-2 and the downlink physical channel setup according to Annex C.3.1.

The test purposes are specified in Table 5.2.2.1.2-1.

Table 5.2.2.1.2-1: Tests purpose

Purpose	Test index
Verify the PDSCH mapping Type A normal performance under 2 receive antenna conditions and CSI-RS overlapped with PDSCH	1-1

Table 5.2.2.1.2-2: Test parameters

Parameter		Unit	Value
Channel bandwidth		MHz	10
Duplex mode			FDD
Active DL BWP index			1
DL BWP configuration #1	First PRB		0
	Number of contiguous PRB	PRBs	52
	Subcarrier spacing	kHz	15
PDCCH configuration	Number of PRBs in CORESET	PRBs	48
PDSCH configuration	Mapping type		Type A
	k0		0
	Starting symbol (S)		2
	Length (L)		12
	PDSCH aggregation factor		1
	PRB bundling type		Static
	PRB bundling size		2
	Resource allocation type		Type 0
	VRB-to-PRB mapping type		Non-interleaved
	VRB-to-PRB mapping interleaver bundle size		N/A
PDSCH DMRS configuration	DMRS Type		Type 1
	Number of additional DMRS		1
	Length		1
NZP CSI-RS for CSI acquisition	OFDM symbols in the PRB used for CSI-RS		$l_0 = 13$
	CSI-RS periodicity		5
ZP CSI-RS for CSI acquisition	Subcarrier index in the PRB used for CSI-RS		$(k_0, k_1, k_2, k_3)=(2, 4, 6, 8)$
	Number of CSI-RS ports (X)		8
	CSI-RS periodicity		5
Number of HARQ Processes			4
K1 value (PDSCH-to-HARQ-timing-indicator)			2

Table 5.2.2.1.2-3: Minimum performance for Rank 2

Test num.	Reference channel	Modulation format and code rate	Propagation condition	Correlation matrix and antenna configuration	Reference value	
					Fraction of maximum throughput (%)	SNR (dB)
1-1	R.PDSCH.1-5.1 FDD	16QAM, 0.48	TDLC300-100	2x2, ULA Low	70	[14.8]

5.2.2.1.3 Minimum requirements for PDSCH Mapping Type B

The performance requirements are specified in Table 5.2.2.1.3-3, with the addition of test parameters in Table 5.2.2.1.3-2 and the downlink physical channel setup according to Annex C.3.1.

The test purposes are specified in Table 5.2.2.1.3-1.

Table 5.2.2.1.3-1: Tests purpose

Purpose	Test index
Verify PDSCH mapping Type B performance under 2 receive antenna conditions	1-1

Table 5.2.2.1.3-2: Test parameters

Parameter		Unit	Value
Channel bandwidth		MHz	10
Duplex mode			FDD
Active DL BWP index			1
DL BWP configuration #1	First PRB		0
	Number of contiguous PRB	PRBs	52
	Subcarrier spacing	kHz	15
PDCCH configuration	Number of PRBs in CORESET	PRBs	48
PDSCH configuration	Mapping type		Type B
	k0		0
	Starting symbol (S)		5
	Length (L)		7
	PDSCH aggregation factor		1
	PRB bundling type		Static
	PRB bundling size		2
	Resource allocation type		Type 0
	VRB-to-PRB mapping type		Non-interleaved
	VRB-to-PRB mapping interleaver bundle size		N/A
PDSCH DMRS configuration	DMRS Type		Type 1
	Number of additional DMRS		1
	Length		1
Number of HARQ Processes			4
K1 value (PDSCH-to-HARQ-timing-indicator)			2

Table 5.2.2.1.3-3: Minimum performance for Rank 1

Test num.	Reference channel	Modulation format and code rate	Propagation condition	Correlation matrix and antenna configuration	Reference value	
					Fraction of maximum throughput (%)	SNR (dB)
1-1	R.PDSCH.1-1.4 FDD	QPSK, 0.30	TDLA30-10	2x2, ULA Low	70	[-0.9]

5.2.2.1.4 Minimum requirements for PDSCH Mapping Type A and LTE-NR coexistence

The performance requirements are specified in Table 5.2.2.1.4-3, with the addition of test parameters in Table 5.2.2.1.4-2 and the downlink physical channel setup according to Annex C.3.1.

The test purposes are specified in Table 5.2.2.1.4-1.

Table 5.2.2.1.4-1: Tests purpose

Purpose	Test index
Verify the PDSCH mapping Type A normal performance under 2 receive antenna conditions with CRS rate matching configured	1-1, 1-2

Table 5.2.2.1.4-2: Test parameters

Parameter		Unit	Value
Channel bandwidth		MHz	10
Duplex mode			FDD
Active DL BWP index			1
DL BWP configuration #1	First PRB		0
	Number of contiguous PRB	PRBs	52
	Subcarrier spacing	kHz	15
PDCCH configuration	Number of PRBs in CORESET	PRBs	48
PDSCH configuration	Mapping type		Type A
	k0		0
	Starting symbol (S)		3
	Length (L)		9 for Test 1-1 11 for Test 1-2
	PDSCH aggregation factor		1
	PRB bundling type		Static
	PRB bundling size		2
	Resource allocation type		Type 0
	VRB-to-PRB mapping type		Non-interleaved
	VRB-to-PRB mapping interleaver bundle size		N/A
PDSCH DMRS configuration	DMRS Type		Type 1
	Number of additional DMRS		1
	Length		1
CRS for rate matching	LTE carrier centre subcarrier location		Same as NR carrier centre subcarrier location
	LTE carrier BW	MHz	10
	Number of antenna ports		4
	v-shift		0
Number of HARQ Processes			4
K1 value (PDSCH-to-HARQ-timing-indicator)			2

Table 5.2.2.1.4-3: Minimum performance for Rank 1

Test num.	Reference channel	Modulation format and code rate	Propagation condition	Correlation matrix and antenna configuration	Reference value	
					Fraction of maximum throughput (%)	SNR (dB)
1-1	R.PDSCH.1-1.4 FDD	QPSK, 0.30	TDLA30-10	4x2, ULA Low	70	[-1.0]
1-2	R.PDSCH.1-1.5 FDD	QPSK, 0.30	TDLA30-10	4x2, ULA Low	70	[-1.0]

5.2.2.2 TDD

5.2.2.2.1 Minimum requirements for PDSCH Mapping Type A

The performance requirements are specified in Table 5.2.2.2.1-3 and Table 5.2.2.2.1-4, with the addition of test parameters in Table 5.2.2.2.1-2 and the downlink physical channel setup according to Annex C.3.1.

The test purposes are specified in Table 5.2.2.2.1-1.

Table 5.2.2.2.1-1: Tests purpose

Purpose	Test index
Verify the PDSCH mapping Type A normal performance under 2 receive antenna conditions and with different channel models, MCSs and number of MIMO layers	1-1, 1-2, 1-3, 1-5, 1-6, 2-1, 2-2
Verify the PDSCH mapping Type A HARQ soft combining performance under 2 receive antenna conditions.	1-4
Verify the PDSCH mapping Type A enhanced performance requirement Type X under 2 receive antenna conditions and with 2 MIMO layers.	3-1

Table 5.2.2.2.1-2: Test parameters

Parameter		Unit	Value
Channel bandwidth		MHz	20 for Test 2-3 40 for other tests
Duplex mode			TDD
Active DL BWP index			1
DL BWP configuration #1	First PRB		0
	Number of contiguous PRB	PRBs	51 for Test 2-3 106 for other tests
	Subcarrier spacing	kHz	30
PDCCH configuration	Number of PRBs in CORESET	PRBs	48 for Test 2-3 102 for other tests
PDSCH configuration	Mapping type		Type A
	k0		0
	Starting symbol (S)		2
	Length (L)		Specific to each Reference channel
	PDSCH aggregation factor		1
	PRB bundling type		Static
	PRB bundling size		4 for Tests 1-1 2 for other tests
	Resource allocation type		Type 0
	VRB-to-PRB mapping type		Non-interleaved
	VRB-to-PRB mapping interleaver bundle size		N/A
PDSCH DMRS configuration	DMRS Type		Type 1
	Number of additional DMRS		2 for Test 1-1 1 for other tests
	Length		1
Number of HARQ Processes			16 for Test 1-4, [2-1] 8 for other tests
K1 value (PDSCH-to-HARQ-timing-indicator)			Specific to each UL-DL pattern

Table 5.2.2.2.1-3: Minimum performance for Rank 1

Test num.	Reference channel	Modulation format and code rate	TDD UL-DL pattern	Propagation condition	Correlation matrix and antenna configuration	Reference value	
						Fraction of maximum throughput (%)	SNR (dB)
1-1	R.PDSCH.2-1.1 TDD	QPSK, 0.30	FR1.30-1	TDLB100-400	2x2, ULA Low	70	[-1.1]
1-2	R.PDSCH.2-1.2 TDD	QPSK, 0.30	FR1.30-1	TDLC300-100	2x2, ULA Low	70	[0.3]
1-3	R.PDSCH.2-4.1 TDD	256QAM, 0.82	FR1.30-1	TDLA30-10	2x2, ULA Low	70	[25.3]
1-4	R.PDSCH.2-2.1 TDD	16QAM, 0.48	FR1.30-1	TDLC300-100	2x2, ULA Low	30	[1.6]
1-5	R.PDSCH.2-5.1 TDD	QPSK, 0.3	FR1.30-2	TDLA30-10	2x2, ULA Low	70	[-0.8]
1-6	R.PDSCH.2-6.1 TDD	QPSK, 0.30	FR1.30-3	TDLA30-10	2x2, ULA Low	70	[-0.9]

Table 5.2.2.2.1-4: Minimum performance for Rank 2

Test num.	Reference channel	Modulation format and code rate	TDD UL-DL pattern	Propagation condition	Correlation matrix and antenna configuration	Reference value	
						Fraction of maximum throughput (%)	SNR (dB)
2-1	R.PDSCH.2-3.1 TDD	64QAM, 0.51	FR1.30-1	TDLA30-10	2x2, ULA Low	70	TBD
2-2	R.PDSCH.2-3.2 TDD	64QAM, 0.51	FR1.30-1	TDLA30-10	2x2, ULA Low	70	[19.8]

Table 5.2.2.2.1-5: Minimum performance for Rank 2 and Enhanced Type X Receiver

Test num.	Reference channel	Modulation format and code rate	TDD UL-DL pattern	Propagation condition	Correlation matrix and antenna configuration	Reference value	
						Fraction of maximum throughput (%)	SNR (dB)
3-1	R.PDSCH.2-2.2 TDD	16QAM, 0.48	FR1.30-1	TDLA30-10	2x2, ULA Medium	70	[18.1]

5.2.2.2.2 Minimum requirements for PDSCH Mapping Type A and CSI-RS overlapped with PDSCH

The performance requirements are specified in Table 5.2.2.2.2-3, with the addition of test parameters in Table 5.2.2.2.2-2 and the downlink physical channel setup according to Annex C.3.1.

The test purposes are specified in Table 5.2.2.2.2-1.

Table 5.2.2.2.2-1: Tests purpose

Purpose	Test index
Verify the PDSCH mapping Type A normal performance under 2 receive antenna conditions and CSI-RS overlapped with PDSCH	1-1

Table 5.2.2.2.2-2: Test parameters

Parameter		Unit	Value
Channel bandwidth		MHz	40
Duplex mode			TDD
Active DL BWP index			1
DL BWP configuration #1	First PRB		0
	Number of contiguous PRB	PRBs	106
	Subcarrier spacing	kHz	30
PDCCH configuration	Number of PRBs in CORESET	PRBs	102
PDSCH configuration	Mapping type		Type A
	k0		0
	Starting symbol (S)		2
	Length (L)		Specific to each Reference channel
	PDSCH aggregation factor		1
	PRB bundling type		Static
	PRB bundling size		2
	Resource allocation type		Type 0
	VRB-to-PRB mapping type		Non-interleaved
	VRB-to-PRB mapping interleaver bundle size		N/A
PDSCH DMRS configuration	DMRS Type		Type 1
	Number of additional DMRS		1
	Length		1
NZP CSI-RS for CSI acquisition	OFDM symbols in the PRB used for CSI-RS		$l_0 = 13$
	CSI-RS periodicity		5
ZP CSI-RS for CSI acquisition	Subcarrier index in the PRB used for CSI-RS		$(k_0, k_1, k_2, k_3)=(2, 4, 6, 8)$
	Number of CSI-RS ports (X)		8
	CSI-RS periodicity		5
Number of HARQ Processes			8
K1 value (PDSCH-to-HARQ-timing-indicator)			Specific to each UL-DL pattern

Table 5.2.2.2.2-3: Minimum performance for Rank 2

Test num.	Reference channel	Modulation format and code rate	TDD UL-DL pattern	Propagation condition	Correlation matrix and antenna configuration	Reference value	
						Fraction of maximum throughput (%)	SNR (dB)
1-1	R.PDSCH.2-7.1 TDD	16QAM, 0.48	FR1.30-1	TDLC300-100	2x2, ULA Low	70	[14.8]

5.2.2.2.3 Minimum requirements for PDSCH Mapping Type B

The performance requirements are specified in Table 5.2.2.2.3-3, with the addition of test parameters in Table 5.2.2.2.3-2 and the downlink physical channel setup according to Annex C.3.1.

The test purposes are specified in Table 5.2.2.2.3-1.

Table 5.2.2.2.3-1: Tests purpose

Purpose	Test index
Verify PDSCH mapping Type B performance under 2 receive antenna conditions	1-1

Table 5.2.2.2.3-2: Test parameters

Parameter		Unit	Value
Channel bandwidth		MHz	40
Duplex mode			TDD
Active DL BWP index			1
DL BWP configuration #1	First PRB		0
	Number of contiguous PRB	PRBs	106
	Subcarrier spacing	kHz	30
PDCCH configuration	Number of PRBs in CORESET	PRBs	102
PDSCH configuration	Mapping type		Type B
	k0		0
	Starting symbol (S)		5
	Length (L)		7
	PDSCH aggregation factor		1
	PRB bundling type		Static
	PRB bundling size		2
	Resource allocation type		Type 0
	VRB-to-PRB mapping type		Non-interleaved
	VRB-to-PRB mapping interleaver bundle size		N/A
PDSCH DMRS configuration	DMRS Type		Type 1
	Number of additional DMRS		1
	Length		1
Number of HARQ Processes			4
K1 value (PDSCH-to-HARQ-timing-indicator)			Specific to each UL-DL pattern

Table 5.2.2.2.3-3: Minimum performance for Rank 1

Test num.	Reference channel	Modulation format and code rate	TDD UL-DL pattern	Propagation condition	Correlation matrix and antenna configuration	Reference value	
						Fraction of maximum throughput (%)	SNR (dB)
1-1	R.PDSCH,2-1.3 TDD	QPSK, 0.30	FR1.30-1	TDLA30-10	2x2, ULA Low	70	[-0.9]

5.2.3 4RX requirements

5.2.3.1 FDD

5.2.3.1.1 Minimum requirements for PDSCH Mapping Type A

The performance requirements are specified in Table 5.2.3.1.1-3, Table 5.2.3.1.1-4, Table 5.2.3.1.1-5 and Table 5.2.3.1.1-6, with the addition of test parameters in Table 5.2.3.1.1-2 and the downlink physical channel setup according to Annex C.3.1.

The test purposes are specified in Table 5.2.3.1.1-1.

Table 5.2.3.1.1-1: Tests purpose

Purpose	Test index
Verify the PDSCH mapping Type A normal performance under 4 receive antenna conditions and with different channel models, MCSs and number of MIMO layers	1-1, 1-2, 1-3, 2-1, 2-2, 3-1, 4-1
Verify the PDSCH mapping Type A HARQ soft combining performance under 4 receive antenna conditions.	1-4
Verify the PDSCH mapping Type A enhanced performance requirement Type X under 4 receive antenna conditions and with 3 MIMO layers.	5-1

Table 5.2.3.1.1-2: Test parameters

Parameter		Unit	Value
Channel bandwidth		MHz	20 for Test 2-2 10 for other tests
Duplex mode			FDD
Active DL BWP index			1
DL BWP configuration #1	First PRB		0
	Number of contiguous PRB	PRBs	51 for Test 2-2 52 for other tests
	Subcarrier spacing	kHz	30 for Test 2-2 15 for other tests
PDCCH configuration	Number of PRBs in CORESET	PRBs	51 for Test 2-2 52 for other tests
PDSCH configuration	Mapping type		Type A
	k0		0
	Starting symbol (S)		2
	Length (L)		12
	PDSCH aggregation factor		1
	PRB bundling type		Static
	PRB bundling size		4 for Test 1-1 WB for Test 3-1 2 for other tests
	Resource allocation type		Type 0
	VRB-to-PRB mapping type		Non-interleaved
	VRB-to-PRB mapping interleaver bundle size		N/A
PDSCH DMRS configuration	DMRS Type		Type 1
	Number of additional DMRS		2 for Test 1-1 1 for other tests
	Length		1
Number of HARQ Processes			8 for Test 1-4, [2-1] 4 for other tests
K1 value (PDSCH-to-HARQ-timing-indicator)			2

Table 5.2.3.1.1-3: Minimum performance for Rank 1

Test num.	Reference channel	Modulation format and code rate	Propagation condition	Correlation matrix and antenna configuration	Reference value	
					Fraction of maximum throughput (%)	SNR (dB)
1-1	R.PDSCH.1-1.1 FDD	QPSK, 0.30	TDLB100-400	2x4, ULA Low	70	[-3.5]
1-2	R.PDSCH.1-1.2 FDD	QPSK, 0.30	TDLC300-100	2x4, ULA Low	70	[-2.8]
1-3	R.PDSCH.1-4.1 FDD	256QAM, 0.82	TDLA30-10	2x4, ULA Low	70	[21.0]
1-4	R.PDSCH.1-2.1 FDD	16QAM, 0.48	TDLC300-100	2x4, ULA Low	30	[-1.3]

Table 5.2.3.1.1-4: Minimum performance for Rank 2

Test num.	Reference channel	Modulation format and code rate	Propagation condition	Correlation matrix and antenna configuration	Reference value	
					Fraction of maximum throughput (%)	SNR (dB)
2-1	R.PDSCH.1-3.1 FDD	64QAM, 0.51	TDLA30-10	2x4, ULA Low	70	[TBD]
2-2	R.PDSCH.2-1.1 FDD	64QAM, 0.51	TDLA30-10	2x4, ULA Low	70	[13.7]

Table 5.2.3.1.1-5: Minimum performance for Rank 3

Test num.	Reference channel	Modulation format and code rate	Propagation condition	Correlation matrix and antenna configuration	Reference value	
					Fraction of maximum throughput (%)	SNR (dB)
3-1	R.PDSCH.1-2.3 FDD	16QAM, 0.48	TDLA30-10	4x4, ULA Low	70	[10.9]

Table 5.2.3.1.1-6: Minimum performance for Rank 4

Test num.	Reference channel	Modulation format and code rate	Propagation condition	Correlation matrix and antenna configuration	Reference value	
					Fraction of maximum throughput (%)	SNR (dB)
4-1	R.PDSCH.1-2.4 FDD	16QAM, 0.48	TDLA30-10	4x4, ULA Low	70	[15.5]

Table 5.2.3.1.1-7: Minimum performance for Rank 3 and Enhanced Type X Receiver

Test num.	Reference channel	Modulation format and code rate	Propagation condition	Correlation matrix and antenna configuration	Reference value	
					Fraction of maximum throughput (%)	SNR (dB)
5-1	R.PDSCH.1-2.3 FDD	16QAM, 0.48	TDLA30-10	4x4, ULA Medium A	70	[22.1]

5.2.3.1.2 Minimum requirements for PDSCH Mapping Type A and CSI-RS overlapped with PDSCH

The performance requirements are specified in Table 5.2.3.1.2-3, with the addition of test parameters in table 5.2.3.1.2-2 and the downlink physical channel setup according to Annex C.3.1.

The test purposes are specified in Table 5.2.3.1.2-1.

Table 5.2.3.1.2-1: Tests purpose

Purpose	Test index
Verify the PDSCH mapping Type A normal performance under 4 receive antenna conditions and CSI-RS overlapped with PDSCH	1-1

Table 5.2.3.1.2-2: Test parameters

Parameter		Unit	Value
Channel bandwidth		MHz	10
Duplex mode			FDD
Active DL BWP index			1
DL BWP configuration #1	First PRB		0
	Number of contiguous PRB	PRBs	52
	Subcarrier spacing	kHz	15
PDCCH configuration	Number of PRBs in CORESET	PRBs	48
PDSCH configuration	Mapping type		Type A
	k0		0
	Starting symbol (S)		2
	Length (L)		12
	PDSCH aggregation factor		1
	PRB bundling type		Static
	PRB bundling size		2
	Resource allocation type		Type 0
	VRB-to-PRB mapping type		Non-interleaved
	VRB-to-PRB mapping interleaver bundle size		N/A
PDSCH DMRS configuration	DMRS Type		Type 1
	Number of additional DMRS		1
	Length		1
NZP CSI-RS for CSI acquisition	OFDM symbols in the PRB used for CSI-RS		$l_0 = 13$
	CSI-RS periodicity		5
ZP CSI-RS for CSI acquisition	Subcarrier index in the PRB used for CSI-RS		$(k_0, k_1, k_2, k_3)=(2, 4, 6, 8)$
	Number of CSI-RS ports (X)		8
	CSI-RS periodicity		5
Number of HARQ Processes			4
K1 value (PDSCH-to-HARQ-timing-indicator)			2

Table 5.2.3.1.2-3: Minimum performance for Rank 2

Test num.	Reference channel	Modulation format and code rate	Propagation condition	Correlation matrix and antenna configuration	Reference value	
					Fraction of maximum throughput (%)	SNR (dB)
1-1	R.PDSCH.1-5.1 FDD	16QAM, 0.48	TDLC300-100	4x4, ULA Low	70	[9.1]

5.2.3.1.3 Minimum requirements for PDSCH Mapping Type B

The performance requirements are specified in Table 5.2.3.1.3-3, with the addition of test parameters in Table 5.2.3.1.3-2 and the downlink physical channel setup according to Annex C.3.1.

The test purposes are specified in Table 5.2.3.1.3-1.

Table 5.2.3.1.3-1: Tests purpose

Purpose	Test index
PDSCH mapping Type B performance under 4 receive antenna conditions	1-1

Table 5.2.3.1.3-2: Test parameters

Parameter		Unit	Value
Channel bandwidth		MHz	10
Duplex mode			FDD
Active DL BWP index			1
DL BWP configuration #1	First PRB		0
	Number of contiguous PRB	PRBs	52
	Subcarrier spacing	kHz	15
PDCCH configuration	Number of PRBs in CORESET	PRBs	48
PDSCH configuration	Mapping type		Type B
	k0		0
	Starting symbol (S)		5
	Length (L)		7
	PDSCH aggregation factor		1
	PRB bundling type		Static
	PRB bundling size		2
	Resource allocation type		Type 0
	VRB-to-PRB mapping type		Non-interleaved
	VRB-to-PRB mapping interleaver bundle size		N/A
PDSCH DMRS configuration	DMRS Type		Type 1
	Number of additional DMRS		1
	Length		1
Number of HARQ Processes			4
K1 value (PDSCH-to-HARQ-timing-indicator)			2

Table 5.2.3.1.3-3: Minimum performance for Rank 1

Test num.	Reference channel	Modulation format and code rate	Propagation condition	Correlation matrix and antenna configuration	Reference value	
					Fraction of maximum throughput (%)	SNR (dB)
1-1	R.PDSCH.1-1.4 FDD	QPSK, 0.30	TDLA30-10	4x4, ULA Low	70	[-3.8]

5.2.3.1.4 Minimum requirements for PDSCH Mapping Type A and LTE-NR coexistence

The performance requirements are specified in Table 5.2.3.1.4-3, with the addition of test parameters in Table 5.2.3.1.4-2 and the downlink physical channel setup according to Annex C.3.1.

The test purposes are specified in Table 5.2.3.1.4-1.

Table 5.2.3.1.4-1: Tests purpose

Purpose	Test index
Verify the PDSCH mapping Type A normal performance under 4 receive antenna conditions with CRS rate matching configured	1-1, 1-2

Table 5.2.3.1.4-2: Test parameters

Parameter		Unit	Value
Channel bandwidth		MHz	10
Duplex mode			FDD
Active DL BWP index			1
DL BWP configuration #1	First PRB		0
	Number of contiguous PRB	PRBs	52
	Subcarrier spacing	kHz	15
PDCCH configuration	Number of PRBs in CORESET	PRBs	48
PDSCH configuration	Mapping type		0
	k0		52
	Starting symbol (S)		15
	Length (L)		48
	PDSCH aggregation factor		Type A
	PRB bundling type		0
	PRB bundling size		3
	Resource allocation type		9 for Test 1-1 11 for Test 1-2
	VRB-to-PRB mapping type		1
	VRB-to-PRB mapping interleaver bundle size		Static
PDSCH DMRS configuration	DMRS Type		2
	Number of additional DMRS		Type 0
	Length		Non-interleaved
CRS for rate matching	LTE carrier centre subcarrier location		Same as NR carrier centre subcarrier location
	LTE carrier BW	MHz	10
	Number of antenna ports		4
	v-shift		0
Number of HARQ Processes			4
K1 value (PDSCH-to-HARQ-timing-indicator)			2

Table 5.2.3.1.4-3: Minimum performance for Rank 1

Test num.	Reference channel	Modulation format and code rate	Propagation condition	Correlation matrix and antenna configuration	Reference value	
					Fraction of maximum throughput (%)	SNR (dB)
1-1	R.PDSCH.1-1.4 FDD	QPSK, 0.30	TDLA30-10	4x4, ULA Low	70	[-4.0]
1-2	R.PDSCH.1-1.5 FDD	QPSK, 0.30	TDLA30-10	4x4, ULA Low	70	[-4.0]

5.2.3.2 TDD

5.2.3.2.1 Minimum requirements for PDSCH Mapping Type A

The performance requirements are specified in Table 5.2.3.2.1-3, Table 5.2.3.2.1-4, Table 5.2.3.2.1-5 and Table 5.2.3.2.1-6, with the addition of test parameters in Table 5.2.3.2.1-2 and the downlink physical channel setup according to Annex C.3.1.

The test purposes are specified in Table 5.2.3.2.1-1.

Table 5.2.3.2.1-1: Tests purpose

Purpose	Test index
Verify the PDSCH mapping Type A normal performance under4 receive antenna conditions and with different channel models, MCSs and number of MIMO layers	1-1, 1-2, 1-3, 1-5, 1-6, 2-1, 2-2, 3-1, 4-1
Verify the PDSCH mapping Type A HARQ soft combining performance under 4 receive antenna conditions.	1-4
Verify the PDSCH mapping Type A enhanced performance requirement Type X under 4 receive antenna conditions and with 3 MIMO layers.	5-1

Table 5.2.3.2.1-2: Test parameters

Parameter		Unit	Value
Channel bandwidth		MHz	20 for Test 2-2 40 for other tests
Duplex mode			TDD
Active DL BWP index			1
DL BWP configuration #1	First PRB		0
	Number of contiguous PRB	PRBs	51 for Test 2-2 106 for other tests
	Subcarrier spacing	kHz	30
PDCCH configuration	Number of PRBs in CORESET	PRBs	48 for Test 2-2 102 for other tests
PDSCH configuration	Mapping type		Type A
	k0		0
	Starting symbol (S)		2
	Length (L)		Specific to each Reference channel
	PDSCH aggregation factor		1
	PRB bundling type		Static
	PRB bundling size		4 for Test 1-1 2 for other tests
	Resource allocation type		Type 0
	VRB-to-PRB mapping type		Non-interleaved
	VRB-to-PRB mapping interleaver bundle size		N/A
PDSCH DMRS configuration	DMRS Type		Type 1
	Number of additional DMRS		2 for Tests 1-1 1 for other tests
	Length		1
Number of HARQ Processes			16 for Test 1-4, [2-1] 8 for other tests
K1 value (PDSCH-to-HARQ-timing-indicator)			Specific to each UL-DL pattern

Table 5.2.3.2.1-3: Minimum performance for Rank 1

Test num.	Reference channel	Modulation format and code rate	TDD UL-DL pattern	Propagation condition	Correlation matrix and antenna configuration	Reference value	
						Fraction of maximum throughput (%)	SNR (dB)
1-1	R.PDSCH.2-1.1 TDD	QPSK, 0.30	FR1.30-1	TDLB100-400	2x4, ULA Low	70	[-4.1]
1-2	R.PDSCH.2-1.2 TDD	QPSK, 0.30	FR1.30-1	TDLC300-100	2x4, ULA Low	70	[-2.6]
1-3	R.PDSCH.2-4.1 TDD	256QAM, 0.82	FR1.30-1	TDLA30-10	2x4, ULA Low	70	[21.6]
1-4	R.PDSCH.2-2.1 TDD	16QAM, 0.48	FR1.30-1	TDLC300-100	2x4, ULA Low	30	[-1.0]
1-5	[R.PDSCH.2-5.1 TDD]	QPSK, 0.3	FR1.30-2	TDLA30-10	2x4, ULA Low	70	[-3.6]
1-6	[R.PDSCH.2-6.1 TDD]	QPSK, 0.30	FR1.30-3	TDLA30-10	2x4, ULA Low	70	[-3.8]

Table 5.2.3.2.1-4: Minimum performance for Rank 2

Test num.	Reference channel	Modulation format and code rate	TDD UL-DL pattern	Propagation condition	Correlation matrix and antenna configuration	Reference value	
						Fraction of maximum throughput (%)	SNR (dB)
2-1	R.PDSCH.2-3.1 TDD	64QAM, 0.51	FR1.30-1	TDLA30-10	2x4, ULA Low	70	TBD
2-2	R.PDSCH.2-3.2 TDD	64QAM, 0.51	FR1.30-1	TDLA30-10	2x4, ULA Low	70	[13.7]

Table 5.2.3.2.1-5: Minimum performance for Rank 3

Test num.	Reference channel	Modulation format and code rate	TDD UL-DL pattern	Propagation condition	Correlation matrix and antenna configuration	Reference value	
						Fraction of maximum throughput (%)	SNR (dB)
3-1	R.PDSCH.2-2.3 TDD	16QAM, 0.48	FR1.30-1	TDLA30-10	4x4, ULA Low	70	[11.1]

Table 5.2.3.2.1-6: Minimum performance for Rank 4

Test num.	Reference channel	Modulation format and code rate	TDD UL-DL pattern	Propagation condition	Correlation matrix and antenna configuration	Reference value	
						Fraction of maximum throughput (%)	SNR (dB)
4-1	R.PDSCH.2-2.4 TDD	16QAM, 0.48	FR1.30-1	TDLA30-10	4x4, ULA Low	70	[15.7]

Table 5.2.3.2.1-7: Minimum performance for Rank 3 and Enhanced Type X Receiver

Test num.	Reference channel	Modulation format and code rate	TDD UL-DL pattern	Propagation condition	Correlation matrix and antenna configuration	Reference value	
						Fraction of maximum throughput (%)	SNR (dB)
5-1	R.PDSCH.2-2.3 TDD	16QAM, 0.48	FR1.30-1	TDLA30-10	4x4, ULA Medium A	70	[22.9]

5.2.3.2.2 Minimum requirements for PDSCH Mapping Type A and CSI-RS overlapped with PDSCH

The performance requirements are specified in Table 5.2.3.2.2-3, with the addition of test parameters in table 5.2.3.2.2-2 and the downlink physical channel setup according to Annex C.3.1.

The test purposes are specified in Table 5.2.3.2.2-1.

Table 5.2.3.2.2-1: Tests purpose

Purpose	Test index
Verify the PDSCH mapping Type A normal performance under 4 receive antenna conditions and CSI-RS overlapped with PDSCH	1-1

Table 5.2.3.2.2-2: Test parameters

Parameter		Unit	Value
Channel bandwidth		MHz	40
Duplex mode			TDD
Active DL BWP index			1
DL BWP configuration #1	First PRB		0
	Number of contiguous PRB	PRBs	106
	Subcarrier spacing	kHz	30
PDCCH configuration	Number of PRBs in CORESET	PRBs	102
PDSCH configuration	Mapping type		Type A
	k0		0
	Starting symbol (S)		2
	Length (L)		12
	PDSCH aggregation factor		1
	PRB bundling type		Static
	PRB bundling size		2
	Resource allocation type		Type 0
	VRB-to-PRB mapping type		Non-interleaved
	VRB-to-PRB mapping interleaver bundle size		N/A
PDSCH DMRS configuration	DMRS Type		Type 1
	Number of additional DMRS		1
	Length		1
NZP CSI-RS for CSI acquisition	OFDM symbols in the PRB used for CSI-RS		$l_0 = 13$
	CSI-RS periodicity		5
ZP CSI-RS for CSI acquisition	Subcarrier index in the PRB used for CSI-RS		$(k_0, k_1, k_2, k_3)=(2, 4, 6, 8)$
	Number of CSI-RS ports (X)		8
	CSI-RS periodicity		5
Number of HARQ Processes			8
K1 value (PDSCH-to-HARQ-timing-indicator)			Specific to each UL-DL pattern

Table 5.2.3.2.2-3: Minimum performance for Rank 2

Test num.	Reference channel	Modulation format and code rate	TDD UL-DL pattern	Propagation condition	Correlation matrix and antenna configuration	Reference value	
						Fraction of maximum throughput (%)	SNR (dB)
1-1	R.PDSCH.2-7.1 TDD	16QAM, 0.48	FR1.30-1	TDLC300-100	4x4, ULA Low	70	[9.0]

5.2.3.2.3 Minimum requirements for PDSCH Mapping Type B

The performance requirements are specified in Table 5.2.3.2.3-3, with the addition of test parameters in Table 5.2.3.2.3-2 and the downlink physical channel setup according to Annex C.3.1.

The test purposes are specified in Table 5.2.3.2.3-1.

Table 5.2.3.2.3-1: Tests purpose

Purpose	Test index
PDSCH mapping Type B performance under 4 receive antenna conditions	1-1

Table 5.2.3.2.3-2: Test parameters

Parameter		Unit	Value
Channel bandwidth		MHz	40
Duplex mode			TDD
Active DL BWP index			1
DL BWP configuration #1	First PRB		0
	Number of contiguous PRB	PRBs	106
	Subcarrier spacing	kHz	30
PDCCH configuration	Number of PRBs in CORESET	PRBs	102
PDSCH configuration	Mapping type		Type B
	k0		0
	Starting symbol (S)		5
	Length (L)		7
	PDSCH aggregation factor		1
	PRB bundling type		Static
	PRB bundling size		2
	Resource allocation type		Type 0
	VRB-to-PRB mapping type		Non-interleaved
	VRB-to-PRB mapping interleaver bundle size		N/A
PDSCH DMRS configuration	DMRS Type		Type 1
	Number of additional DMRS		1
	Length		1
Number of HARQ Processes			8
K1 value (PDSCH-to-HARQ-timing-indicator)			Specific to each UL-DL pattern

Table 5.2.3.2.3-3: Minimum performance for Rank 1

Test num.	Reference channel	Modulation format and code rate	TDD UL-DL pattern	Propagation condition	Correlation matrix and antenna configuration	Reference value	
						Fraction of maximum throughput (%)	SNR (dB)
1-1	R.PDSCH,2-1.3 TDD	QPSK, 0.30	FR1.30-1	TDLA30-10	2x4, ULA Low	70	[-3.9]

5.3 PDCCH demodulation requirements

The receiver characteristics of the PDCCH are determined by the probability of miss-detection of the Downlink Scheduling Grant (Pm-dsg).

The parameters specified in Table 5.3-1 are valid for all PDCCH tests unless otherwise stated.

Table 5.3-1: Common test Parameters

Parameter			Unit	Value
DL BWP configuration #1	Cyclic prefix			Normal
Common serving cell parameters	Physical Cell ID			0
	SSB position in burst			1
	SSB periodicity		ms	20
PDCCH configuration	Slots for PDCCH monitoring			Each slot
	Number of PDCCH candidates			1
	TCI state			TCI state #1
CSI-RS for tracking	First subcarrier index in the PRB used for CSI-RS (k_0)			0
	First OFDM symbol in the PRB used for CSI-RS (l_0)			CSI-RS resource 1: 4 CSI-RS resource 2: 8 CSI-RS resource 3: 4 CSI-RS resource 4: 8
	Number of CSI-RS ports (X)			1
	CDM Type			No CDM
	Density (ρ)			3
	CSI-RS periodicity		Slots	15 kHz SCS: 20 30 kHz SCS: 40
	CSI-RS offset		Slots	15 kHz SCS: 10 for CSI-RS resource 1 and 2 11 for CSI-RS resource 3 and 4 30 kHz SCS: 20 for CSI-RS resource 1 and 2 21 for CSI-RS resource 3 and 4
	Frequency Occupation			Start PRB 0 Number of PRB = BWP size
	QCL info			TCI state #0
TCI state #0	Type 1 QCL information	SSB index		SSB #0
		QCL Type		Type C
	Type 2 QCL information	SSB index		SSB #0
		QCL Type		Type D
TCI state #1	Type 1 QCL information	CSI-RS resource		CSI-RS resource 1 from 'CSI-RS for tracking' configuration
		QCL Type		Type A
	Type 2 QCL information	CSI-RS resource		CSI-RS resource 1 from 'CSI-RS for tracking' configuration
		QCL Type		Type D
Precoding configuration				SP Type I, Random per slot with REG bundling granularity for number of Tx larger than 1
Symbols for all unused REs				OCNG in Annex A.5

5.3.1 1RX requirements

(Void)

5.3.2 2RX requirements

5.3.2.1 FDD

The parameters specified in Table 5.3.2.1-1 are valid for all FDD tests unless otherwise stated.

Table 5.3.2.1-1: Test Parameters

Parameter	Unit	1 Tx Antenna	2 Tx Antenna
CCE to REG mapping type		nonInterleaved	
REG bundle size		6	
Shift index		0	

5.3.2.1.1 1 Tx Antenna performances

For the parameters specified in Table 5.3.2.1-1, the average probability of a missed downlink scheduling grant (Pm-dsg) shall be below the specified value in Table 5.3.2.1.1-1. The downlink physical setup is in accordance with Annex C.3.1.

Table 5.3.2.1.1-1: Minimum performance for PDCCH with 15 kHz SCS

Test number	Bandwidth	CORESET RB	CORESET duration	Aggregation level	Reference Channel	Propagation Condition	Antenna configuration and correlation Matrix	Reference value	
								Pm-dsg (%)	SNR (dB)
1	10 MHz	24	2	2	R.PDCCH.1-2.1 FDD	TDLA30-10	1x2 Low	1	[8.0]
2	10 MHz	24	2	2	R.PDCCH.1-2.3 FDD	TDLC300-100	1x2 Low	1	[8.0]
3	10 MHz	48	2	4	R.PDCCH.1-2.4 FDD	TDLA30-10	1x2 Low	1	[5.5]
4	10 MHz	48	1	4	R.PDCCH.1-1.1 FDD	TDLA30-10	1x2 Low	1	[4.3]
5	10MHz	48	2	16	R.PDCCH.1-2.6 FDD	TDLA30-10	1x2 Low	1	[-2.1]

5.3.2.1.2 2 Tx Antenna performances

For the parameters specified in Table 5.3.2.1-1, the average probability of a missed downlink scheduling grant (Pm-dsg) shall be below the specified value in Table 5.3.2.1.2-1. The downlink physical setup is in accordance with Annex C.3.1.

Table 5.3.2.1.2-1: Minimum performance for PDCCH with 15 kHz SCS

Test number	Bandwidth	CORESET RB	CORESET duration	Aggregation level	Reference Channel	Propagation Condition	Antenna configuration and correlation Matrix	Reference value	
								Pm-dsg (%)	SNR (dB)
1	10 MHz	24	2	4	R.PDCCH.1-2.2 FDD	TDLC300-100	2x2 Low	1	TBD
2	10 MHz	48	2	8	R.PDCCH.1-2.5 FDD	TDLC300-100	2x2 Low	1	[-1.5]
3	10 MHz	48	1	8	R.PDCCH.1-1.3 FDD	TDLA30-10	2x2 Low	1	[-0.3]

5.3.2.2 TDD

The parameters specified in Table 5.3.2.2-1 are valid for all TDD tests unless otherwise stated.

Table 5.3.2.2-1: Test Parameters

Parameter	Unit	1 Tx Antenna	2 Tx Antenna
TDD UL-DL pattern		FR1.30-1	
CCE to REG mapping type		interleaved	
Interleaver size		3	
REG bundle size		2	6
Shift Index		0	

5.3.2.2.1 1 Tx Antenna performances

For the parameters specified in Table 5.3.2.2-1, the average probability of a missed downlink scheduling grant (Pm-dsg) shall be below the specified value in Table 5.3.2.2.1-1. The downlink physical setup is in accordance with Annex C.3.1.

Table 5.3.2.2.1-1: Minimum performance for PDCCH with 30 kHz SCS

Test number	Bandwidth	CORESET RB	CORESET duration	Aggregation level	Reference Channel	Propagation Condition	Antenna configuration and correlation Matrix	Reference value	
								Pm-dsg (%)	SNR (dB)
1	40 MHz	102	1	2	R.PDCCH.2-1.1 TDD	TDLA30-10	1x2 Low	1	[6.7]
2	40 MHz	102	1	4	R.PDCCH.2-1.2 TDD	TDLC300-100	1x2 Low	1	[2.7]
3	40 MHz	48	2	16	R.PDCCH.2-2.1 TDD	TDLC300-100	1x2 Low	1	[-4.4]

5.3.2.2.2 2 Tx Antenna performances

For the parameters specified in Table 5.3.2.2-1, the average probability of a missed downlink scheduling grant (Pm-dsg) shall be below the specified value in Table 5.3.2.2.2-1. The downlink physical setup is in accordance with Annex C.3.1.

Table 5.3.2.2.2-1: Minimum performance for PDCCH with 30 kHz SCS

Test number	Bandwidth	CORESET RB	CORESET duration	Aggregation level	Reference Channel	Propagation Condition	Antenna configuration and correlation Matrix	Reference value	
								Pm-dsg (%)	SNR (dB)
1	40 MHz	[90]	1	8	R.PDCCH.2-1.3 TDD	TDLC300-100	2x2 Low	1	[-1.5]

5.3.3 4RX requirements

5.3.3.1 FDD

The parameters specified in Table 5.3.3.1-1 are valid for all FDD tests unless otherwise stated.

Table 5.3.3.1-1: Test Parameters

Parameter	Unit	1 Tx Antenna	2 Tx Antenna
CCE to REG mapping type		nonInterleaved	
REG bundle size		6	
Shift index		0	

5.3.3.1.1 1 Tx Antenna performances

For the parameters specified in Table 5.3.3.1-1, the average probability of a missed downlink scheduling grant (Pm-dsg) shall be below the specified value in Table 5.3.3.1.1-1. The downlink physical setup is in accordance with Annex C.3.1.

Table 5.3.3.1.1-1: Minimum performance for PDCCH with 15 kHz SCS

Test number	Bandwidth	CORESET RB	CORESET duration	Aggregation level	Reference Channel	Propagation Condition	Antenna configuration and correlation Matrix	Reference value	
								Pm-dsg (%)	SNR (dB)
1	10 MHz	24	2	2	R.PDCCH.1-2.1 FDD	TDLA30-10	1x4 Low	1	[2.3]
2	10 MHz	24	2	2	R.PDCCH.1-2.3 FDD	TDLC300-100	1x4 Low	1	[2.5]
3	10 MHz	48	2	4	R.PDCCH.1-2.4 FDD	TDLA30-10	1x4 Low	1	[0.0]
4	10 MHz	48	1	4	R.PDCCH.1-1.1 FDD	TDLA30-10	1x4 Low	1	[-0.7]

5.3.3.1.2 2 Tx Antenna performances

For the parameters specified in Table 5.3.3.1-1, the average probability of a missed downlink scheduling grant (Pm-dsg) shall be below the specified value in Table 5.3.3.1.2-1. The downlink physical setup is in accordance with Annex C.3.1.

Table 5.3.3.1.2-1: Minimum performance for PDCCH with 15 kHz SCS

Test number	Bandwidth	CORESET RB	CORESET duration	Aggregation level	Reference Channel	Propagation Condition	Antenna configuration and correlation Matrix	Reference value	
								Pm-dsg (%)	SNR (dB)
1	10 MHz	24	2	4	R.PDCCH.1-2.2 FDD	TDLC300-100	2x4 Low	1	TBD
2	10 MHz	48	2	8	R.PDCCH.1-2.5 FDD	TDLC300-100	2x4 Low	1	[-4.8]
3	10 MHz	48	1	4	R.PDCCH.1-1.3 FDD	TDLA30-10	2x4 Low	1	TBD

5.3.3.2 TDD

The parameters specified in Table 5.3.3.2-1 are valid for all TDD tests unless otherwise stated.

Table 5.3.3.2-1: Common Test Parameters

Parameter	Unit	1 Tx Antenna	2 Tx Antenna
TDD UL-DL pattern		FR1.30-1	
CCE to REG mapping type		interleaved	
Interleaver size		3	
REG bundle size		2	6
Shift Index		0	

5.3.3.2.1 1 Tx Antenna performances

For the parameters specified in Table 5.3.3.2-1, the average probability of a missed downlink scheduling grant (Pm-dsg) shall be below the specified value in Table 5.3.3.2.1-1. The downlink physical setup is in accordance with Annex C.3.1.

Table 5.3.3.2.1-1: Minimum performance for PDCCH with 30 kHz SCS

Test number	Bandwidth	CORESET RB	CORESET duration	Aggregation level	Reference Channel	Propagation Condition	Antenna configuration and correlation Matrix	Reference value	
								Pm-dsg (%)	SNR (dB)
1	40 MHz	102	1	2	R.PDCCH.2-1.1 TDD	TDLA30-10	1x4 Low	1	TBD
2	40 MHz	102	1	4	R.PDCCH.2-1.2 TDD	TDLC300-100	1x4 Low	1	TBD
3	40 MHz	48	2	16	R.PDCCH.2-2.1 TDD	TDLA30-10	1x4 Medium A	1	[-4.1]

5.3.3.2.2 2 Tx Antenna performances

For the parameters specified in Table 5.3.3.2-1, the average probability of a missed downlink scheduling grant (Pm-dsg) shall be below the specified value in Table 5.3.3.2.2-1. The downlink physical setup is in accordance with Annex C.3.1.

Table 5.3.3.2.2-1: Minimum performance for PDCCH with 30 kHz SCS

Test number	Bandwidth	CORESET RB	CORESET duration	Aggregation level	Reference Channel	Propagation Condition	Antenna configuration and correlation Matrix	Reference value	
								Pm-dsg (%)	SNR (dB)
1	40 MHz	90	1	8	TBD	TDLC300-100	2x4 Low	1	[-4.6]

5.4 PBCH demodulation requirements

The receiver characteristics of PBCH are determined by the probability of miss-detection of the PBCH (Pm-bch), which is defined as

$$\mathrm{Pm-bch} = 1 - \frac{A}{B}$$

Where A is the number of correctly decoded MIB PDUs and B is the number of transmitted MIB PDUs. The Pm-bch is derived with the assumption UE combines the PBCH symbols of the same SS/PBCH block index within the MIB TTI (80ms).

5.4.1 1RX requirements

(Void)

5.4.2 2RX requirements

5.4.2.1 FDD

Table 5.4.2.1-1: Test parameters for PBCH

Parameter	Unit	Single antenna port
Physical Cell ID		0
Cyclic prefix		Normal
Number of SS/PBCH blocks within an SS burst set periodicity		1
SS/PBCH block index Note1		0
SS/PBCH block periodicity	ms	20
Note 1: as specified in TS 38.213 [11, Section 4.1]		

For the parameters specified in Table 5.4.2.1-1 the average probability of a miss-detected PBCH (Pm-bch) shall be below the specified values in Table 5.4.2.1-2 in case SS/PBCH block index is not known and below the specifies values

in Table.5.4.2.1-3 in case SS/PBCH block index is known. The downlink physical setup is in accordance with Annex C.3.1.

Table 5.4.2.1-2: Minimum performance PBCH in case SS/PBCH block index is not known

Test number	Bandwidth	Reference channel	Propagation condition	Antenna configuration and correlation matrix	Reference value	
					Pm-bch (%)	SNR (dB)
1	10 MHz	R.PBCH.1	TDLC300-100	1 x 2 Low	1	[-6.4]

Table 5.4.2.1-3 Minimum performance PBCH in case SS/PBCH block index is known

Test number	Bandwidth	Reference channel	Propagation condition	Antenna configuration and correlation matrix	Reference value	
					Pm-bch (%)	SNR (dB)
1	10 MHz	R.PBCH.1	TDLC300-100	1 x 2 Low	1	[-8.5]

5.4.2.2 TDD

Table 5.4.2.2-1: Test parameters for PBCH

Parameter	Unit	Single antenna port
Physical Cell ID		0
Cyclic prefix		Normal
Number of SS/PBCH blocks within an SS burst set periodicity		1
SS/PBCH block index Note1		0
SS/PBCH block periodicity	ms	20
TDD UL-DL pattern		FR1.30-1
Note 1: as specified in TS 38.213 [11, Section 4.1] Note 2: as specified in TS 38.213 [11, Section 11.1]		

For the parameters specified in Table 5.4.2.2-1 the average probability of a miss-detected PBCH (Pm-bch) shall be below the specified values in Table 5.4.2.2-2 in case SS/PBCH block index is not known and below the specified values in Table.5.4.2.2-3 in case SS/PBCH block index is known. The downlink physical setup is in accordance with Annex C.3.1.

Table 5.4.2.2-2: Minimum performance PBCH in case SS/BPCH block index is not known

Test number	Bandwidth	Reference channel	Propagation condition	Antenna configuration and correlation matrix	Reference value	
					Pm-bch (%)	SNR (dB)
1	40 MHz	R.PBCH.2	TDLA30-10	1 x 2 Low	1	[-5]

Table 5.4.2.2-3 Minimum performance PBCH in case SS/BPCH block index is known

Test number	Bandwidth	Reference channel	Propagation condition	Antenna configuration and correlation matrix	Reference value	
					Pm-bch (%)	SNR (dB)
1	40 MHz	R.PBCH.2	TDLA30-10	1 x 2 Low	1	[-6.4]

5.4.3 4RX requirements

5.4.3.1 FDD

Table 5.4.3.1-1: Test parameters for PBCH

Parameter	Unit	Single antenna port
Physical Cell ID		0
Cyclic prefix		Normal
Number of SS/PBCH blocks within an SS burst set periodicity		1
SS/PBCH block index Note1		0
SS/PBCH block periodicity	ms	20
Note 1: as specified in clause 4.1 of TS 38.213 [11]		

For the parameters specified in Table 5.4.3.1-1 the average probability of a miss-detected PBCH (Pm-bch) shall be below the specified values in Table 5.4.3.1-2 in case SS/PBCH block index is not known and below the specified values in Table.5.4.3.1-3 in case SS/PBCH block index is known. The downlink physical setup is in accordance with Annex C.3.1.

Table 5.4.3.1-2: Minimum performance PBCH in case SS/PBCH block index is not known

Test number	Bandwidth	Reference channel	Propagation condition	Antenna configuration and correlation matrix	Reference value	
					Pm-bch (%)	SNR (dB)
1	10 MHz	R.PBCH.1	TDLC300-100	1 x 4 Low	1	[-9.1]

Table 5.4.3.1-3 Minimum performance PBCH in case SS/PBCH block index is known

Test number	Bandwidth	Reference channel	Propagation condition	Antenna configuration and correlation matrix	Reference value	
					Pm-bch (%)	SNR (dB)
1	10 MHz	R.PBCH.1	TDLC300-100	1 x 4 Low	1	TBD

5.4.3.2 TDD

Table 5.4.3.2-1: Test parameters for PBCH

Parameter	Unit	Single antenna port
Physical Cell ID		0
Cyclic prefix		Normal
Number of SS/PBCH blocks within an SS burst set periodicity		1
SS/PBCH block index Note1		0
SS/PBCH block periodicity	ms	20
TDD UL-DL pattern		FR1.30-1
Note 1: as specified in clause 4.1 of TS 38.213 [11] Note 2: as specified in clause 11.1 of TS 38.213 [11]		

For the parameters specified in Table 5.4.3.2-1 the average probability of a miss-detected PBCH (Pm-bch) shall be below the specified values in Table 5.4.3.2-2 in case SS/PBCH block index is not known and below the specified values in Table.5.4.3.2-3 in case SS/PBCH block index is known. The downlink physical setup is in accordance with Annex C.3.1.

Table 5.4.3.2-2: Minimum performance PBCH in case SS/BPCH block index is not known

Test number	Bandwidth	Reference channel	Propagation condition	Antenna configuration and correlation matrix	Reference value	
					Pm-bch (%)	SNR (dB)
1	40 MHz	R.PBCH.2	TDLA30-10	1 x 4 Low	1	[-8.5]

Table 5.4.3.2-3: Minimum performance PBCH in case SS/BPCH block index is known

Test number	Bandwidth	Reference channel	Propagation condition	Antenna configuration and correlation matrix	Reference value	
					Pm-bch (%)	SNR (dB)
1	40 MHz	R.PBCH.2	TDLA30-10	1 x 4 Low	1	[-9.9]

5.5 Sustained downlink data rate provided by lower layers

5.5.1 FR1 single carrier requirements

The requirements in this clause are applicable to the FR1 single carrier case.

The requirements and procedure defined in Clause 5.5A.1 apply using operating band instead of CA configuration, and bandwidth instead of bandwidth combination.

5.5A Sustained downlink data rate provided by lower layers

5.5A.1 FR1 CA requirements

<Editor's note: Open issues to be resolved:

Sustained rate minimum duration

Whether same requirements apply for FR1 DC>

The Sustained Data Rate (SDR) requirements in this clause are applicable to the FR1 CA.

The purpose of the test is to verify that the Layer 1 and Layer 2 correctly process in a sustained manner the received packets corresponding to the maximum data rate indicated by UE capabilities. The sustained downlink data rate shall be verified in terms of the success rate of delivered PDCP SDU(s) by Layer 2. The test case below specifies the RF conditions and the required success rate of delivered TB by Layer 1 to meet the sustained data rate requirement.

The test parameters are determined by the following procedure:

- Select one CA bandwidth combination among all supported CA configurations and set of per component carrier (CC) UE capabilities among all supported UE capabilities that provides the largest data rate [TS 38.306 [14, Section 4.1.2]].
    - Set of per CC UE capabilities includes channel bandwidth, subcarrier spacing, number of PDSCH MIMO layers, modulation format and scaling factor [TS 38.306 [14, Section 4.1.2]].
    - When there are multiple sets of CA bandwidth combinations and UE capabilities (channel bandwidth, subcarrier spacing, number of MIMO layer, modulation format, scaling factor) with same largest data rate, select one among sets with the smallest aggregated channel bandwidth.
- For each CC in CA bandwidth combination, use Table 5.5A-5 to determine MCS based on test parameters and indicated UE capabilities.

The TB success rate shall be higher than 85% when PDSCH is scheduled with MCS defined for the selected CA bandwidth combination and with the downlink physical channel setup according to Annex C.3.1.

The TB success rate is defined as $100\%*N_{DL\_correct\_rx} / (N_{DL\_newtx} + N_{DL\_retx})$, where N_{DL_newtx} is the number of newly transmitted DL transport blocks, N_{DL_retx} is the number of retransmitted DL transport blocks, and $N_{DL\_correct\_rx}$ is the number of correctly received DL transport blocks. The TB success rate shall be sustained during at least TBD ms.

The common test parameters are specified in Table 5.5A-1. The parameters specified in Table 5.5A-2 are applicable for tests on FDD CCs and parameters specified in Table 5.5A-3 are applicable for tests on TDD CCs.

Unless otherwise stated, no user data is scheduled on slot #0, 10 and 11 within 20 ms for SCS 15 kHz.

Unless otherwise stated, no user data is scheduled on slot #0, 20 and 21 within 20 ms for SCS 30 kHz.

Table 5.5A-1: Common test parameters for FDD and TDD component carriers

Parameter		Unit	Value
PDSCH transmission scheme			Transmission scheme 1
EPRE ratio of PTRS to PDSCH		dB	N/A
Channel bandwidth		MHz	Channel bandwidth from selected CA bandwidth combination
Common serving cell parameters	Physical Cell ID		0
	SSB position in burst		First SSB in Slot #0
	SSB periodicity	ms	20
	First DMRS position for Type A PDSCH mapping		2
Cross carrier scheduling			Not configured
Active DL BWP index			1
DL BWP configuration #1	First PRB		0
	Number of contiguous PRB		Maximum transmission bandwidth configuration as specified in TS 38.101-1 [6, Section 5.3.2] for tested channel bandwidth and subcarrier spacing
	Subcarrier spacing	kHz	[15 or 30]
	Cyclic prefix		Normal
PDCCH configuration	Slots for PDCCH monitoring		Each slot
	Symbols with PDCCH		Symbols #0
	Number of PRBs in CORESET		Table 5.5A-4
	Number of PDCCH candidates and aggregation levels		1/[AL 8]
	DCI format		1_1
	TCI State		TCI state #1
PDSCH configuration	Mapping type		Type A
	k0		0
	PDSCH aggregation factor		1
	PRB bundling type		Static
	PRB bundling size		WB
	Resource allocation type		Type 0
	VRB-to-PRB mapping type		Non-interleaved
	VRB-to-PRB mapping interleaver bundle size		N/A
PDSCH DMRS configuration	DMRS Type		Type 1
	Number of additional DMRS		1
	Length		1
	Antenna ports indexes		{1000} for 1 Layer CCs {1000, 1001} for 2 Layers CCs {1000 – 1003} for 4 Layers CCs
	Number of PDSCH DMRS CDM group(s) without data		1 for 1 layer and 2 layers CCs 2 for 4 Layers CCs
PTRS configuration			PTRS is not configured
CSI-RS for tracking	Subcarrier indexes in the PRB used for CSI-RS		k_0 = 3 for CSI-RS resource 1,2,3,4
	OFDM symbols in the PRB used for CSI-RS		l_0 = 6 for CSI-RS resource 1 and 3 l_0 = 10 for CSI-RS resource 2 and 4
	Number of CSI-RS ports (X)		1 for CSI-RS resource 1,2,3,4
	CDM Type		'No CDM' for CSI-RS resource 1,2,3,4
	Density (ρ)		3 for CSI-RS resource 1,2,3,4
	CSI-RS periodicity	Slots	15 kHz SCS: 20 for CSI-RS resource 1,2,3,4 30 kHz SCS: 40 for CSI-RS resource 1,2,3,4
	CSI-RS offset	Slots	15 kHz SCS: 10 for CSI-RS resource 1 and 2 11 for CSI-RS resource 3 and 4 30 kHz SCS: 20 for CSI-RS resource 1 and 2 21 for CSI-RS resource 3 and 4
	Frequency Occupation		Start PRB 0

				Number of PRB = BWP size
	QCL info			TCI state #0
NZP CSI-RS for CSI acquisition	Subcarrier indexes in the PRB used for CSI-RS			$k_0 = 4$
	OFDM symbols in the PRB used for CSI-RS			$l_0 = 12$
	Number of CSI-RS ports (X)			Same as number of transmit antenna
	CDM Type			'FD-CDM2'
	Density (ρ)			1
	CSI-RS periodicity			15 kHz SCS: 20 30 kHz SCS: 40
	CSI-RS offset			0
	Frequency Occupation			Start PRB 0 Number of PRB = BWP size
	QCL info			TCI state #1
ZP CSI-RS for CSI acquisition	Subcarrier indexes in the PRB used for CSI-RS			$k_0 = 0$
	OFDM symbols in the PRB used for CSI-RS			$l_0 = 12$
	Number of CSI-RS ports (X)			4
	CDM Type			'FD-CDM2'
	Density (ρ)			1
	CSI-RS periodicity			15 kHz SCS: 20 30 kHz SCS: 40
	CSI-RS offset			0
	Frequency Occupation			Start PRB 0 Number of PRB = BWP size
TCI state #0	Type 1 QCL information	SSB index		SSB #0
		QCL Type		Type C
	Type 2 QCL information	SSB index		N/A
		QCL Type		N/A
TCI state #1 TCI state #0	Type 1 QCL information	CSI-RS resource		CSI-RS resource 1 from 'CSI-RS for tracking' configuration
		QCL Type		Type A
	Type 2 QCL information	CSI-RS resource		N/A
	Type 1 QCL information	SSB index		SSB #0
Maximum number of code block groups for ACK/NACK feedback				1
Maximum number of HARQ transmission				4
HARQ ACK/NACK bundling				Multiplexed
Redundancy version coding sequence				{0,2,3,1}
Precoding configuration				SP Type I, Random per slot with PRB bundling granularity
Symbols for all unused Res				OCNG Annex A.5
Propagation condition				Static propagation condition No external noise sources are applied
Antenna configuration	1 layer CCs			[1x2 or 1x4]
	2 layers CCs			[2x2 or 2x4]
	4 layers CCs			[4x4]
Note 1: UE assumes that the TCI state for the PDSCH is identical to the TCI state applied for the PDCCH transmission				

Table 5.5A-2: Additional test parameters for FDD CC

Parameter		Unit	Value
Duplex mode			FDD
PDSCH configuration	Starting symbol (S)		1
	Length (L)		13
Number of HARQ Processes			TBD
K1 value			2

Table 5.5A-3: Additional test parameters for TDD CC

Parameter		Unit	Value
Duplex mode			TDD
PDSCH configuration	Starting symbol (S)		1
	Length (L)		13
Number of HARQ Processes			TBD
K1 value			Specific to each UL-DL pattern
TDD UL-DL pattern			15 kHz SCS: FR1.15-1 30 kHz SCS: FR1.30-1
Note 1: PDSCH is scheduled only on full DL slots			

Table 5.5A-4: Number of PRBs in CORESET

SCS (kHz)	5MHz	10MHz	15MHz	20 MHz	25 MHz	30 MHz	40 MHz	50MHz	60 MHz	80 MHz	100 MHz
15	24	48	78	102	132	156	216	270	N/A	N/A	N/A
30	6	24	36	48	60	78	102	132	162	216	270

Table 5.5A-5: MCS indexes for indicated UE capabilities

Maximum number of PDSCH MIMO layers	Maximum modulation format	Scaling factor	MCS
1	8	1	[26]
1	8	0.8	[21]
1	8	0.75	[20]
1	8	0.4	[11]
1	6	1	[27]
1	6	0.8	[23]
1	6	0.75	[22]
1	6	0.4	[14]
1	4	1	[16]
1	4	0.8	[16]
1	4	0.75	[16]
1	4	0.4	[10]
1	2	1	[9]
1	2	0.8	[9]
1	2	0.75	[9]
1	2	0.4	[4]
2	8	1	[26]
2	8	0.8	[21]
2	8	0.75	[20]
2	8	0.4	[11]
2	6	1	[27]
2	6	0.8	[23]
2	6	0.75	[22]
2	6	0.4	[14]
2	4	1	[16]
2	4	0.8	[16]
2	4	0.75	[16]
2	4	0.4	[10]
2	2	1	[9]
2	2	0.8	[9]
2	2	0.75	[9]
2	2	0.4	[4]
4	8	1	[26]
4	8	0.8	[23]
4	8	0.75	[22]
4	8	0.4	[12]
4	6	1	[27]
4	6	0.8	[24]
4	6	0.75	[23]
4	6	0.4	[14]
4	4	1	[16]
4	4	0.8	[16]
4	4	0.75	[16]
4	4	0.4	[11]
4	2	1	[9]
4	2	0.8	[9]
4	2	0.75	[9]
4	2	0.4	[5]

6 CSI reporting requirements (Conducted requirements)

6.1 General

This section includes conducted requirements for the reporting of channel state information (CSI).

6.1.1 Applicability of requirements

6.1.2 Common test parameters

Parameters specified in Table 6.1.2-1 are applied for all test cases in this section unless otherwise stated.

Table 6.1.2-1: Test parameters for CSI test cases

Parameter		Unit	Value
PDSCH transmission scheme			Transmission scheme 1
EPRE ratio of PTRS to PDSCH		dB	
Active DL BWP index			1
Cyclic prefix			Normal
Common serving cell parameters	Physical Cell ID		0
	SSB position in burst		First SSB in Slot #0
	SSB periodicity	ms	20
PDCCH configuration	Slots for PDCCH monitoring		Each slot
	Symbols with PDCCH		0,1
	Number of PDCCH candidates and aggregation levels		1/[8]
	DCI format		1_1
	TCI state		TCI state #1
Cross carrier scheduling			Not configured
PDSCH configuration	Mapping type		Type A
	k0		0
	Starting symbol (S)		2
	Length (L)		12
	PDSCH aggregation factor		1
	PRB bundling type		Static
	PRB bundling size		2
	Resource allocation type		0
	VRB-to-PRB mapping type		Non-interleaved
	VRB-to-PRB mapping interleaver bundle size		N/A
PDSCH DMRS configuration	DMRS Type		Type 1
	Number of additional DMRS		1
	Length		Single-symbol DM-RS
	DMRS ports indexes		{1000} for Rank1 {1000,1001} for Rank2 {1000,1001,1002} for Rank3 {1000,1001,1002,1003} for Rank4
	Number of PDSCH DMRS CDM group(s) without data		2
PTRS configuration	Frequency density ($K_{PT\text{-}RS}$)		N/A
	Time density ($L_{PT\text{-}RS}$)		N/A
CSI-RS for tracking	First subcarrier index in the PRB used for CSI-RS (k_0)		[0]
	First OFDM symbol in the PRB used for CSI-RS (l_0)		[4]
	Number of CSI-RS ports (X)		1
	CDM Type		No CDM
	Density (ρ)		3
	CSI-RS periodicity	slot	15 kHz SCS: 20 30 kHz SCS: 40
	CSI-RS offset	slot	15 kHz SCS: 10 for CSI-RS resource 1 and 2 11 for CSI-RS resource 3 and 4 30 kHz SCS: 20 for CSI-RS resource 1 and 2 21 for CSI-RS resource 3 and 4
	Frequency Occupation		Start PRB 0 Number of PRB = BWP size
	QCL info		TCI state #0

NZP CSI-RS for CSI acquisition	Frequency Occupation			Start PRB 0 Number of PRB = BWP size
	QCL info			TCI state #1
ZP CSI-RS for CSI acquisition	Frequency Occupation			Start PRB 0 Number of PRB = BWP size
TCI state #0	Type 1 QCL information	SSB index		SSB #0
		QCL Type		Type C
	Type 2 QCL information	SSB index		N/A
		QCL Type		N/A
TCI state #1	Type 1 QCL information	CSI-RS resource		CSI-RS resource 1 from 'CSI-RS for tracking' configuration
		QCL Type		Type A
	Type 2 QCL information	CSI-RS resource		N/A
		QCL Type		N/A
Number of HARQ Processes				4 For FDD 8 for TDD
HARQ ACK/NACK bundling				Multiplexed
Redundancy version coding sequence				{0,2,3,1}
K1 value (PDSCH-to-HARQ-timing-indicator)				2 for FDD Defined in Annex A.1.2 for TDD
Symbols for unused Res				OCNG as specified in A.5
Note 1: PDSCH is not scheduled on slots containing CSI-RS or slots which are not full DL. Note 2: UE assumes that the TCI state for the PDSCH is identical to the TCI state applied for the PDCCH transmission.				

6.2 Reporting of Channel Quality Indicator (CQI)

<Editor's note: The requirements were introduced based on current results from companies; these requirements can be revised based on more results from companies.>

This section includes the requirements for the reporting of channel quality indicator (CQI).

6.2.1 1RX requirements

(Void)

6.2.2 2RX requirements

This sub-clause includes the requirements for reporting of CQI for UE equipped with 2 receiver antennas.

6.2.2.1 FDD

6.2.2.1.1 CQI reporting definition under AWGN conditions

The reporting accuracy of the channel quality indicator (CQI) under frequency non-selective conditions is determined by the reporting variance and the BLER performance using the transport format indicated by the reported CQI median. The purpose is to verify that the reported CQI values are in accordance with the CQI definition given in TS 38.214 [12]. To account for sensitivity of the input SNR the reporting definition is considered to be verified if the reporting accuracy is met for at least one of two SNR levels separated by an offset of [1] dB.

6.2.2.1.1.1 Minimum requirement for periodic CQI reporting

For the parameters specified in Table 6.2.2.1.1.1-1, and using the downlink physical channels specified in Annex C.3.1, the minimum requirements are specified by the following:

a) The reported CQI value according to the reference channel shall be in the range of ±1 of the reported median more than [90]% of the time.

b) If the PDSCH BLER using the transport format indicated by median CQI is less than or equal to 0.1, then the BLER using the transport format indicated by the (median CQI+1) shall be greater than 0.1. If the PDSCH BLER using the transport format indicated by the median CQI is greater than 0.1, then the BLER using transport format indicated by (median CQI-1) shall be less than or equal to 0.1.

Table 6.2.2.1.1.1-1: CQI reporting definition test

Parameter			Unit	Test 1	Test 2
Bandwidth			MHz	10	
Duplex Mode				FDD	
DL BWP configuration #1		First PRB		0	
		Number of contiguous PRB		52	
		Subcarrier spacing	kHz	15	
SNR			dB	[8]	[9] / [14] / [15]
Propagation channel				AWGN	
Antenna configuration				2×2 with static channel specified in Annex B.1	
Beamforming Model				As specified in Section [Annex TBD]	
ZP CSI-RS configuration		CSI-RS resource Type		Periodic	
		Number of CSI-RS ports (*X*)		4	
		CDM Type		FD-CDM2	
		Density (ρ)		1	
		First subcarrier index in the PRB used for CSI-RS (k_0)		Row 5,4	
		First OFDM symbol in the PRB used for CSI-RS (l_0)		9	
		CSI-RS periodicity and offset	slot	5/1	
NZP CSI-RS for CSI acquisition		CSI-RS resource Type		Periodic	
		Number of CSI-RS ports (*X*)		2	
		CDM Type		FD-CDM2	
		Density (ρ)		1	
		First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 3,(6,-)	
		First OFDM symbol in the PRB used for CSI-RS (l_0)		13	
		NZP CSI-RS-timeConfig periodicity and offset	slot	5/1	
CSI-IM configuration		CSI-IM RE pattern		0	
		CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(4, 9)	
		CSI-IM timeConfig periodicity and offset	slot	5/1	
ReportConfigType				Periodic	
CQI-table				Table 2	
reportQuantity				cri-RI-PMI-CQI	
timeRestrictionForChannelMeasurements				Not configured	
timeRestrictionForInterferenceMeasurements				Not configured	
cqi-FormatIndicator				Wideband	
pmi-FormatIndicator				Wideband	
Sub-band Size			RB	N/A	
CSI-Report periodicity and offset			slot	5/1	
aperiodicTriggeringOffset				Not configured	
Codebook configuration		Codebook Type		typeI-SinglePanel	
		Codebook Mode		1	
		(CodebookConfig-N1,CodebookConfig-N2)		Not configured	
		CodebookSubsetRestriction		[010000]	
		RI Restriction		[N/A]	
Physical channel for CSI report				[PUCCH]	
CQI/RI/PMI delay			ms	8	
Maximum number of HARQ transmission				1	
Measurement channel				As specified in Table A.4-1, TBS.2-2	

6.2.2.1.2 CQI reporting under fading conditions

6.2.2.1.2.1 Minimum requirement for wideband CQI reporting

The purpose of the requirements is to verify that the UE is tracking the channel variations and selecting the largest transport format possible according to the prevailing channel state for the frequency non-selective scheduling.

The reporting accuracy of CQI under frequency non-selective fading conditions is determined by the reporting variance, the relative increase of the throughput obtained when the transport format is indicated by the reported CQI compared to the throughput obtained when a fixed transport format is configured according to the reported median CQI, and a minimum BLER using the transport formats indicated by the reported CQI. To account for sensitivity of the input SNR the sub-band CQI reporting under frequency selective fading conditions is considered to be verified if the reporting accuracy is met for at least one of two SNR levels separated by an offset of [1] dB.

For the parameters specified in Table 6.2.2.1.2.1-1 and using the downlink physical channels specified in Annex C.3.1, the minimum requirements are specified by the following:

a) A CQI index not in the set {median CQI -1, median CQI, median CQI +1} shall be reported at least α% of the time where α% is specified in Table 6.2.2.1.2.1-2;

b) The ratio of the throughput obtained when transmitting the transport format indicated by each reported wideband CQI index and that obtained when transmitting a fixed transport format configured according to the wideband CQI median shall be $\geq \gamma$, where γ is specified in Table 6.2.2.1.2.1-2;

c) When transmitting the transport format indicated by each reported wideband CQI index, the average BLER for the indicated transport formats shall be greater than or equal to [0.02].

Table 6.2.2.1.2.1-1: Wideband CQI reporting test under frequency non-selective fading conditions

Parameter			Unit	Test 1	Test 2		
Bandwidth			MHz	10			
Duplex Mode				FDD			
DL BWP configuration #1		First PRB		0			
		Number of contiguous PRB		52			
		Subcarrier spacing	kHz	15			
SNR			dB	[6]	[7]	[12]	[13]
Propagation channel				TDLA30-5			
Antenna configuration				2×2			
Correlation configuration				ULA high			
Beamforming Model				As specified in Section [Annex TBD]			
ZP CSI-RS configuration		CSI-RS resource Type		Periodic			
		Number of CSI-RS ports (*X*)		4			
		CDM Type		FD-CDM2			
		Density (ρ)		1			
		First subcarrier index in the PRB used for CSI-RS (k_0)		Row 5,4			
		First OFDM symbol in the PRB used for CSI-RS (l_0)		9			
		CSI-RS periodicity and offset	slot	5/1			
NZP CSI-RS for CSI acquisition		CSI-RS resource Type		Periodic			
		Number of CSI-RS ports (*X*)		2			
		CDM Type		FD-CDM2			
		Density (ρ)		1			
		First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 3,(6,-)			
		First OFDM symbol in the PRB used for CSI-RS (l_0)		13			
		NZP CSI-RS-timeConfig periodicity and offset	slot	5/1			
CSI-IM configuration		CSI-IM RE pattern		0			
		CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(4, 9)			
		CSI-IM timeConfig periodicity and offset	slot	5/1			
ReportConfigType				Periodic			
CQI-table				Table 2			
reportQuantity				cri-RI-PMI-CQI			
timeRestrictionForChannelMeasurements				Not configured			
timeRestrictionForInterferenceMeasurements				Not configured			
cqi-FormatIndicator				Wideband			
pmi-FormatIndicator				Wideband			
Sub-band Size			RB	[8]			
Csi-ReportingBand				[1111111]			
CSI-Report periodicity and offset			slot	5/1			
aperiodicTriggeringOffset				Not configured			
Codebook configuration		Codebook Type		typeI-SinglePanel			
		Codebook Mode		1			
		(CodebookConfig-N1,CodebookConfig-N2)		Not configured			
		CodebookSubsetRestriction		000001			
		RI Restriction		[N/A]			
Physical channel for CSI report				[PUCCH]			
CQI/RI/PMI delay			ms	8			
Maximum number of HARQ transmission				1			
Measurement channel				As specified in Table A.4-1, TBS.2-1			

Table 6.2.2.1.2.1-2: Minimum requirements

Parameters	Test 1	Test 2
α [%]	[20]	[20]
γ	[1.05]	[1.05]

6.2.2.1.2.2 Minimum requirement for sub-band CQI reporting

The purpose of the requirements is to verify that the preferred sub-bands can be used for frequency-selective scheduling under the frequency-selective fading conditions.

The accuracy of sub-band channel CQI reporting under the frequency-selective fading conditions is determined by a double-sided percentile of the reported differential CQI offset level 0 per sub-band, and the relative increase of the throughput obtained when transmitting the transport format indicated by the corresponding reported sub-band CQI on a randomly selected sub-band among the sub-bands with the highest reported differential CQI offset level compared to the throughput when transmitting a fixed transport format according to the wideband CQI median on a randomly selected sub-band among all the sub-bands.

For the parameters specified in Table 6.2.2.1.2.2-1 and using the downlink physical channels specified in Annex C.3.1, the minimum requirements are specified by the following:

a) A sub-band differential CQI offset level of 0 shall be reported at least α% of the time but less than β% of the time for each sub-band, where α and β are specified in Table 6.2.2.1.2.2-2;

b) The ratio of the throughput obtained when transmitting the corresponding transport format on a randomly selected sub-band among the sub-bands with the highest differential CQI offset level and that obtained when transmitting the transport format indicated by the reported wideband CQI median on a randomly selected sub-band among all the sub-bands shall be $\geq \gamma$, where γ is specified in Table 6.2.2.1.2.2-2;

c) When transmitting the corresponding transport format on a randomly selected sub-band among the sub-bands with the highest differential CQI offset level, the average BLER for the indicated transport format shall be greater than or equal to TBD.

The requirements only apply for sub-bands of full size and the random scheduling across the sub-bands is done by selecting a new sub-band in each TTI for FDD.

Table 6.2.2.1.2.2-1: Sub-band CQI reporting test under frequency-selective fading conditions

Parameter			Unit	Test 1	Test 2
Bandwidth			MHz	10	
Duplex Mode				FDD	
DL BWP configuration #1		First PRB		0	
		Number of contiguous PRB		52	
		Subcarrier spacing	kHz	15	
SNR			dB	TBD	TBD / TBD / TBD
Propagation channel				[Two tap model specified in Annex B.2.4 with a=1, f_D = 5Hz, and τ_d=0.45μs]	
Antenna configuration				TBD	
Correlation configuration				As per Annex B.1	
Beamforming Model				As specified in Section [Annex TBD]	
ZP CSI-RS configuration		CSI-RS resource Type		Periodic	
		Number of CSI-RS ports (X)		4	
		CDM Type		FD-CDM2	
		Density (ρ)		1	
		First subcarrier index in the PRB used for CSI-RS (k_0)		Row 5,4	
		First OFDM symbol in the PRB used for CSI-RS (l_0)		9	
		CSI-RS periodicity and offset	slot	5/1	
NZP CSI-RS for CSI acquisition		CSI-RS resource Type		Periodic	
		Number of CSI-RS ports (X)		2	
		CDM Type		FD-CDM2	
		Density (ρ)		1	
		First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 3,(6,-)	
		First OFDM symbol in the PRB used for CSI-RS (l_0)		13	
		NZP CSI-RS-timeConfig periodicity and offset	slot	5/1	
CSI-IM configuration		CSI-IM RE pattern		0	
		CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(4, 9)	
		CSI-IM timeConfig periodicity and offset	slot	5/1	
ReportConfigType				Periodic	
CQI-table				Table 2	
reportQuantity				cri-RI-PMI-CQI	
timeRestrictionForChannelMeasurements				Not configured	
timeRestrictionForInterferenceMeasurements				Not configured	
cqi-FormatIndicator				Subband	
pmi-FormatIndicator				Wideband	
Sub-band Size			RB	8	
CSI-Report periodicity and offset			slot	5/1	
aperiodicTriggeringOffset				Not configured	
Codebook configuration		Codebook Type		typeI-SinglePanel	
		Codebook Mode		1	
		(CodebookConfig-N1,CodebookConfig-N2)		Not configured	
		CodebookSubsetRestriction		000001	
		RI Restriction		[N/A]	
Physical channel for CSI report				TBD	
CQI/RI/PMI delay			ms	8	
Maximum number of HARQ transmission				1	
Measurement channel				TBD	

Table 6.2.2.1.2.2-2: Minimum requirements

Parameters	Test 1	Test 2
α [%]	TBD	TBD
β [%]	TBD	TBD
γ	TBD	TBD

6.2.2.2 TDD

6.2.2.2.1 CQI reporting definition under AWGN conditions

6.2.2.2.1.1 Minimum requirement for periodic CQI reporting

The purpose of the requirements is to verify that the reported CQI values are in accordance with the CQI definition given in TS38.214 [12]. The reporting accuracy of CQI under AWGN condition is determined by the reporting variance and BLER performance using the transport format indicated by the reported CQI median.

For the parameters specified in Table 6.2.2.2.1.1-1, and using the downlink physical channels specified in Annex C.3.1, the minimum requirements are specified by the following:

a) The reported CQI value according to the reference channel shall be in the range of ±1 of the reported median more than [90]% of the time.

b) If the PDSCH BLER using the transport format indicated by median CQI is less than or equal to 0.1, then the BLER using the transport format indicated by the (median CQI+1) shall be greater than 0.1. If the PDSCH BLER using the transport format indicated by the median CQI is greater than 0.1, then the BLER using transport format indicated by (median CQI-1) shall be less than or equal to 0.1.

Table 6.2.2.2.1.1-1: CQI reporting definition test

Parameter		Unit	Test 1	Test 2
Bandwidth		MHz	40	
Duplex Mode			TDD	
TDD UL-DL pattern			FR1.30-1	
DL BWP configuration #1	First PRB		0	
	Number of contiguous PRB		106	
	Subcarrier spacing	kHz	30	
SNR		dB	[8]	[9] / [14] / [15]
Propagation channel			AWGN	
Antenna configuration			2×2 with static channel specified in Annex B.1	
Beamforming Model			As specified in Section [Annex TBD]	
ZP CSI-RS configuration	CSI-RS resource Type		Periodic	
	Number of CSI-RS ports (*X*)		4	
	CDM Type		FD-CDM2	
	Density (ρ)		1	
	First subcarrier index in the PRB used for CSI-RS (k_0)		Row 5,4	
	First OFDM symbol in the PRB used for CSI-RS (l_0)		9	
	CSI-RS periodicity and offset	slot	10/1	
NZP CSI-RS for CSI acquisition	CSI-RS resource Type		Periodic	
	Number of CSI-RS ports (*X*)		2	
	CDM Type		FD-CDM2	
	Density (ρ)		1	
	First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 3,(6,-)	
	First OFDM symbol in the PRB used for CSI-RS (l_0)		13	
	NZP CSI-RS-timeConfig periodicity and offset	slot	10/1	
CSI-IM configuration	CSI-IM RE pattern		0	
	CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(4, 9)	
	CSI-IM timeConfig periodicity and offset	slot	10/1	
ReportConfigType			Periodic	
CQI-table			Table 2	
reportQuantity			cri-RI-PMI-CQI	
timeRestrictionForChannelMeasurements			Not configured	
timeRestrictionForInterferenceMeasurements			Not configured	
cqi-FormatIndicator			Wideband	
pmi-FormatIndicator			Wideband	
Sub-band Size		RB	N/A	
CSI-Report periodicity and offset		slot	10/1	
aperiodicTriggeringOffset			Not configured	
Codebook configuration	Codebook Type		typeI-SinglePanel	
	Codebook Mode		1	
	(CodebookConfig-N1,CodebookConfig-N2)		Not configured	
	CodebookSubsetRestriction		[010000]	
	RI Restriction		[N/A]	
Physical channel for CSI report			[PUCCH]	
CQI/RI/PMI delay		ms	[9.5]	
Maximum number of HARQ transmission			1	
Measurement channel			As specified in Table A.4-1, TBS.2-4	

6.2.2.2.2 Wideband CQI reporting under fading conditions

6.2.2.2.2.1 Minimum requirement for wideband CQI reporting

The purpose of the requirements is to verify that the UE is tracking the channel variations and selecting the largest transport format possible according to the prevailing channel state for the frequency non-selective scheduling.

The reporting accuracy of CQI under frequency non-selective fading conditions is determined by the reporting variance, the relative increase of the throughput obtained when the transport format is indicated by the reported CQI compared to the throughput obtained when a fixed transport format is configured according to the reported median CQI, and a minimum BLER using the transport formats indicated by the reported CQI.

For the parameters specified in Table 6.2.2.2.2.1-1 and using the downlink physical channels specified in Annex C.3.1, the minimum requirements are specified by the following:

a) A CQI index not in the set {median CQI -1, median CQI, median CQI +1} shall be reported at least α% of the time where α% is specified in Table 6.2.2.2.2.1-2;

b) The ratio of the throughput obtained when transmitting the transport format indicated by each reported wideband CQI index and that obtained when transmitting a fixed transport format configured according to the wideband CQI median shall be $\geq \gamma$, where γ is specified in Table 6.2.2.2.2.1-2;

c) When transmitting the transport format indicated by each reported wideband CQI index, the average BLER for the indicated transport formats shall be greater than or equal to [0.02].

Table 6.2.2.2.2.1-1: Wideband CQI reporting test under frequency non-selective fading conditions

Parameter			Unit	Test 1	Test 2		
Bandwidth			MHz	40			
Duplex Mode				TDD			
TDD UL-DL pattern				FR1.30-1			
DL BWP configuration #1		First PRB		0			
		Number of contiguous PRB		106			
		Subcarrier spacing	kHz	30			
SNR			dB	6	7	12	13
Propagation channel				[TDLA30-5]			
Antenna configuration				2×2			
Correlation configuration				ULA high			
Beamforming Model				As specified in Section [Annex TBD]			
ZP CSI-RS configuration		CSI-RS resource Type		Periodic			
		Number of CSI-RS ports (*X*)		4			
		CDM Type		FD-CDM2			
		Density (ρ)		1			
		First subcarrier index in the PRB used for CSI-RS (k_0)		Row 5,4			
		First OFDM symbol in the PRB used for CSI-RS (l_0)		9			
		CSI-RS periodicity and offset	slot	10/1			
NZP CSI-RS for CSI acquisition		CSI-RS resource Type		Periodic			
		Number of CSI-RS ports (*X*)		2			
		CDM Type		FD-CDM2			
		Density (ρ)		1			
		First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 3,(6,-)			
		First OFDM symbol in the PRB used for CSI-RS (l_0)		13			
		NZP CSI-RS-timeConfig periodicity and offset	slot	10/1			
CSI-IM configuration		CSI-IM RE pattern		0			
		CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(4, 9)			
		CSI-IM timeConfig periodicity and offset	slot	10/1			
ReportConfigType				Periodic			
CQI-table				Table 2			
reportQuantity				cri-RI-PMI-CQI			
timeRestrictionForChannelMeasurements				Not configured			
timeRestrictionForInterferenceMeasurements				Not configured			
cqi-FormatIndicator				Wideband			
pmi-FormatIndicator				Wideband			
Sub-band Size			RB	[16]			
Csi-ReportingBand				[1111111]			
CSI-Report periodicity and offset			slot	10/1			
aperiodicTriggeringOffset				Not configured			
Codebook configuration		Codebook Type		typeI-SinglePanel			
		Codebook Mode		1			
		(CodebookConfig-N1,CodebookConfig-N2)		Not configured			
		CodebookSubsetRestriction		000001			
		RI Restriction		[N/A]			
Physical channel for CSI report				[PUCCH]			
CQI/RI/PMI delay			ms	[9.5]			
Maximum number of HARQ transmission				1			
Measurement channel				As specified in Table A.4-1, TBS.2-3			

Table 6.2.2.2.2.1-2: Minimum requirements

Parameters	Test 1	Test 2
α [%]	[20]	[20]
γ	[1.05]	[1.05]

6.2.2.2.2.2 Minimum requirement for sub-band CQI reporting

The purpose of the requirements is to verify that the preferred sub-bands can be used for frequency-selective scheduling under the frequency-selective fading conditions.

The accuracy of sub-band channel CQI reporting under the frequency-selective fading conditions is determined by a double-sided percentile of the reported differential CQI offset level 0 per sub-band, and the relative increase of the throughput obtained when transmitting the transport format indicated by the corresponding reported sub-band CQI on a randomly selected sub-band among the sub-bands with the highest reported differential CQI offset level compared to the throughput when transmitting a fixed transport format according to the wideband CQI median on a randomly selected sub-band among all the sub-bands.

For the parameters specified in Table 6.2.2.2.2.2-1 and using the downlink physical channels specified in Annex C.3.1, the minimum requirements are specified by the following:

a) A sub-band differential CQI offset level of 0 shall be reported at least α% of the time but less than β% of the time for each sub-band, where α and β are specified in Table 6.2.2.2.2.2-2;

b) The ratio of the throughput obtained when transmitting the corresponding transport format on a randomly selected sub-band among the sub-bands with the highest differential CQI offset level and that obtained when transmitting the transport format indicated by the reported wideband CQI median on a randomly selected sub-band among all the sub-bands shall be $\geq \gamma$, where γ is specified in Table 6.2.2.2.2.2-2;

c) When transmitting the corresponding transport format on a randomly selected sub-band among the sub-bands with the highest differential CQI offset level, the average BLER for the indicated transport format shall be greater than or equal to TBD.

The requirements only apply for sub-bands of full size and the random scheduling across the sub-bands is done by selecting a new sub-band in each available downlink transmission instance for TDD.

Table 6.2.2.2.2.2-1: Sub-band CQI reporting test under frequency-selective fading conditions

Parameter			Unit	Test 1	Test 2
Bandwidth			MHz	40	
Duplex Mode				TDD	
TDD UL-DL pattern				FR1.30-1	
DL BWP configuration #1		First PRB		0	
		Number of contiguous PRB		106	
		Subcarrier spacing	kHz	30	
SNR			dB	TBD	TBD	TBD	TBD
Propagation channel				[Two tap model specified in Annex B.2.4 with a=1, f_D = 5Hz, and τ_d=0.1125μs]	
Antenna configuration				TBD	
Correlation configuration				As per Annex B.1	
Beamforming Model				As specified in Section [Annex TBD]	
ZP CSI-RS configuration		CSI-RS resource Type		Periodic	
		Number of CSI-RS ports (X)		4	
		CDM Type		FD-CDM2	
		Density (ρ)		1	
		First subcarrier index in the PRB used for CSI-RS (k_0)		Row 5,4	
		First OFDM symbol in the PRB used for CSI-RS (l_0)		9	
		CSI-RS periodicity and offset	slot	10/1	
NZP CSI-RS for CSI acquisition		CSI-RS resource Type		Periodic	
		Number of CSI-RS ports (X)		2	
		CDM Type		FD-CDM2	
		Density (ρ)		1	
		First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 3,(6,-)	
		First OFDM symbol in the PRB used for CSI-RS (l_0)		13	
		NZP CSI-RS-timeConfig periodicity and offset	slot	10/1	
CSI-IM configuration		CSI-IM RE pattern		0	
		CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(4, 9)	
		CSI-IM timeConfig periodicity and offset	slot	10/1	
ReportConfigType				Periodic	
CQI-table				Table 2	
reportQuantity				cri-RI-PMI-CQI	
timeRestrictionForChannelMeasurements				Not configured	
timeRestrictionForInterferenceMeasurements				Not configured	
cqi-FormatIndicator				Subband	
pmi-FormatIndicator				Wideband	
Sub-band Size			RB	16	
CSI-Report periodicity and offset			slot	10/1	
aperiodicTriggeringOffset				Not configured	
Codebook configuration		Codebook Type		typeI-SinglePanel	
		Codebook Mode		1	
		(CodebookConfig-N1,CodebookConfig-N2)		Not configured	
		CodebookSubsetRestriction		000001	
		RI Restriction		[N/A]	
Physical channel for CSI report				TBD	
CQI/RI/PMI delay			ms	[9.5]	
Maximum number of HARQ transmission				1	
Measurement channel				TBD	

Table 6.2.2.2.2.2-2: Minimum requirements

Parameters	Test 1	Test 2
α [%]	TBD	TBD
β [%]	TBD	TBD
γ	TBD	TBD

6.2.3 4RX requirements

This sub-clause includes the requirements for reporting of CQI for UE equipped with 4 receiver antennas.

6.2.3.1 FDD

6.2.3.1.1 CQI reporting definition under AWGN conditions

The purpose of the requirements is to verify that the reported CQI values are in accordance with the CQI definition given in TS38.214 [12]. The reporting accuracy of CQI under AWGN condition is determined by the reporting variance and BLER performance using the transport format indicated by the reported CQI median.

6.2.3.1.1.1 Minimum requirement for period CQI reporting

For the parameters specified in Table 6.2.3.1.1.1-1, and using the downlink physical channels specified in Annex C.3.1, the minimum requirements are specified by the following:

a) The reported CQI value according to the reference channel shall be in the range of ±1 of the reported median more than [90]% of the time.

b) If the PDSCH BLER using the transport format indicated by median CQI is less than or equal to 0.1, then the BLER using the transport format indicated by the (median CQI+1) shall be greater than 0.1. If the PDSCH BLER using the transport format indicated by the median CQI is greater than 0.1, then the BLER using transport format indicated by (median CQI-1) shall be less than or equal to 0.1.

Table 6.2.2.1.1.1-1: CQI reporting definition test

Parameter			Unit	Test 1	Test 2
Bandwidth			MHz	10	
Duplex Mode				FDD	
DL BWP configuration #1		First PRB		0	
		Number of contiguous PRB		52	
		Subcarrier spacing	kHz	15	
SNR			dB	[5]	[6] / [11] / [12]
Propagation channel				AWGN	
Antenna configuration				2×4 with static channel specified in Annex B.1	
Beamforming Model				As specified in Section [Annex TBD]	
ZP CSI-RS configuration		CSI-RS resource Type		Periodic	
		Number of CSI-RS ports (*X*)		4	
		CDM Type		FD-CDM2	
		Density (ρ)		1	
		First subcarrier index in the PRB used for CSI-RS (k_0)		Row 5,4	
		First OFDM symbol in the PRB used for CSI-RS (l_0)		9	
		CSI-RS periodicity and offset	slot	5/1	
NZP CSI-RS for CSI acquisition		CSI-RS resource Type		Periodic	
		Number of CSI-RS ports (*X*)		2	
		CDM Type		FD-CDM2	
		Density (ρ)		1	
		First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 3,(6,-)	
		First OFDM symbol in the PRB used for CSI-RS (l_0)		13	
		NZP CSI-RS-timeConfig periodicity and offset	slot	5/1	
CSI-IM configuration		CSI-IM RE pattern		0	
		CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(4, 9)	
		CSI-IM timeConfig periodicity and offset	slot	5/1	
ReportConfigType				Periodic	
CQI-table				Table 2	
reportQuantity				cri-RI-PMI-CQI	
timeRestrictionForChannelMeasurements				Not configured	
timeRestrictionForInterferenceMeasurements				Not configured	
cqi-FormatIndicator				Wideband	
pmi-FormatIndicator				Wideband	
Sub-band Size			RB	N/A	
CSI-Report periodicity and offset			slot	5/1	
aperiodicTriggeringOffset				Not configured	
Codebook configuration		Codebook Type		typeI-SinglePanel	
		Codebook Mode		1	
		(CodebookConfig-N1,CodebookConfig-N2)		Not configured	
		CodebookSubsetRestriction		[010000]	
		RI Restriction		[N/A]	
Physical channel for CSI report				[PUCCH]	
CQI/RI/PMI delay			ms	8	
Maximum number of HARQ transmission				1	
Measurement channel				As specified in Table A.4-1, TBS.2-2	

6.2.3.1.2 Wideband CQI reporting under fading conditions

6.2.3.1.2.1 Minimum requirement for wideband CQI reporting

The purpose of the requirements is to verify that the UE is tracking the channel variations and selecting the largest transport format possible according to the prevailing channel state for the frequency non-selective scheduling.

The reporting accuracy of CQI under frequency non-selective fading conditions is determined by the reporting variance, the relative increase of the throughput obtained when the transport format is indicated by the reported CQI compared to the throughput obtained when a fixed transport format is configured according to the reported median CQI, and a minimum BLER using the transport formats indicated by the reported CQI.

For the parameters specified in Table 6.2.3.1.2.1-1 and using the downlink physical channels specified in Annex C.3.1, the minimum requirements are specified by the following:

a) A CQI index not in the set {median CQI -1, median CQI, median CQI +1} shall be reported at least α% of the time where α% is specified in Table 6.2.3.1.2.1-2;

b) The ratio of the throughput obtained when transmitting the transport format indicated by each reported wideband CQI index and that obtained when transmitting a fixed transport format configured according to the wideband CQI median shall be $\geq \gamma$, where γ is specified in Table 6.2.3.1.2.1-2;

c) When transmitting the transport format indicated by each reported wideband CQI index, the average BLER for the indicated transport formats shall be greater than or equal to [0.02].

Table 6.2.3.1.2.1-1: Wideband CQI reporting test under frequency non-selective fading conditions

Parameter			Unit	Test 1	Test 2
Bandwidth			MHz	10	
Duplex Mode				FDD	
DL BWP configuration #1		First PRB		0	
		Number of contiguous PRB		52	
		Subcarrier spacing	kHz	15	
SNR			dB	[3]	[4] / [9] / [10]
Propagation channel				TDLA30-5	
Antenna configuration				2×4	
Correlation configuration				XP High	
Beamforming Model				As specified in Section [Annex TBD]	
ZP CSI-RS configuration		CSI-RS resource Type		Periodic	
		Number of CSI-RS ports (*X*)		4	
		CDM Type		FD-CDM2	
		Density (ρ)		1	
		First subcarrier index in the PRB used for CSI-RS (k_0)		Row 5,4	
		First OFDM symbol in the PRB used for CSI-RS (l_0)		9	
		CSI-RS periodicity and offset	slot	5/1	
NZP CSI-RS for CSI acquisition		CSI-RS resource Type		Periodic	
		Number of CSI-RS ports (*X*)		2	
		CDM Type		FD-CDM2	
		Density (ρ)		1	
		First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 3,(6,-)	
		First OFDM symbol in the PRB used for CSI-RS (l_0)		13	
		NZP CSI-RS-timeConfig periodicity and offset	slot	5/1	
CSI-IM configuration		CSI-IM RE pattern		0	
		CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(4, 9)	
		CSI-IM timeConfig periodicity and offset	slot	5/1	
ReportConfigType				Periodic	
CQI-table				Table 2	
reportQuantity				cri-RI-PMI-CQI	
timeRestrictionForChannelMeasurements				Not configured	
timeRestrictionForInterferenceMeasurements				Not configured	
cqi-FormatIndicator				Wideband	
pmi-FormatIndicator				Wideband	
Sub-band Size			RB	[8]	
csi-ReportingBand				[1111111]	
CSI-Report periodicity and offset			slot	5/1	
aperiodicTriggeringOffset				Not configured	
Codebook configuration		Codebook Type		typeI-SinglePanel	
		Codebook Mode		1	
		(CodebookConfig-N1,CodebookConfig-N2)		Not configured	
		CodebookSubsetRestriction		000001	
		RI Restriction		[N/A]	
Physical channel for CSI report				[PUCCH]	
CQI/RI/PMI delay			ms	8	
Maximum number of HARQ transmission				1	
Measurement channel				As specified in Table A.4-1, TBS.2-1	

Table 6.2.3.1.2.1-2: Minimum requirements

Parameters	Test 1	Test 2
α [%]	[5]	[5]
γ	[1.05]	[1.05]

6.2.3.1.2.2 Minimum requirement for sub-band CQI reporting

The purpose of the requirements is to verify that the preferred sub-bands can be used for frequency-selective scheduling under the frequency-selective fading conditions.

The accuracy of sub-band channel CQI reporting under the frequency-selective fading conditions is determined by a double-sided percentile of the reported differential CQI offset level 0 per sub-band, and the relative increase of the throughput obtained when transmitting the transport format indicated by the corresponding reported sub-band CQI on a randomly selected sub-band among the sub-bands with the highest reported differential CQI offset level compared to the throughput when transmitting a fixed transport format according to the wideband CQI median on a randomly selected sub-band among all the sub-bands.

For the parameters specified in Table 6.2.3.1.2.2-1 and using the downlink physical channels specified in Annex C.3.1, the minimum requirements are specified by the following:

a) A sub-band differential CQI offset level of 0 shall be reported at least α% of the time but less than β% of the time for each sub-band, where α and β are specified in Table 6.2.3.1.2.2-2;

b) The ratio of the throughput obtained when transmitting the corresponding transport format on a randomly selected sub-band among the sub-bands with the highest differential CQI offset level and that obtained when transmitting the transport format indicated by the reported wideband CQI median on a randomly selected sub-band among all the sub-bands shall be $\geq \gamma$, where γ is specified in Table 6.2.3.1.2.2-2;

c) When transmitting the corresponding transport format on a randomly selected sub-band among the sub-bands with the highest differential CQI offset level, the average BLER for the indicated transport format shall be greater than or equal to TBD.

The requirements only apply for sub-bands of full size and the random scheduling across the sub-bands is done by selecting a new sub-band in each TTI for FDD.

Table 6.2.3.1.2.2-1: Sub-band CQI reporting test under frequency-selective fading conditions

Parameter			Unit	Test 1	Test 2
Bandwidth			MHz	10	
Duplex Mode				FDD	
DL BWP configuration #1		First PRB		0	
		Number of contiguous PRB		52	
		Subcarrier spacing	kHz	15	
SNR			dB	TBD	TBD / TBD / TBD
Propagation channel				[Two tap model specified in Annex B.2.4 with a=1, f_D = 5Hz, and τ_d=0.45μs]	
Antenna configuration				TBD	
Correlation configuration				As per Annex B.1	
Beamforming Model				As specified in Section [Annex TBD]	
ZP CSI-RS configuration		CSI-RS resource Type		Periodic	
		Number of CSI-RS ports (X)		4	
		CDM Type		FD-CDM2	
		Density (ρ)		1	
		First subcarrier index in the PRB used for CSI-RS (k_0)		Row 5,4	
		First OFDM symbol in the PRB used for CSI-RS (l_0)		9	
		CSI-RS periodicity and offset	slot	5/1	
NZP CSI-RS for CSI acquisition		CSI-RS resource Type		Periodic	
		Number of CSI-RS ports (X)		2	
		CDM Type		FD-CDM2	
		Density (ρ)		1	
		First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 3,(6,-)	
		First OFDM symbol in the PRB used for CSI-RS (l_0)		13	
		NZP CSI-RS-timeConfig periodicity and offset	slot	5/1	
CSI-IM configuration		CSI-IM RE pattern		0	
		CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(4, 9)	
		CSI-IM timeConfig periodicity and offset	slot	5/1	
ReportConfigType				Periodic	
CQI-table				Table 2	
reportQuantity				cri-RI-PMI-CQI	
timeRestrictionForChannelMeasurements				Not configured	
timeRestrictionForInterferenceMeasurements				Not configured	
cqi-FormatIndicator				Subband	
pmi-FormatIndicator				Wideband	
Sub-band Size			RB	8	
CSI-Report periodicity and offset			slot	5/1	
aperiodicTriggeringOffset				Not configured	
Codebook configuration		Codebook Type		typeI-SinglePanel	
		Codebook Mode		1	
		(CodebookConfig-N1,CodebookConfig-N2)		Not configured	
		CodebookSubsetRestriction		000001	
		RI Restriction		[N/A]	
Physical channel for CSI report				TBD	
CQI/RI/PMI delay			ms	8	
Maximum number of HARQ transmission				1	
Measurement channel				TBD	

Table 6.2.3.1.2.2-2: Minimum requirements

Parameters	Test 1	Test 2
α [%]	TBD	TBD
β [%]	TBD	TBD
γ	TBD	TBD

6.2.3.2 TDD

6.2.3.2.1 CQI reporting definition under AWGN

6.2.3.2.1.1 Minimum requirement for CQI periodic reporting

The purpose of the requirements is to verify that the reported CQI values are in accordance with the CQI definition given in TS38.214 [12]. The reporting accuracy of CQI under AWGN condition is determined by the reporting variance and BLER performance using the transport format indicated by the reported CQI median.

For the parameters specified in Table 6.2.3.2.1.1-1, and using the downlink physical channels specified in Annex C.3.1, the minimum requirements are specified by the following:

a) The reported CQI value according to the reference channel shall be in the range of ±1 of the reported median more than [90]% of the time.

b) If the PDSCH BLER using the transport format indicated by median CQI is less than or equal to 0.1, then the BLER using the transport format indicated by the (median CQI+1) shall be greater than 0.1. If the PDSCH BLER using the transport format indicated by the median CQI is greater than 0.1, then the BLER using transport format indicated by (median CQI-1) shall be less than or equal to 0.1.

Table 6.2.3.2.1.1-1: CQI reporting definition test

Parameter			Unit	Test 1	Test 2
Bandwidth			MHz	40	
Duplex Mode				TDD	
TDD UL-DL pattern				FR1.30-1	
DL BWP configuration #1		First PRB		0	
		Number of contiguous PRB		106	
		Subcarrier spacing	kHz	30	
SNR			dB	[5]	[6] / [11] / [12]
Propagation channel				AWGN	
Antenna configuration				2×4 with static channel specified in Annex B.1	
Beamforming Model				As specified in Section [Annex TBD]	
ZP CSI-RS configuration		CSI-RS resource Type		Periodic	
		Number of CSI-RS ports (*X*)		4	
		CDM Type		FD-CDM2	
		Density (ρ)		1	
		First subcarrier index in the PRB used for CSI-RS (k_0)		Row 5,4	
		First OFDM symbol in the PRB used for CSI-RS (l_0)		9	
		CSI-RS periodicity and offset	slot	10/1	
NZP CSI-RS for CSI acquisition		CSI-RS resource Type		Periodic	
		Number of CSI-RS ports (*X*)		2	
		CDM Type		FD-CDM2	
		Density (ρ)		1	
		First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 3,(6,-)	
		First OFDM symbol in the PRB used for CSI-RS (l_0)		13	
		NZP CSI-RS-timeConfig periodicity and offset	slot	10/1	
CSI-IM configuration		CSI-IM RE pattern		0	
		CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(4, 9)	
		CSI-IM timeConfig periodicity and offset	slot	10/1	
ReportConfigType				Periodic	
CQI-table				Table 2	
reportQuantity				cri-RI-PMI-CQI	
timeRestrictionForChannelMeasurements				Not configured	
timeRestrictionForInterferenceMeasurements				Not configured	
cqi-FormatIndicator				Wideband	
pmi-FormatIndicator				Wideband	
Sub-band Size			RB	N/A	
CSI-Report periodicity and offset			slot	10/1	
aperiodicTriggeringOffset				Not configured	
Codebook configuration		Codebook Type		typeI-SinglePanel	
		Codebook Mode		1	
		(CodebookConfig-N1,CodebookConfig-N2)		Not configured	
		CodebookSubsetRestriction		[010000]	
		RI Restriction		[N/A]	
Physical channel for CSI report				[PUCCH]	
CQI/RI/PMI delay			ms	[9.5]	
Maximum number of HARQ transmission				1	
Measurement channel				As specified in Table A.4-1, TBS.2-4	

6.2.3.2.2 Wideband CQI reporting under fading conditions

6.2.3.2.2.1 Minimum requirement for wideband CQI reporting

The purpose of the requirements is to verify that the UE is tracking the channel variations and selecting the largest transport format possible according to the prevailing channel state for the frequency non-selective scheduling.

The reporting accuracy of CQI under frequency non-selective fading conditions is determined by the reporting variance, the relative increase of the throughput obtained when the transport format is indicated by the reported CQI compared to the throughput obtained when a fixed transport format is configured according to the reported median CQI, and a minimum BLER using the transport formats indicated by the reported CQI.

For the parameters specified in Table 6.2.3.2.2.1-1 and using the downlink physical channels specified in Annex C.3.1, the minimum requirements are specified by the following:

a) A CQI index not in the set {median CQI -1, median CQI, median CQI +1} shall be reported at least α% of the time where α% is specified in Table 6.2.3.2.2.1-2;

b) The ratio of the throughput obtained when transmitting the transport format indicated by each reported wideband CQI index and that obtained when transmitting a fixed transport format configured according to the wideband CQI median shall be $\geq \gamma$, where γ is specified in Table 6.2.3.2.2.1-2;

c) When transmitting the transport format indicated by each reported wideband CQI index, the average BLER for the indicated transport formats shall be greater than or equal to [0.02].

Table 6.2.3.2.2.1-1: Wideband CQI reporting test under frequency non-selective fading conditions

Parameter			Unit	Test 1	Test 2
Bandwidth			MHz	40	
Duplex Mode				TDD	
TDD UL-DL pattern				FR1.30-1	
DL BWP configuration #1		First PRB		0	
		Number of contiguous PRB		106	
		Subcarrier spacing	kHz	30	
SNR			dB	[3]	[4] / [9] / [10]
Propagation channel				[TDLA30-5]	
Antenna configuration				2×4	
Correlation configuration				XP High	
Beamforming Model				As specified in Section [Annex TBD]	
ZP CSI-RS configuration		CSI-RS resource Type		Periodic	
		Number of CSI-RS ports (*X*)		4	
		CDM Type		FD-CDM2	
		Density (ρ)		1	
		First subcarrier index in the PRB used for CSI-RS (k_0)		Row 5,4	
		First OFDM symbol in the PRB used for CSI-RS (l_0)		9	
		CSI-RS periodicity and offset	slot	10/1	
NZP CSI-RS for CSI acquisition		CSI-RS resource Type		Periodic	
		Number of CSI-RS ports (*X*)		2	
		CDM Type		FD-CDM2	
		Density (ρ)		1	
		First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 3,(6,-)	
		First OFDM symbol in the PRB used for CSI-RS (l_0)		13	
		NZP CSI-RS-timeConfig periodicity and offset	slot	10/1	
CSI-IM configuration		CSI-IM RE pattern		0	
		CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(4, 9)	
		CSI-IM timeConfig periodicity and offset	slot	10/1	
ReportConfigType				Periodic	
CQI-table				Table 2	
reportQuantity				cri-RI-PMI-CQI	
timeRestrictionForChannelMeasurements				Not configured	
timeRestrictionForInterferenceMeasurements				Not configured	
cqi-FormatIndicator				Wideband	
pmi-FormatIndicator				Wideband	
Sub-band Size			RB	[16]	
csi-ReportingBand				[1111111]	
CSI-Report periodicity and offset			slot	10/1	
aperiodicTriggeringOffset				Not configured	
Codebook configuration		Codebook Type		typeI-SinglePanel	
		Codebook Mode		1	
		(CodebookConfig-N1,CodebookConfig-N2)		Not configured	
		CodebookSubsetRestriction		000001	
		RI Restriction		[N/A]	
Physical channel for CSI report				[PUCCH]	
CQI/RI/PMI delay			ms	[9.5]	
Maximum number of HARQ transmission				1	
Measurement channel				As specified in Table A.4-1, TBS.2-3	

Table 6.2.3.2.2.1-2: Minimum requirements

Parameters	Test 1	Test 2
α [%]	[5]	[5]
γ	[1.05]	[1.05]

6.2.3.2.2.2 Minimum requirement for sub-band CQI reporting

The purpose of the requirements is to verify that the preferred sub-bands can be used for frequency-selective scheduling under the frequency-selective fading conditions.

The accuracy of sub-band channel CQI reporting under the frequency-selective fading conditions is determined by a double-sided percentile of the reported differential CQI offset level 0 per sub-band, and the relative increase of the throughput obtained when transmitting the transport format indicated by the corresponding reported sub-band CQI on a randomly selected sub-band among the sub-bands with the highest reported differential CQI offset level compared to the throughput when transmitting a fixed transport format according to the wideband CQI median on a randomly selected sub-band among all the sub-bands.

For the parameters specified in Table 6.2.3.2.2.2-1 and using the downlink physical channels specified in Annex C.3.1, the minimum requirements are specified by the following:

a) A sub-band differential CQI offset level of 0 shall be reported at least α% of the time but less than β% of the time for each sub-band, where α and β are specified in Table 6.2.3.2.2.2-2;

b) The ratio of the throughput obtained when transmitting the corresponding transport format on a randomly selected sub-band among the sub-bands with the highest differential CQI offset level and that obtained when transmitting the transport format indicated by the reported wideband CQI median on a randomly selected sub-band among all the sub-bands shall be $\geq \gamma$, where γ is specified in Table 6.2.3.2.2.2-2;

c) When transmitting the corresponding transport format on a randomly selected sub-band among the sub-bands with the highest differential CQI offset level, the average BLER for the indicated transport format shall be greater than or equal to TBD.

The requirements only apply for sub-bands of full size and the random scheduling across the sub-bands is done by selecting a new sub-band in each available downlink transmission instance for TDD.

Table 6.2.3.2.2.2-1: Sub-band CQI reporting test under frequency-selective fading conditions

Parameter			Unit	Test 1	Test 2
Bandwidth			MHz	40	
Duplex Mode				TDD	
TDD UL-DL pattern				FR1.30-1	
DL BWP configuration #1		First PRB		0	
		Number of contiguous PRB		106	
		Subcarrier spacing	kHz	30	
SNR			dB	TBD	TBD	TBD	TBD
Propagation channel				[Two tap model specified in Annex B.2.4 with a=1, f_D = 5Hz, and τ_d=0.1125μs]	
Antenna configuration				TBD	
Correlation configuration				As per Annex B.1	
Beamforming Model				As specified in Section [Annex TBD]	
ZP CSI-RS configuration		CSI-RS resource Type		Periodic	
		Number of CSI-RS ports (X)		4	
		CDM Type		FD-CDM2	
		Density (ρ)		1	
		First subcarrier index in the PRB used for CSI-RS (k_0)		Row 5,4	
		First OFDM symbol in the PRB used for CSI-RS (l_0)		9	
		CSI-RS periodicity and offset	slot	10/1	
NZP CSI-RS for CSI acquisition		CSI-RS resource Type		Periodic	
		Number of CSI-RS ports (X)		2	
		CDM Type		FD-CDM2	
		Density (ρ)		1	
		First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 3,(6,-)	
		First OFDM symbol in the PRB used for CSI-RS (l_0)		13	
		NZP CSI-RS-timeConfig periodicity and offset	slot	10/1	
CSI-IM configuration		CSI-IM RE pattern		0	
		CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(4, 9)	
		CSI-IM timeConfig periodicity and offset	slot	10/1	
ReportConfigType				Periodic	
CQI-table				Table 2	
reportQuantity				cri-RI-PMI-CQI	
timeRestrictionForChannelMeasurements				Not configured	
timeRestrictionForInterferenceMeasurements				Not configured	
cqi-FormatIndicator				Subband	
pmi-FormatIndicator				Wideband	
Sub-band Size			RB	16	
CSI-Report periodicity and offset			slot	10/1	
aperiodicTriggeringOffset				Not configured	
Codebook configuration		Codebook Type		typeI-SinglePanel	
		Codebook Mode		1	
		(CodebookConfig-N1,CodebookConfig-N2)		Not configured	
		CodebookSubsetRestriction		000001	
		RI Restriction		[N/A]	
Physical channel for CSI report				TBD	
CQI/RI/PMI delay			ms	[9.5]	
Maximum number of HARQ transmission				1	
Measurement channel				TBD	

Table 6.2.2.1.2.2-2: Minimum requirements

Parameters	Test 1	Test 2
α [%]	TBD	TBD
β [%]	TBD	TBD
γ	TBD	TBD

6.3 Reporting of Precoding Matrix Indicator (PMI)

<Editor's note: The requirements were introduced based on current results from companies; these requirements can be revised based on more results from companies.>

The minimum performance requirements of PMI reporting are defined based on the precoding gain, expressed as the relative increase in throughput when the transmitter is configured according to the UE reports compared to the case when the transmitter is using random precoding, respectively. When the transmitter uses random precoding, for each PDSCH allocation a precoder is randomly generated and applied to the PDSCH. A fixed transport format (FRC) is configured for all requirements.

The requirements for transmission mode 1 with higher layer parameter *codebookType* set to 'typeI-SinglePanel' are specified in terms of the ratio:

$$\gamma = \frac{t_{ue,follow1,follow2}}{t_{rnd1,rnd2}}$$

In the definition of γ, for 4TX and 8TX PMI requirements, $t_{follow1,follow2}$ is [90] % of the maximum throughput obtained at $SNR_{follow1,follow2}$ using the precoders configured according to the UE reports, and $t_{rnd1,rnd2}$ is the throughput measured at $SNR_{follow1,follow2}$ with random precoding.

6.3.1 1RX requirements

(Void)

6.3.2 2RX requirements

6.3.2.1 FDD

6.3.2.1.1 Single PMI with 4TX TypeI-SinglePanel Codebook

For the parameters specified in Table 6.3.2.1.1-1, and using the downlink physical channels specified in Annex C.3.1, the minimum requirements are specified in Table 6.3.2.1.1-2.

Table 6.3.2.1.1-1: Test parameters (single layer)

Parameter		Unit	Test 1
Bandwidth		MHz	10
Duplex Mode			FDD
DL BWP configuration #1	First PRB		0
	Number of contiguous PRB		52
	Subcarrier spacing	kHz	15
Propagation channel			TDLA30-5
Antenna configuration			High XP 4 x 2 (N1,N2) = (2,1)
Beamforming Model			TBD
ZP CSI-RS configuration	CSI-RS resource Type		Aperiodic
	Number of CSI-RS ports (*X*)		4
	CDM Type		FD-CDM2
	Density (ρ)		1
	First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 5, (4,-)
	First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(9,-)
	CSI-RS interval and offset	slot	5/1
NZP CSI-RS for CSI acquisition	CSI-RS resource Type		Aperiodic
	Number of CSI-RS ports (*X*)		4
	CDM Type		FD-CDM2
	Density (ρ)		1
	First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 4, (0,-)
	First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(13,-)
	CSI-RS interval and offset		5/1
CSI-IM configuration	CSI-IM RE pattern		Patten 0
	CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(4,9)
	CSI-IM timeConfig interval and offset	slot	5/1
ReportConfigType			Aperiodic
CQI-table			Table 1
reportQuantity			cri-RI-PMI-CQI
timeRestrictionForChannelMeasurements			Not configured
timeRestrictionForInterferenceMeasurements			Not configured
cqi-FormatIndicator			Wideband
pmi-FormatIndicator			Wideband
Sub-band Size		RB	[8]
csi-ReportingBand			[1111111]
CSI-Report interval and offset		slot	5/1
aperiodicTriggeringOffset			0
	Codebook Type		typeI-SinglePanel

Codebook configuration	Codebook Mode		1
	(CodebookConfig-N1,CodebookConfig-N2)		(2,1)
	CodebookSubsetRestriction		11111111
	RI Restriction		00000001
Physical channel for CSI report			PUSCH
CQI/RI/PMI delay		ms	6
Maximum number of HARQ transmission			4
Measurement channel			R.PDSCH.1-6.1 FDD
Note 1: For random precoder selection, the precoder shall be updated in each slot (1 ms granularity). Note 2: If the UE reports in an available uplink reporting instance at slot#n based on PMI estimation at a downlink slot not later than slot#[(n-3)], this reported PMI cannot be applied at the eNB downlink before slot#[(n+3)]. Note 3: Randomization of the principle beam direction shall be used as specified in TBD.			

Table 6.3.2.1.1-2: Minimum requirement

Parameter	Test 1
γ	[1.3]

6.3.2.1.2 Single PMI with 8TX TypeI-SinglePanel Codebook

For the parameters specified in Table 6.3.2.1.2-1, and using the downlink physical channels specified in Annex C.3.1, the minimum requirements are specified in Table 6.3.2.1.2-2.

Table 6.3.2.1.2-1: Test parameters (dual-layer)

Parameter		Unit	Test 1
Bandwidth		MHz	10
Duplex Mode			FDD
DL BWP configuration #1	First PRB		0
	Number of contiguous PRB		52
	Subcarrier spacing	kHz	15
Propagation channel			TDLA30-5
Antenna configuration			High XP 8 x 2 (N1,N2) = (4,1)
Beamforming Model			TBD
ZP CSI-RS configuration	CSI-RS resource Type		Aperiodic
	Number of CSI-RS ports (*X*)		4
	CDM Type		FD-CDM2
	Density (ρ)		1
	First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 5, (4,-)
	First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(9,-)
	CSI-RS interval and offset	slot	5/1
NZP CSI-RS for CSI acquisition	CSI-RS resource Type		Aperiodic
	Number of CSI-RS ports (*X*)		8
	CDM Type		CDM4 (FD2, TD2)
	Density (ρ)		1
	First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 8, (4,6)
	First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(5,-)
	CSI-RS interval and offset	slot	5/1
CSI-IM configuration	CSI-IM RE pattern		Patten 0
	CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(4,9)
	CSI-IM timeConfig interval and offset	slot	5/1
ReportConfigType			Aperiodic
CQI-table			Table 1
reportQuantity			cri-RI-PMI-CQI
timeRestrictionForChannelMeasurements			Not configured
timeRestrictionForInterferenceMeasurements			Not configured
cqi-FormatIndicator			Wideband
pmi-FormatIndicator			Wideband
Sub-band Size		RB	[8]
csi-ReportingBand			[1111111]
CSI-Report interval and offset		slot	5/1
aperiodicTriggeringOffset			0
	Codebook Type		typeI-SinglePanel

Codebook configuration	Codebook Mode		1
	(CodebookConfig-N1,CodebookConfig-N2)		(4,1)
	CodebookSubset Restriction		0x FFFF
	RI Restriction		00000010
Physical channel for CSI report			PUSCH
CQI/RI/PMI delay		ms	8
Maximum number of HARQ transmission			4
Measurement channel			R.PDSCH.1-6.2
Note 1: For random precoder selection, the precoder shall be updated in each slot (1 ms granularity). Note 2: If the UE reports in an available uplink reporting instance at slot#n based on PMI estimation at a downlink slot not later than slot#[(n-4)], this reported PMI cannot be applied at the eNB downlink before slot#[(n+4)]. Note 3: Randomization of the principle beam direction shall be used as specified in TBD.			

Table 6.3.2.1.2-2: Minimum requirement

Parameter	Test 1
γ	[1.5]

6.3.2.2 TDD

6.3.2.2.1 Single PMI with 4TX TypeI-SinglePanel Codebook

For the parameters specified in Table 6.3.2.2.1-1, and using the downlink physical channels specified in Annex C.3.1, the minimum requirements are specified in Table 6.3.2.2.1-2.

Table 6.3.2.2.1-1: Test parameters (single layer)

Parameter		Unit	Test 1
Bandwidth		MHz	40
Duplex Mode			TDD
TDD DL-UL configuration			FR1.30-1 as specified in Annex A
DL BWP configuration #1	First PRB		0
	Number of contiguous PRB		106
	Subcarrier spacing	kHz	30
Propagation channel			TDLA30-5
Antenna configuration			High XP 4 x 2 (N1,N2) = (2,1)
Beamforming Model			TBD
ZP CSI-RS configuration	CSI-RS resource Type		Aperiodic
	Number of CSI-RS ports (*X*)		4
	CDM Type		FD-CDM2
	Density (ρ)		1
	First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 5, (4,-)
	First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(9,-)
	CSI-RS interval and offset	slot	10/1
NZP CSI-RS for CSI acquisition	CSI-RS resource Type		Aperiodic
	Number of CSI-RS ports (*X*)		4
	CDM Type		FD-CDM2
	Density (ρ)		1
	First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 4, (0,-)
	First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(13,-)
	CSI-RS interval and offset	slot	10/1
CSI-IM configuration	CSI-IM RE pattern		Patten 0
	CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(4,9)
	CSI-IM timeConfig interval and offset	slot	10/1
ReportConfigType			Aperiodic
CQI-table			Table 1
reportQuantity			cri-RI-PMI-CQI
timeRestrictionForChannelMeasurements			Not configured
timeRestrictionForInterferenceMeasurements			Not configured
cqi-FormatIndicator			Wideband
pmi-FormatIndicator			Wideband
Sub-band Size		RB	[16]
csi-ReportingBand			[1111111]
CSI-Report interval and offset		slot	10/1

aperiodicTriggeringOffset			0
Codebook configuration	Codebook Type		typeI-SinglePanel
	Codebook Mode		1
	(CodebookConfig-N1,CodebookConfig-N2)		(2,1)
	CodebookSubset Restriction		11111111
	RI Restriction		00000001
Physical channel for CSI report			PUSCH
CQI/RI/PMI delay		ms	5.5
Maximum number of HARQ transmission			4
Measurement channel			R.PDSCH.2-8.1 TDD
Note 1: For random precoder selection, the precoder shall be updated in each slot (0.5 ms granularity). Note 2: If the UE reports in an available uplink reporting instance at slot #n based on PMI estimation at a downlink slot not later than slot#[(n-4)], this reported PMI cannot be applied at the eNB downlink before slot#[(n+4)]. Note 3: Randomization of the principle beam direction shall be used as specified in TBD.			

Table 6.3.2.2.1-2: Minimum requirement

Parameter	Test 1
γ	[1.3]

6.3.2.2.2 Single PMI with 8TX TypeI-SinglePanel Codebook

For the parameters specified in Table 6.3.2.2.2-1, and using the downlink physical channels specified in Annex TBD, the minimum requirements are specified in Table 6.3.2.2.2-2.

Table 6.3.2.2.2-1: Test parameters (dual-layer)

Parameter		Unit	Test 1
Bandwidth		MHz	40
Duplex Mode			TDD
TDD DL-UL configurations			FR1.30-1 as specified in Annex A
DL BWP configuration #1	First PRB		0
	Number of contiguous PRB		106
	Subcarrier spacing	kHz	30
Propagation channel			TDLA30-5
Antenna configuration			High XP 8 x 2 (N1,N2) = (4,1)
Beamforming Model			TBD
ZP CSI-RS configuration	CSI-RS resource Type		Aperiodic
	Number of CSI-RS ports (*X*)		4
	CDM Type		FD-CDM2
	Density (ρ)		1
	First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 5, (4,-)
	First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(9,-)
	CSI-RS interval and offset	slot	10/1
NZP CSI-RS for CSI acquisition	CSI-RS resource Type		Aperiodic
	Number of CSI-RS ports (*X*)		8
	CDM Type		CDM4 (FD2, TD2)
	Density (ρ)		1
	First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 8, (4,6)
	First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(5,-)
	CSI-RS interval and offset	slot	10/1
CSI-IM configuration	CSI-IM RE pattern		Patten 0
	CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(4,9)
	CSI-IM timeConfig interval and offset	slot	10/1
ReportConfigType			Aperiodic
CQI-table			Table 1
reportQuantity			cri-RI-PMI-CQI
timeRestrictionForIChannelMeasurements			Not configured
timeRestrictionForInterferenceMeasurements			Not configured
cqi-FormatIndicator			Wideband
pmi-FormatIndicator			Wideband
Sub-band Size		RB	[16]
csi-ReportingBand			[1111111]
CSI-Report interval and offset		slot	10/1

aperiodicTriggeringOffset			0
Codebook configuration	Codebook Type		typeI-SinglePanel
	Codebook Mode		1
	(CodebookConfig-N1,CodebookConfig-N2)		(4,1)
	CodebookSubset Restriction		0x FFFF
	RI Restriction		00000010
Physical channel for CSI report			PUSCH
CQI/RI/PMI delay		ms	6.5
Maximum number of HARQ transmission			4
Measurement channel			R.PDSCH.2-8.2 TDD
Note 1: For random precoder selection, the precoder shall be updated in each slot (0.5 ms granularity). Note 2: If the UE reports in an available uplink reporting instance at slot#n based on PMI estimation at a downlink slot not later than slot#[(n-6)], this reported PMI cannot be applied at the eNB downlink before slot#[(n+6)]. Note 3: Randomization of the principle beam direction shall be used as specified in TBD.			

Table 6.3.2.2.2-2: Minimum requirement

Parameter	Test 1
γ	[1.5]

6.3.3 4RX requirements

6.3.3.1 FDD

6.3.3.1.1 Single PMI with 4TX TypeI-SinglePanel Codebook

For the parameters specified in Table 6.3.3.1.1-1, and using the downlink physical channels specified in Annex C.3.1, the minimum requirements are specified in Table 6.3.3.1.1-2.

Table 6.3.3.1.1-1: Test parameters (single layer)

Parameter		Unit	Test 1
Bandwidth		MHz	10
Duplex Mode			FDD
DL BWP configuration #1	First PRB		0
	Number of contiguous PRB		52
	Subcarrier spacing	kHz	15
Propagation channel			TDLA30-5
Antenna configuration			High XP 4 x 4 (N1,N2) = (2,1)
Beamforming Model			TBD
ZP CSI-RS configuration	CSI-RS resource Type		Aperiodic
	Number of CSI-RS ports (*X*)		4
	CDM Type		FD-CDM2
	Density (ρ)		1
	First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 5, (4,-)
	First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(9,-)
	CSI-RS interval and offset	slot	5/1
NZP CSI-RS for CSI acquisition	CSI-RS resource Type		Aperiodic
	Number of CSI-RS ports (*X*)		4
	CDM Type		FD-CDM2
	Density (ρ)		1
	First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 4, (0,-)
	First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(13,-)
	CSI-RS interval and offset	slot	5/1
CSI-IM configuration	CSI-IM RE pattern		Patten 0
	CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(4,9)
	CSI-IM timeConfig interval and offset	slot	5/1
ReportConfigType			Aperiodic
CQI-table			Table 1
reportQuantity			cri-RI-PMI-CQI
timeRestrictionForChannelMeasurements			Not configured
timeRestrictionForInterferenceMeasurements			Not configured
cqi-FormatIndicator			Wideband
pmi-FormatIndicator			Wideband
Sub-band Size		RB	[8]
csi-ReportingBand			[1111111]
CSI-Report interval and offset		slot	5/1
aperiodicTriggeringOffset			0
	Codebook Type		typeI-SinglePanel

Codebook configuration	Codebook Mode		1
	(CodebookConfig-N1,CodebookConfig-N2)		(2,1)
	CodebookSubsetRestriction		11111111
	RI Restriction		00000001
Physical channel for CSI report			PUSCH
CQI/RI/PMI delay		ms	6
Maximum number of HARQ transmission			4
Measurement channel			R.PDSCH.1-6.1 FDD
Note 1: For random precoder selection, the precoder shall be updated in each slot (1 ms granularity). Note 2: If the UE reports in an available uplink reporting instance at slot#n based on PMI estimation at a downlink slot not later than slot#[(n-3)], this reported PMI cannot be applied at the eNB downlink before slot#[(n+3)]. Note 3: Randomization of the principle beam direction shall be used as specified in TBD.			

Table 6.3.3.1.1-2: Minimum requirement

Parameter	Test 1
γ	[1.3]

6.3.3.1.2 Single PMI with 8TX TypeI-SinglePanel Codebook

For the parameters specified in Table 6.3.3.1.2-1, and using the downlink physical channels specified in Annex C.3.1, the minimum requirements are specified in Table 6.3.3.1.2-2.

Table 6.3.3.1.2-1: Test parameters (dual-layer)

Parameter		Unit	Test 1
Bandwidth		MHz	10
Duplex Mode			FDD
DL BWP configuration #1	First PRB		0
	Number of contiguous PRB		52
	Subcarrier spacing	kHz	15
Propagation channel			TDLA30-5
Antenna configuration			High XP 8 x 4 (N1,N2) = (4,1)
Beamforming Model			TBD
ZP CSI-RS configuration	CSI-RS resource Type		Aperiodic
	Number of CSI-RS ports (*X*)		4
	CDM Type		FD-CDM2
	Density (ρ)		1
	First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 5, (4,-)
	First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(9,-)
	CSI-RS interval and offset	slot	5/1
NZP CSI-RS for CSI acquisition	CSI-RS resource Type		Aperiodic
	Number of CSI-RS ports (*X*)		8
	CDM Type		CDM4 (FD2, TD2)
	Density (ρ)		1
	First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 8, (4,6)
	First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(5,-)
	CSI-RS interval and offset	slot	5/1
CSI-IM configuration	CSI-IM RE pattern		Patten 0
	CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(4,9)
	CSI-IM timeConfig interval and offset	slot	5/1
ReportConfigType			Aperiodic
CQI-table			Table 1
reportQuantity			cri-RI-PMI-CQI
timeRestrictionForChannelMeasurements			Not configured
timeRestrictionForInterferenceMeasurements			Not configured
cqi-FormatIndicator			Wideband
pmi-FormatIndicator			Wideband
Sub-band Size		RB	[8]
csi-ReportingBand			[1111111]
CSI-Report interval and offset		slot	5/1
aperiodicTriggeringOffset			0
	Codebook Type		typeI-SinglePanel

Codebook configuration	Codebook Mode		1
	(CodebookConfig-N1,CodebookConfig-N2)		(4,1)
	CodebookSubsetRestriction		0x FFFF
	RI Restriction		00000010
Physical channel for CSI report			PUSCH
CQI/RI/PMI delay		ms	8
Maximum number of HARQ transmission			4
Measurement channel			R.PDSCH.1-6.2 FDD
Note 1: For random precoder selection, the precoder shall be updated in each slot (1 ms granularity). Note 2: If the UE reports in an available uplink reporting instance at slot#n based on PMI estimation at a downlink slot not later than slot#[(n-4)], this reported PMI cannot be applied at the eNB downlink before slot#[(n+4)]. Note 3: Randomization of the principle beam direction shall be used as specified in TBD.			

Table 6.3.3.1.2-2: Minimum requirement

Parameter	Test 1
γ	[1.5]

6.3.3.2 TDD

6.3.3.2.1 Single PMI with 4TX TypeI-SinglePanel Codebook

For the parameters specified in Table 6.3.3.2.1-1, and using the downlink physical channels specified in Annex TBD, the minimum requirements are specified in Table 6.3.3.2.1-2.

Table 6.3.3.2.1-1: Test parameters (single layer)

Parameter		Unit	Test 1
Bandwidth		MHz	40
Duplex Mode			TDD
TDD DL-UL configuration			FR1.30-1 as specified in Annex A
DL BWP configuration #1	First PRB		0
	Number of contiguous PRB		106
	Subcarrier spacing	kHz	30
Propagation channel			TDLA30-5
Antenna configuration			High XP 4 x 4 (N1,N2) = (2,1)
Beamforming Model			TBD
ZP CSI-RS configuration	CSI-RS resource Type		Aperiodic
	Number of CSI-RS ports (*X*)		4
	CDM Type		FD-CDM2
	Density (ρ)		1
	First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 5, (4,-)
	First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(9,-)
	CSI-RS interval and offset	slot	10/1
NZP CSI-RS for CSI acquisition	CSI-RS resource Type		Aperiodic
	Number of CSI-RS ports (*X*)		4
	CDM Type		FD-CDM2
	Density (ρ)		1
	First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 4, (0,-)
	First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(13,-)
	CSI-RS interval and offset		10/1
CSI-IM configuration	CSI-IM RE pattern		Patten 0
	CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(4,9)
	CSI-IM timeConfig interval and offset	slot	10/1
ReportConfigType			Aperiodic
CQI-table			Table 1
reportQuantity			cri-RI-PMI-CQI
timeRestrictionForChannelMeasurements			Not configured
timeRestrictionForInterferenceMeasurements			Not configured
cqi-FormatIndicator			Wideband
pmi-FormatIndicator			Wideband
Sub-band Size		RB	[16]
csi-ReportingBand			[1111111]
CSI-Report interval and offset		slot	10/1

aperiodicTriggeringOffset			0
Codebook configuration	Codebook Type		typeI-SinglePanel
	Codebook Mode		1
	(CodebookConfig-N1,CodebookConfig-N2)		(2,1)
	CodebookSubset Restriction		11111111
	RI Restriction		00000001
Physical channel for CSI report			PUSCH
CQI/RI/PMI delay		ms	5.5
Maximum number of HARQ transmission			4
Measurement channel			R.PDSCH.2-8.1 TDD
Note 1: For random precoder selection, the precoder shall be updated in each slot (0.5 ms granularity). Note 2: If the UE reports in an available uplink reporting instance at slot#n based on PMI estimation at a downlink slot not later than slot#[(n-4)], this reported PMI cannot be applied at the eNB downlink before slot#[(n+4)]. Note 3: Randomization of the principle beam direction shall be used as specified in TBD.			

Table 6.3.3.2.1-2: Minimum requirement

Parameter	Test 1
γ	[1.3]

6.3.3.2.2 Single PMI with 8TX TypeI-SinglePanel Codebook

For the parameters specified in Table 6.3.3.2.2-1, and using the downlink physical channels specified in Annex TBD, the minimum requirements are specified in Table 6.3.3.2.2-2.

Table 6.3.3.2.2-1: Test parameters (dual-layer)

Parameter		Unit	Test 1
Bandwidth		MHz	40
Duplex Mode			TDD
TDD DL-UL configurations			FR1.30-1 as specified in Annex A
DL BWP configuration #1	First PRB		0
	Number of contiguous PRB		106
	Subcarrier spacing	kHz	30
Propagation channel			TDLA30-5
Antenna configuration			High XP 8 x 4 (N1,N2) = (4,1)
Beamforming Model			TBD
ZP CSI-RS configuration	CSI-RS resource Type		Aperiodic
	Number of CSI-RS ports (*X*)		4
	CDM Type		FD-CDM2
	Density (ρ)		1
	First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 5, (4,-)
	First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(9,-)
	CSI-RS interval and offset	slot	10/1
NZP CSI-RS for CSI acquisition	CSI-RS resource Type		Aperiodic
	Number of CSI-RS ports (*X*)		8
	CDM Type		CDM4 (FD2, TD2)
	Density (ρ)		1
	First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 8, (4,6)
	First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(5,-)
	CSI-RS interval and offset	slot	10/1
CSI-IM configuration	CSI-IM RE pattern		Patten 0
	CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(4,9)
	CSI-IM timeConfig interval and offset	slot	10/1
ReportConfigType			Aperiodic
CQI-table			Table 1
reportQuantity			cri-RI-PMI-CQI
timeRestrictionForChannnelMeasurements			Not configured
timeRestrictionForInterferenceMeasurements			Not configured
cqi-FormatIndicator			Wideband
pmi-FormatIndicator			Wideband
Sub-band Size		RB	[16]
csi-ReportingBand			[1111111]
CSI-Report interval and offset		slot	10/1

aperiodicTriggeringOffset			0
Codebook configuration	Codebook Type		typeI-SinglePanel
	Codebook Mode		1
	(CodebookConfig-N1,CodebookConfig-N2)		(4,1)
	CodebookSubset Restriction		0x FFFF
	RI Restriction		00000010
Physical channel for CSI report			PUSCH
CQI/RI/PMI delay		ms	6.5
Maximum number of HARQ transmission			4
Measurement channel			R.PDSCH.2-8.2 TDD
Note 1: For random precoder selection, the precoder shall be updated in each slot (0.5 ms granularity). Note 2: If the UE reports in an available uplink reporting instance at slot#n based on PMI estimation at a downlink slot not later than slot#[(n-6)], this reported PMI cannot be applied at the eNB downlink before slot#[(n+6)]. Note 3: Randomization of the principle beam direction shall be used as specified in TBD.			

Table 6.3.3.2.2-2: Minimum requirement

Parameter	Test 1
γ	[1.5]

6.4 Reporting of Rank Indicator (RI)

The purpose of this test is to verify that the reported rank indicator accurately represents the channel rank. The accuracy of RI reporting is determined by the relative increase of the throughput obtained when transmitting based on the reported rank compared to the case for which a fixed rank is used for transmission.

6.4.1 1RX requirements

(Void)

6.4.2 2RX requirements

6.4.2.1 FDD

The minimum performance requirement in Table 6.4.2.1-2 is defined as

a) The ratio of the throughput obtained when transmitting based on UE reported RI and that obtained when transmitting with fixed rank 1 shall be $\geq \gamma_1$;

b) The ratio of the throughput obtained when transmitting based on UE reported RI and that obtained when transmitting with fixed rank 2 shall be $\geq \gamma_2$;

For the parameters specified in Table 6.4.2.1-1, and using the downlink physical channels specified in Annex C.3.1, the minimum requirements are specified in Table 6.4.2.1-2.

Table 6.4.2.1-1: RI Test (FDD)

Parameter			Unit	Test 1	Test 2	Test 3
Bandwidth			MHz	10	10	10
Duplex Mode				FDD	FDD	FDD
DL BWP configuration #1		First PRB		0	0	0
		Number of contiguous PRB		52	52	52
		Subcarrier spacing	kHz	15	15	15
SNR			dB	[0]	[20]	[20]
Propagation channel				TDLA30-5	TDLA30-5	TDLA30-5
Antenna configuration				ULA Low 2x2	ULA Low 2x2	ULA High 2x2
Beamforming Model				As defined in Annex B.4.1	As defined in Annex B.4.1	As defined in Annex B.4.1
ZP CSI-RS configuration		CSI-RS resource Type		Periodic	Periodic	Periodic
		Number of CSI-RS ports (*X*)		4	4	4
		CDM Type		FD-CDM2	FD-CDM2	FD-CDM2
		Density (ρ)		1	1	1
		First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 5, (4,-)	Row 5, (4,-)	Row 5, (4,-)
		First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(9,-)	(9,-)	(9,-)
		CSI-RS periodicity and offset	slot	5/1	5/1	5/1
NZP CSI-RS for CSI acquisition		CSI-RS resource Type		Periodic	Periodic	Periodic
		Number of CSI-RS ports (*X*)		2	2	2
		CDM Type		FD-CDM2	FD-CDM2	FD-CDM2
		Density (ρ)		1	1	1
		First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 3 (6,-)	Row 3 (6,-)	Row 3 (6,-)
		First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(13,-)	(13,-)	(13,-)
		NZP CSI-RS-timeConfig periodicity and offset	slot	5/1	5/1	5/1
CSI-IM configuration		CSI-IM RE pattern		Pattern 0	Pattern 0	Pattern 0
		CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(4,9)	(4,9)	(4,9)
		CSI-IM timeConfig periodicity and offset	slot	5/1	5/1	5/1
ReportConfigType				Periodic	Periodic	Periodic
CQI-table				Table 2	Table 2	Table 2
reportQuantity				cri-RI-PMI-CQI	cri-RI-PMI-CQI	cri-RI-PMI-CQI
timeRestrictionForChannelMeasurements				not configured	not configured	not configured
timeRestrictionForInterferenceMeasurements				not configured	not configured	not configured
cqi-FormatIndicator				Wideband	Wideband	Wideband
pmi-FormatIndicator				Wideband	Wideband	Wideband
Sub-band Size			RB	[8]	[8]	[8]
csi-ReportingBand				[1111111]	[1111111]	[1111111]
CSI-Report periodicity and offset			slot	5/1	5/1	5/1
Codebook configuration		Codebook Type		typeI-SinglePanel	typeI-SinglePanel	typeI-SinglePanel
		Codebook Mode		1	1	1
		(CodebookConfig-N1,CodebookConfig-N2)		N/A	N/A	N/A
		CodebookSubsetRestriction		[010000 for fixed rank 2, 010011 for following rank]	[000011 for fixed rank 1, 010011 for following rank]	[000011 for fixed rank 1, 010011 for following rank]
		RI Restriction		N/A	N/A	N/A
Physical channel for CSI report				PUCCH	PUCCH	PUCCH
CQI/RI/PMI delay			ms	8	8	8

Maximum number of HARQ transmission		1	1	1
RI Configuration		Fixed RI = 2 and follow RI	Fixed RI = 1 and follow RI	Fixed RI = 1 and follow RI

Table 6.4.2.1-2: Minimum requirement (FDD)

	Test 1	Test 2	Test 3
γ_1	N/A	[1.05]	[0.9]
γ_2	[1.0]	N/A	N/A

6.4.2.2 TDD

The minimum performance requirement in Table 6.4.2.2-2 is defined as

a) The ratio of the throughput obtained when transmitting based on UE reported RI and that obtained when transmitting with fixed rank 1 shall be $\geq \gamma_1$;

b) The ratio of the throughput obtained when transmitting based on UE reported RI and that obtained when transmitting with fixed rank 2 shall be $\geq \gamma_2$;

For the parameters specified in Table 6.4.2.2-1, and using the downlink physical channels specified in Annex C.3.1, the minimum requirements are specified in Table 6.4.2.2-2.

Table 6.4.2.2-1: RI Test (TDD)

Parameter			Unit	Test 1	Test 2	Test 3
Bandwidth			MHz	40	40	40
Duplex Mode				TDD	TDD	TDD
TDD Slot Configuration				FR1.30-1	FR1.30-1	FR1.30-1
DL BWP configuration #1		First PRB		0	0	0
		Number of contiguous PRB		106	106	106
		Subcarrier spacing	kHz	30	30	30
SNR			dB	[0]	[20]	[20]
Propagation channel				TDLA30-5	TDLA30-5	TDLA30-5
Antenna configuration				ULA Low 2x2	ULA Low 2x2	ULA High 2x2
Beamforming Model				As defined in Annex B.4.1	As defined in Annex B.4.1	As defined in Annex B.4.1
ZP CSI-RS configuration		CSI-RS resource Type		Periodic	Periodic	Periodic
		Number of CSI-RS ports (*X*)		4	4	4
		CDM Type		FD-CDM2	FD-CDM2	FD-CDM2
		Density (ρ)		1	1	1
		First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 5, (4,-)	Row 5, (4,-)	Row 5, (4,-)
		First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(9,-)	(9,-)	(9,-)
		CSI-RS periodicity and offset	slot	10/1	10/1	10/1
NZP CSI-RS for CSI acquisition		CSI-RS resource Type		Periodic	Periodic	Periodic
		Number of CSI-RS ports (*X*)		2	2	2
		CDM Type		FD-CDM2	FD-CDM2	FD-CDM2
		Density (ρ)		1	1	1
		First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 3 (6,-)	Row 3 (6,-)	Row 3 (6,-)
		First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(13,-)	(13,-)	(13,-)
		NZP CSI-RS-timeConfig periodicity and offset	slot	10/1	10/1	10/1
CSI-IM configuration		CSI-IM RE pattern		Pattern 0	Pattern 0	Pattern 0
		CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(4,9)	(4,9)	(4,9)
		CSI-IM timeConfig periodicity and offset	slot	10/1	10/1	10/1
ReportConfigType				Periodic	Periodic	Periodic
CQI-table				Table 2	Table 2	Table 2
reportQuantity				cri-RI-PMI-CQI	cri-RI-PMI-CQI	cri-RI-PMI-CQI
timeRestrictionForChannelMeasurements				not configured	not configured	not configured
timeRestrictionForInterferenceMeasurements				not configured	not configured	not configured
cqi-FormatIndicator				Wideband	Wideband	Wideband
pmi-FormatIndicator				Wideband	Wideband	Wideband
Sub-band Size			RB	[16]	[16]	[16]
csi-ReportingBand				[1111111]	[1111111]	[1111111]
CSI-Report periodicity and offset			slot	10/1	10/1	10/1
Codebook configuration		Codebook Type		typeI-SinglePanel	typeI-SinglePanel	typeI-SinglePanel
		Codebook Mode		1	1	1
		(CodebookConfig-N1,CodebookConfig-N2)		N/A	N/A	N/A
		CodebookSubsetRestriction		[010000 for fixed rank 2, 010011 for following rank]	[000011 for fixed rank 1, 010011 for following rank]	[000011 for fixed rank 1, 010011 for following rank]
		RI Restriction		N/A	N/A	N/A
Physical channel for CSI report				PUCCH	PUCCH	PUCCH

CQI/RI/PMI delay	ms	9.5	9.5	9.5
Maximum number of HARQ transmission		1	1	1
RI Configuration		Fixed RI = 2 and follow RI	Fixed RI = 1 and follow RI	Fixed RI = 1 and follow RI

Table 6.4.2.2-2: Minimum requirement (TDD)

	Test 1	Test 2	Test 3
γ_1	N/A	[1.05]	[0.9]
γ_2	[1.0]	N/A	N/A

6.4.3 4RX requirements

6.4.3.1 FDD

The minimum performance requirement in Table 6.4.3.1-2 is defined as

a) The ratio of the throughput obtained when transmitting based on UE reported RI and that obtained when transmitting with fixed rank 1 shall be $\geq \gamma_1$;

b) The ratio of the throughput obtained when transmitting based on UE reported RI and that obtained when transmitting with fixed rank 2 shall be $\geq \gamma_2$;

For the parameters specified in Table 6.4.3.1-1, and using the downlink physical channels specified in Annex C.3.1, the minimum requirements are specified in Table 6.4.3.1-2.

Table 6.4.3.1-1: RI Test (FDD)

Parameter			Unit	Test 1	Test 2	Test 3	Test 4
Bandwidth			MHz	10	10	10	10
Duplex Mode				FDD	FDD	FDD	FDD
DL BWP configuration #1		First PRB		0	0	0	0
		Number of contiguous PRB		52	52	52	52
		Subcarrier spacing	kHz	15	15	15	15
SNR			dB	TBD	[16]	[16]	TBD
Propagation channel				TDLA30-5	TDLA30-5	TDLA30-5	TDLA30-5
Antenna configuration				ULA Low 2x4	ULA Low 2x4	ULA High 2x4	ULA Low 4x4
Beamforming Model				As defined in Annex B.4.1	As defined in Annex B.4.1	As defined in Annex B.4.1	As defined in Annex B.4.1
ZP CSI-RS configuration		CSI-RS resource Type		Periodic	Periodic	Periodic	Periodic
		Number of CSI-RS ports (*X*)		4	4	4	4
		CDM Type		FD-CDM2	FD-CDM2	FD-CDM2	FD-CDM2
		Density (ρ)		1	1	1	1
		First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 5, (4,-)	Row 5, (4,-)	Row 5, (4,-)	Row 5, (4,-)
		First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(9,-)	(9,-)	(9,-)	(9,-)
		CSI-RS periodicity and offset	slot	5/1	5/1	5/1	5/1
NZP CSI-RS for CSI acquisition		CSI-RS resource Type		Periodic	Periodic	Periodic	Periodic
		Number of CSI-RS ports (*X*)		2	2	2	4
		CDM Type		FD-CDM2	FD-CDM2	FD-CDM2	FD-CDM2
		Density (ρ)		1	1	1	1
		First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 3 (6,-)	Row 3 (6,-)	Row 3 (6,-)	Row 4 (0,-)
		First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(13,-)	(13,-)	(13,-)	(13,-)
		NZP CSI-RS-timeConfig periodicity and offset	slot	5/1	5/1	5/1	5/1
CSI-IM configuration		CSI-IM RE pattern		Pattern 0	Pattern 0	Pattern 0	Pattern 0
		CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(4,9)	(4,9)	(4,9)	(4,9)
		CSI-IM timeConfig periodicity and offset	slot	5/1	5/1	5/1	5/1
ReportConfigType				Periodic	Periodic	Periodic	Periodic
CQI-table				Table 2	Table 2	Table 2	Table 2
reportQuantity				cri-RI-PMI-CQI	cri-RI-PMI-CQI	cri-RI-PMI-CQI	cri-RI-PMI-CQI
timeRestrictionForChannelMeasurements				not configured	not configured	not configured	not configured
timeRestrictionForInterferenceMeasurements				not configured	not configured	not configured	not configured
cqi-FormatIndicator				Wideband	Wideband	Wideband	Wideband
pmi-FormatIndicator				Wideband	Wideband	Wideband	Wideband
Sub-band Size			RB	[8]	[8]	[8]	[8]
csi-ReportingBand				[1111111]	[1111111]	[1111111]	[1111111]
CSI-Report periodicity and offset			slot	5/1	5/1	5/1	5/1
Codebook configuration	Codebook Type			typeI-SinglePanel	typeI-SinglePanel	typeI-SinglePanel	typeI-SinglePanel
	Codebook Mode			1	1	1	1
	(CodebookConfig-N1,CodebookConfig-N2)			N/A	N/A	N/A	(2,1)
	CodebookSubsetRestriction			[010000 for fixed rank 2, 010011 for following rank]	[000011 for fixed rank 1, 010011 for following rank]	[000011 for fixed rank 1, 010011 for following rank]	11111111
	RI Restriction			N/A	N/A	N/A	00000010 for fixed Rank 2 and

						00001111 for follow RI
Physical channel for CSI report			PUCCH	PUCCH	PUCCH	PUCCH
CQI/RI/PMI delay		ms	8	8	8	8
Maximum number of HARQ transmission			1	1	1	1
RI Configuration			Fixed RI = 2 and follow RI	Fixed RI = 1 and follow RI	Fixed RI = 1 and follow RI	Fixed RI = 2 and follow RI

Table 6.4.3.1-2: Minimum requirement (FDD)

	Test 1	Test 2	Test 3	Test 4
γ_1	N/A	[1.05]	[0.9]	N/A
γ_2	TBD	N/A	N/A	TBD

6.4.3.2 TDD

The minimum performance requirement in Table 6.4.3.2-2 is defined as

a) The ratio of the throughput obtained when transmitting based on UE reported RI and that obtained when transmitting with fixed rank 1 shall be $\geq \gamma_1$;

b) The ratio of the throughput obtained when transmitting based on UE reported RI and that obtained when transmitting with fixed rank 2 shall be $\geq \gamma_2$;

For the parameters specified in Table 6.4.3.2-1, and using the downlink physical channels specified in Annex TBD, the minimum requirements are specified in Table 6.4.3.2-2.

Table 6.4.3.2-1: RI Test (TDD)

Parameter		Unit	Test 1	Test 2	Test 3	Test 4
Bandwidth		MHz	40	40	40	40
Duplex Mode			TDD	TDD	TDD	TDD
TDD Slot Configuration			FR1.30-1	FR1.30-1	FR1.30-1	FR1.30-1
DL BWP configuration #1	First PRB		0	0	0	0
	Number of contiguous PRB		106	106	106	106
	Subcarrier spacing	kHz	30	30	30	30
SNR		dB	TBD	[16]	[16]	TBD
Propagation channel			TDLA30-5	TDLA30-5	TDLA30-5	TDLA30-5
Antenna configuration			ULA Low 2x4	ULA Low 2x4	ULA High 2x4	ULA Low 4x4
Beamforming Model			As defined in Annex B.4.1	As defined in Annex B.4.1	As defined in Annex B.4.1	As defined in Annex B.4.1
ZP CSI-RS configuration	CSI-RS resource Type		Periodic	Periodic	Periodic	Periodic
	Number of CSI-RS ports (*X*)		4	4	4	4
	CDM Type		FD-CDM2	FD-CDM2	FD-CDM2	FD-CDM2
	Density (ρ)		1	1	1	1
	First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 5, (4,-)	Row 5, (4,-)	Row 5, (4,-)	Row 5, (4,-)
	First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(9,-)	(9,-)	(9,-)	(9,-)
	CSI-RS periodicity and offset	slot	10/1	10/1	10/1	10/1
NZP CSI-RS for CSI acquisition	CSI-RS resource Type		Periodic	Periodic	Periodic	Periodic
	Number of CSI-RS ports (*X*)		2	2	2	2
	CDM Type		FD-CDM2	FD-CDM2	FD-CDM2	FD-CDM2
	Density (ρ)		1	1	1	1
	First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 3 (6,-)	Row 3 (6,-)	Row 3 (6,-)	Row 4 (0,-)
	First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(13,-)	(13,-)	(13,-)	(13,-)
	NZP CSI-RS-timeConfig periodicity and offset	slot	10/1	10/1	10/1	10/1
CSI-IM configuration	CSI-IM RE pattern		Pattern 0	Pattern 0	Pattern 0	Pattern 0
	CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(4,9)	(4,9)	(4,9)	(4,9)
	CSI-IM timeConfig periodicity and offset	slot	10/1	10/1	10/1	10/1
ReportConfigType			Periodic	Periodic	Periodic	Periodic
CQI-table			Table 2	Table 2	Table 2	Table 2
reportQuantity			cri-RI-PMI-CQI	cri-RI-PMI-CQI	cri-RI-PMI-CQI	cri-RI-PMI-CQI
timeRestrictionForChannelMeasurements			not configured	not configured	not configured	not configured
timeRestrictionForInterferenceMeasurements			not configured	not configured	not configured	not configured
cqi-FormatIndicator			Wideband	Wideband	Wideband	Wideband
pmi-FormatIndicator			Wideband	Wideband	Wideband	Wideband
Sub-band Size		RB	[16]	[16]	[16]	[16]
csi-ReportingBand			[1111111]	[1111111]	[1111111]	[1111111]
CSI-Report periodicity and offset		slot	10/1	10/1	10/1	10/1
Codebook configuration	Codebook Type		typeI-SinglePanel	typeI-SinglePanel	typeI-SinglePanel	typeI-SinglePanel
	Codebook Mode		1	1	1	1
	(CodebookConfig-N1,CodebookConfig-N2)		N/A	N/A	N/A	(2,1)
	CodebookSubsetRestriction		[010000 for fixed rank 2, 010011 for following rank]	[000011 for fixed rank 1, 010011 for following rank]	[000011 for fixed rank 1, 010011 for following rank]	11111111
	RI Restriction		N/A	N/A	N/A	00000010 for fixed Rank 2

						and 00001111 for follow RI
Physical channel for CSI report			PUCCH	PUCCH	PUCCH	PUCCH
CQI/RI/PMI delay		ms	9.5	9.5	9.5	9.5
Maximum number of HARQ transmission			1	1	1	1
RI Configuration			Fixed RI = 2 and follow RI	Fixed RI = 1 and follow RI	Fixed RI = 1 and follow RI	Fixed RI = 2 and follow RI

Table 6.4.3.2-2: Minimum requirement (TDD)

	Test 1	Test 2	Test 3	Test 4
γ_1	N/A	[1.05]	[0.9]	N/A
γ_2	TBD	N/A	N/A	TBD

7 Demodulation performance requirements (Radiated requirements)

7.1 General

7.1.1 Applicability of requirements

7.1.1.1 General

The minimum performance requirements are applicable to the FR2 operating bands defined in TS 38.101-2 [7] with F_{DL_high} not exceeding 40000 MHz.

The minimum performance requirements in Clause 7 are mandatary for UE supporting NR operation, except test cases listed in Clause 7.1.1.3.

7.1.1.2 Applicability of requirements for different number of RX antenna ports

UE shall support 2 RX ports for different RF operating bands. The UE requirements applicability is defined in Table 7.1.1.2-1.

Table 7.1.1.2-1: Requirements applicability

Supported RX antenna ports	Test type	Test list
UE supports 2RX antenna ports	PDSCH	All tests in Clause 7.2.2
	PDCCH	All tests in Clause 7.3.2
	PBCH	All tests in Clause 7.4.2

7.1.1.3 Applicability of requirements for optional UE capabilities

For UE which supports optional UE capabilities the additional performance requirements from Table 7.1.1.3-1 should be applied.

Table 7.1.1.3-1: Requirements applicability for optional UE capabilities

UE feature/capability	Test type		Test list	Applicability notes
[Enhanced Type X receiver]	FR2 TDD	PDSCH	7.2.2.2.1 Minimum requirements for PDSCH Mapping Type-A (Test 3-1)	

7.2 PDSCH demodulation requirements

The parameters specified in Table 7.2-1 are valid for all PDSCH demodulation tests unless otherwise stated.

Table 7.2-1: Common Test Parameters

Parameter		Unit	Value
PDSCH transmission scheme			Transmission scheme 1
EPRE ratio of PTRS to PDSCH		dB	0
DL BWP configuration #1	Cyclic prefix		Normal
Common serving cell parameters	Physical Cell ID		0
	SSB position in burst		1
	SSB periodicity	ms	20
	First DMRS position for Type A PDSCH mapping		~~2~~
PDCCH configuration	Slots for PDCCH monitoring		Each slot
	Symbols with PDCCH		0
	Number of PDCCH candidates and aggregation levels		1/[8]
	DCI format		1_1
	TCI state		TCI state #1
Cross carrier scheduling			Not configured
CSI-RS for tracking	First subcarrier index in the PRB used for CSI-RS (k_0)		0
	First OFDM symbol in the PRB used for CSI-RS (l_0)		CSI-RS resource 1: 6 CSI-RS resource 2: 10 CSI-RS resource 3: 6 CSI-RS resource 4: 10
	Number of CSI-RS ports (X)		1
	CDM Type		No CDM
	Density (ρ)		3
	CSI-RS periodicity	Slots	160
	CSI-RS offset	Slots	80 for CSI-RS resource 1 and 2 81 for CSI-RS resource 3 and 4
	Frequency Occupation		Start PRB 0 Number of PRB = BWP size
	QCL info		TCI state #0
NZP CSI-RS for CSI acquisition	First subcarrier index in the PRB used for CSI-RS (k_0)		0
	First OFDM symbol in the PRB used for CSI-RS (l_0)		12
	Number of CSI-RS ports (X)		2
	CDM Type		FD-CDM2
	Density (ρ)		1
	CSI-RS periodicity	Slots	160
	CSI-RS offset		0
	Frequency Occupation		Start PRB 0 Number of PRB = BWP size
	QCL info		TCI state #1
ZP CSI-RS for CSI acquisition	First subcarrier index in the PRB used for CSI-RS (k_0)		4
	First OFDM symbol in the PRB used for CSI-RS (l_0)		12
	Number of CSI-RS ports (X)		4
	CDM Type		FD-CDM2
	Density (ρ)		1
	CSI-RS periodicity	Slots	160
	CSI-RS offset		0
	Frequency Occupation		Start PRB 0 Number of PRB = BWP size
CSI-RS for beam refinement	First subcarrier index in the PRB used for CSI-RS		k_0=0 for CSI-RS resource 1,2
	First OFDM symbol in the PRB used for CSI-RS		l_0 = 8 for CSI-RS resource 1 l_0 = 9 for CSI-RS resource 2
	Number of CSI-RS ports (X)		1 for CSI-RS resource 1,2
	CDM Type		'No CDM' for CSI-RS resource 1,2
	Density (ρ)		3 for CSI-RS resource

				1,2
	CSI-RS periodicity		Slots	120 kHz SCS: 160 for CSI-RS resource 1,2
	CSI-RS offset		Slots	0 for CSI-RS resource 1,2
PDSCH DMRS configuration	Antenna ports indexes			{1000} for Rank 1 tests {1000, 1001} for Rank 2 tests
	Number of PDSCH DMRS CDM group(s) without data			1
TCI state #0	Type 1 QCL information	SSB index		SSB #0
		QCL Type		Type C
	Type 2 QCL information	SSB index		SSB #0
		QCL Type		Type D
TCI state #1	Type 1 QCL information	CSI-RS resource		CSI-RS resource 1 from 'CSI-RS for tracking' configuration
		QCL Type		Type A
	Type 2 QCL information	CSI-RS resource		CSI-RS resource 1 from 'CSI-RS for tracking' configuration
		QCL Type		Type D
PTRS configuration	Frequency density (K_{PT-RS})			2
	Time density (L_{PT-RS})			1
Maximum number of code block groups for ACK/NACK feedback				1
Maximum number of HARQ transmission				4
HARQ ACK/NACK bundling				Multiplexed
Redundancy version coding sequence				{0,2,3,1}
Precoding configuration				SP Type I, Random per slot with PRB bundling granularity
Symbols for all unused Res				OCNG in Annex A.5
Note 1: UE assumes that the TCI state for the PDSCH is identical to the TCI state applied for the PDCCH transmission.				

Table 7.2-2: Number of PRBs in CORESET

SCS (kHz)	50 MHz	100 MHz	200 MHz	400 MHz
60	66	132	264	N.A
120	30	66	132	264

7.2.1 1RX requirements

(Void)

7.2.2 2RX requirements

7.2.2.1 FDD

(Void)

7.2.2.2 TDD

7.2.2.2.1 Minimum requirements for PDSCH Mapping Type-A

For PDSCH Type-A scheduling, the requirements are specified in Table 7.2.2.2.1-3, 7.2.2.2.1-4 and 7.2.2.2.1-5, with the addition of the parameters in Table 7.2.2.2.1-2 and the downlink physical channel setup according to Annex C.5.1. The purpose is to verify the performance of PDSCH Type-A scheduling.

The test purposes are specified in Table 7.2.2.1.1-1.

Table 7.2.2.1.1-1: Tests purpose

Purpose	Test index
Verify the PDSCH mapping Type A normal performance under 2 receive antenna conditions and with different channel models, MCSs andnumber of MIMO layers	[1-1, 1-3, 2-1, 2-2, 2-3, 2-4, 2-5, 2-6]
Verify the PDSCH mapping Type A HARQ soft combining performance under 2 receive antenna conditions.	[1-2]
Verify the PDSCH mapping Type A enhanced performance requirement Type X under 2 receive antenna conditions and with 2 MIMO layers.	[3-1]

Table 7.2.2.2.1-2: Test Parameters

Parameter		Unit	Value
Duplex mode			TDD
Active DL BWP index			1
DL BWP configuration #1	First PRB		0
	Number of contiguous PRB		Maximum transmission bandwidth configuration as specified in subclause 5.3.2 of TS 38.101-2 [7] for tested channel bandwidth and subcarrier spacing
PDCCH configuration	Number of PRBs in CORESET	PRBs	As defined in Table 7.2-2
PDSCH configuration	Mapping type		Type A
	k0		0
	Starting symbol (S)		1
	Length (L)		As defined in Annex A.1.3
	PDSCH aggregation factor		1
	PRB bundling type		Static
	PRB bundling size		WB for 1-1, 2 for other tests
	Resource allocation type		Type 1
	VRB-to-PRB mapping type		Non-interleaved
	VRB-to-PRB mapping interleaver bundle size		N/A
PDSCH DMRS configuration	DMRS Type		Type 1
	Number of additional DMRS		1
	Length		Single-symbol DM-RS
	Antenna ports indexes		{1000} for Rank1 {1000,1001} for Rank2
	Number of PDSCH DMRS CDM group(s) without data		1
Number of HARQ Processes			8 for Test 1-1, 1-3, 2-4 10 for Test 2-1, 2-3, 2-5, 2-6, 3-1 16 for Test 1-2 TBD for Test 2-2
K1 value (PDSCH-to-HARQ-timing-indicator)			As defined in Annex A.1.3

Table 7.2.2.2.1-3: Minimum performance for Rank 1 (FRC)

Test num.	Reference channel	Bandwidth/Subcarrier spacing	Modulation and code rate	TDD UL-DL pattern	Propagation condition	Correlation matrix and antenna configuration	Reference value	
							Fraction of maximum throughput (%)	SNR_{BB} (dB)
1-1	R.PDSCH.5-1.1_TDD	100MHz/120kHz	QPSK, 0.30	FR2.120-1	TDLC60-300	2x2 ULA Low	70	[-0.4]
1-2	R.PDSCH.5-2.1_TDD	100MHz/120kHz	16QAM, 0.48	FR2.120-1	TDLA30-300	2x2 ULA Low	30	[1.7]
1-3	R.PDSCH.5-3.1_TDD	100MHz/120kHz	64QAM, 0.45	FR2.120-1	TDLA30-300	2x2 XPL Med-A	70	[12.4]

Table 7.2.2.2.1-4: Minimum performance for Rank 2 (FRC)

Test num.	Reference channel	Bandwidth/Subcarrier spacing	Modulation and code rate	TDD UL-DL pattern	Propagation condition	Correlation matrix and antenna configuration	Reference value	
							Fraction of maximum throughput (%)	SNR_{BB} (dB)
2-1	R.PDSCH.5-4.1_TDD	100MHz/120kHz	QPSK, 0.30	FR2.120-2	TDLA30-75	2x2 ULA Low	70	[4.1]
2-2	R.PDSCH.5-2.2_TDD	100MHz/120kHz	16QAM, 0.48	FR2.120-1	TDLA30-300	2x2 ULA Low	70	[TBD]
2-3	R.PDSCH.5-5.2_TDD	50MHz/120kHz	16QAM,0.48	FR2.120-2	TDLA30-75	2x2 ULA Low	70	[14.0]
2-4	R.PDSCH.5-2.3_TDD	200MHz/120kHz	16QAM, 0.48	FR2.120-1	TDLA30-300	2x2 ULA Low	70	[14.2]
2-5	R.PDSCH.4-1.1_TDD	50MHz/60kHz	16QAM, 0.48	FR2.60-1	TDLA30-75	2x2 ULA Low	70	[14.3]
2-6	R.PDSCH.5-6.1_TDD	100MHz/120kHz	64QAM, 0.43	FR2.120-2	TBD	2x2 ULA Low	70	[18.6]

Table 7.2.2.2.1-5: Minimum performance for Rank 2 (FRC) for Enhanced Type X Receiver

Test num.	Reference channel	Bandwidth/Subcarrier spacing	Modulation and code rate	TDD UL-DL pattern	Propagation condition	Correlation matrix and antenna configuration	Reference value	
							Fraction of maximum throughput (%)	SNR_{BB} (dB)
3-1	R.PDSCH.5-5.1_TDD	100MHz/120kHz	16QAM, 0.48	FR2.120-2	TDLA30-75	2x2 ULA Med	70	[19.4]

7.3 PDCCH demodulation requirements

The receiver characteristics of the PDCCH are determined by the probability of miss-detection of the Downlink Scheduling Grant (Pm-dsg).

The parameters specified in Table 7.3-1 are valid for all PDCCH tests unless otherwise stated.

Table 7.3-1: Common test Parameters

Parameter			Unit	Value
DL BWP configuration #1	Cyclic prefix			Normal
Common serving cell parameters	Physical Cell ID			0
	SSB position in burst			1
	SSB periodicity		ms	20
PDCCH configuration	Slots for PDCCH monitoring			Each slot
	Number of PDCCH candidates			1
	TCI state			TCI state #1
CSI-RS for tracking	First subcarrier index in the PRB used for CSI-RS (k0)			0
	First OFDM symbol in the PRB used for CSI-RS (l0)			CSI-RS resource 1: 4 CSI-RS resource 2: 8 CSI-RS resource 3: 4 CSI-RS resource 4: 8
	Number of CSI-RS ports (X)			1
	CDM Type			No CDM
	Density (ρ)			3
	CSI-RS periodicity		Slots	160
	CSI-RS offset		Slots	80 for CSI-RS resource 1 and 2 81 for CSI-RS resource 3 and 4
	Frequency Occupation			Start PRB 0 Number of PRB = BWP size
	QCL info			TCI state #0
Precoding configuration				SP Type I, Random per slot with REG bundling granularity for number of Tx larger than 1
TCI state #0	Type 1 QCL information	SSB index		SSB #0
		QCL Type		Type C
	Type 2 QCL information	SSB index		SSB #0
		QCL Type		Type D
TCI state #1	Type 1 QCL information	CSI-RS resource		CSI-RS resource 1 from 'CSI-RS for tracking' configuration
		QCL Type		Type A
	Type 2 QCL information	CSI-RS resource		CSI-RS resource 1 from 'CSI-RS for tracking' configuration
		QCL Type		Type D
Symbols for all unused REs				OCNG in Annex A.5

7.3.1 1RX requirements

(Void)

7.3.2 2RX requirements

7.3.2.1 FDD

(Void)

7.3.2.2 TDD

The parameters specified in Table 7.3.2.2-1 are valid for all TDD tests unless otherwise stated.

Table 7.3.2.2-1: Test Parameters

Parameter	Unit	1 Tx Antenna	2 Tx Antenna
TDD UL-DL pattern		FR2.120-1	
CCE to REG mapping type		Interleaved	
REG bundle size		2 for test 1-1 6 for test 1-2	2
Interleaver size		3 for test 1-1 2 for test 1-2	3
Shift index		0	

7.3.2.2.1 1 Tx Antenna performances

For the parameters specified in Table 7.3.2.2-1, the average probability of a missed downlink scheduling grant (Pm-dsg) shall be below the specified value in Table 7.3.2.2.1-1. The downlink physical setup is in accordance with Annex C.5.1.

Table 7.3.2.2.1-1: Minimum performance requirements with 120 kHz SCS

Test number	Bandwidth	CORESET RB	CORESET duration	Aggregation level	Reference Channel	Propagation Condition	Antenna configuration and correlation Matrix	Reference value	
								Pm-dsg (%)	SNR_{BB} (dB)
1-1	100 MHz	60	1	2 CCE	R.PDCCH.5-1.1 TDD	TDLA30-75	1x2 Low	1	[6.0]
1-2	100 MHz	60	1	4 CCE	R.PDCCH.5-1.2 TDD	TDLA30-300	1x2 Low	1	[2.6]

7.3.2.2.2 2 Tx Antenna performances

For the parameters specified in Table 7.3.2.2-1, the average probability of a missed downlink scheduling grant (Pm-dsg) shall be below the specified value in Table 7.3.2.2.2-1. The downlink physical setup is in accordance with Annex C.5.1.

Table 7.3.2.2.2-1: Minimum performance requirements with 120 kHz SCS

Test number	Bandwidth	CORESET RB	CORESET duration	Aggregation level	Reference Channel	Propagation Condition	Antenna configuration and correlation Matrix	Reference value	
								Pm-dsg (%)	SNR_{BB} (dB)
2-1	100 MHz	60	1	8 CCE	R.PDCCH.5-1.3 TDD	TDLA30-75	2x2 Low	1	[-0.4]
2-2	100 MHz	60	2	16 CCE	R.PDCCH.5-2.1 TDD	TDLA30-75	2x2 Low	1	[-3.4]

7.4 PBCH demodulation requirements

The receiver characteristics of PBCH are determined by the probability of miss-detection of the PBCH (Pm-bch), which is defined as

$$\mathrm{Pm-bch} = 1 - \frac{A}{B}$$

Where A is the number of correctly decoded MIB PDUs and B is the number of transmitted MIB PDUs. The Pm-bch is derived with the assumption UE combines the PBCH symbols of the same SS/PBCH block index within the MIB TTI (80ms).

7.4.1 1RX requirements

(Void)

7.4.2 2RX requirements

7.4.2.1 FDD

(Void)

7.4.2.2 TDD

Table 7.4.2.2-1: Test parameters for PBCH

Parameter	Unit	Single antenna port
Physical Cell ID		0
Cyclic prefix		Normal
Number of SS/PBCH blocks within an SS burst set periodicity		1
SS/PBCH block index Note1		0
SS/PBCH block periodicity	ms	20
TDD UL-DL pattern		FR2.120-1
Note 1: as specified in TS 38.213 [11, Section 4.1] Note 2: as specified in TS 38.213 [11, Section 11.1]		

For the parameters specified in Table 7.4.2.2-1 the average probability of a miss-detected PBCH (Pm-bch) shall be below the specified values in Table 7.4.2.2-2 in case SS/PBCH block index is not known and below the specified values in Table.7.4.2.2-3 in case SS/PBCH block index is known. The downlink physical setup is in accordance with Annex C.5.1.

Table 7.4.2.2-2: Minimum performance PBCH in case SS/PBCH block index is not known

Test number	Bandwidth	Reference channel	Propagation condition	Antenna configuration and correlation matrix	Reference value	
					Pm-bch (%)	SNR_{BB} (dB)
1	100 MHz	R.PBCH.5	[TDLA30-300]	1 x 2 Low	1	[-6.1]
2	100 MHz	R.PBCH.6	[TDLA30-75]	1 x 2 Low	1	TBD

Table 7.4.2.2-3 Minimum performance PBCH in case SS/PBCH block index is known

Test number	Bandwidth	Reference channel	Propagation condition	Antenna configuration and correlation matrix	Reference value	
					Pm-bch (%)	PBCH SNR (dB)
1	100 MHz	R.PBCH.5	TDLA30-300	1 x 2 Low	1	[-8]
2	100 MHz	R.PBCH.6	TDLA30-75	1 x 2 Low	1	[-7.5]

7.5 Sustained downlink data rate provided by lower layers

<TBA>

8 CSI reporting requirements (Radiated requirements)

8.1 General

This section includes radiated requirements for the reporting of channel state information (CSI).

8.1.1 Applicability of requirements

<TBA>

8.1.2 Common test parameters

Parameters specified in Table 8.1.2-1 are applied for all test cases in this section unless otherwise stated.

Table 8.1.2-1: Test parameters for CSI test cases

Parameter		Unit	Value
PDSCH transmission scheme			Transmission scheme 1
Duplex Mode			TDD
EPRE ratio of PTRS to PDSCH		dB	[0]
Active DL BWP index			1
Cyclic prefix			Normal
Common serving cell parameters	Physical Cell ID		0
	SSB position in burst		First SSB in Slot #0
	SSB periodicity	ms	20
PDCCH configuration	Slots for PDCCH monitoring		Each slot
	Symbols with PDCCH		0,1
	Number of PDCCH candidates and aggregation levels		1/[8]
	DCI format		1_1
	TCI state		TCI state #1
Cross carrier scheduling			Not configured
PDSCH configuration	Mapping type		Type A
	k0		0
	Starting symbol (S)		2
	Length (L)		12
	PDSCH aggregation factor		1
	PRB bundling type		Static
	PRB bundling size		2
	Resource allocation type		0
	VRB-to-PRB mapping type		Non-interleaved
	VRB-to-PRB mapping interleaver bundle size		N/A
PDSCH DMRS configuration	DMRS Type		Type 1
	Number of additional DMRS		1
	DMRS ports indexes		{1000} for Rank1 {1000,1001} for Rank2
	Length		Single-symbol DM-RS
	Number of PDSCH DMRS CDM group(s) without data		2
PTRS configuration	Frequency density (K_{PT-RS})		2
	Time density (L_{PT-RS})		1
CSI-RS for tracking	First subcarrier index in the PRB used for CSI-RS (k_0)		[0]
	First OFDM symbol in the PRB used for CSI-RS (l_0)		[4]
	Number of CSI-RS ports (X)		1
	CDM Type		No CDM
	Density (ρ)		3
	CSI-RS periodicity	slot	120kHz SCS: 160
	CSI-RS offset	slot	120 kHz SCS: 80 for CSI-RS resource 1 and 2 81 for CSI-RS resource 3 and 4
	Frequency Occupation		Start PRB 0 Number of PRB = BWP size
	QCL info		TCI state #0
NZP CSI-RS for CSI acquisition	Frequency Occupation		Start PRB 0 Number of PRB = BWP size
	QCL info		TCI state #1
ZP CSI-RS for CSI acquisition	Frequency Occupation		Start PRB 0 Number of PRB = BWP size
CSI-RS for	First subcarrier index in the PRB		k_0=0 for CSI-RS

beam refinement	used for CSI-RS			resource 1,2
	First OFDM symbol in the PRB used for CSI-RS			l_0 = 8 for CSI-RS resource 1 l_0 = 9 for CSI-RS resource 2
	Number of CSI-RS ports (X)			1 for CSI-RS resource 1,2
	CDM Type			'No CDM' for CSI-RS resource 1,2
	Density (ρ)			3 for CSI-RS resource 1,2
	CSI-RS periodicity		Slots	120 kHz SCS: 160 for CSI-RS resource 1,2
	CSI-RS offset		Slots	0 for CSI-RS resource 1,2
	Repetition			ON
TCI state #0	Type 1 QCL information	SSB index		SSB #0
		QCL Type		Type C
	Type 2 QCL information	SSB index		SSB #0
		QCL Type		Type D
TCI state #1	Type 1 QCL information	CSI-RS resource		CSI-RS resource 1 from 'CSI-RS for tracking' configuration
		QCL Type		Type A
	Type 2 QCL information	CSI-RS resource		CSI-RS resource 1 from 'CSI-RS for tracking' configuration
		QCL Type		Type D
Number of HARQ Processes				8
HARQ ACK/NACK bundling				Multiplexed
Redundancy version coding sequence				{0,2,3,1}
K1 value (PDSCH-to-HARQ-timing-indicator)				For FR2.120-1: [3] if mod (i.5) = 0, [6] if mod(i,5) = 2 For FR2.120-2: [11] if mod(i,8) = 0, [7] if mod(i,8) = 4, [6] if mod(i,8) = 5, where i is slot index per radio fame with values 0-79.
Symbols for unused Res				OCNG as specified in A.5
Note 1: PDSCH is not scheduled on slots containing CSI-RS or slots which are not full DL. Note 2: UE assumes that the TCI state for the PDSCH is identical to the TCI state applied for the PDCCH transmission.				

8.2 Reporting of Channel Quality Indicator (CQI)

8.2.1 1RX requirements

(Void)

8.2.2 2RX requirements

8.2.2.1 FDD

(Void)

8.2.2.2 TDD

8.2.2.2.1 CQI reporting under AWGN conditions

<Editor's note: The requirements were introduced based on current results from companies; these requirements can be revised based on more results from companies.>

The reporting accuracy of the channel quality indicator (CQI) under frequency non-selective conditions is determined by the reporting variance and the BLER performance using the transport format indicated by the reported CQI median. The purpose is to verify that the reported CQI values are in accordance with the CQI definition given in TS 38.214 [12]. To account for sensitivity of the input SNR the reporting definition is considered to be verified if the reporting accuracy is met for at least one of two SNR levels separated by an offset of [1] dB.

8.2.2.2.1.1 Minimum requirement for periodic CQI reporting

For the parameters specified in Table 8.2.2.2.1.1-1, and using the downlink physical channels specified in Annex C.5.1, the minimum requirements are specified by the following:

a) the reported CQI value shall be in the range of ±1 of the reported median more than [90%] of the time;

b) if the PDSCH BLER using the transport format indicated by median CQI is less than or equal to 0.1, the BLER using the transport format indicated by the (median CQI + 1) shall be greater than 0.1. If the PDSCH BLER using the transport format indicated by the median CQI is greater than 0.1, the BLER using transport format indicated by (median CQI – 1) shall be less than or equal to 0.1.

Table 8.2.2.2.1.1-1 Test parameters

Parameter		Unit	Test 1	Test 2
Bandwidth		MHz	100	100
Duplex Mode			TDD	TDD
TDD Slot Configuration			FR2.120-2 [Annex A.1.3]	FR2.120-2 [Annex A.1.3]
DL BWP configuration #1	First PRB		0	0
	Number of contiguous PRB		66	66
	Subcarrier spacing	kHz	120	120
SNR_{BB}		dB	[8] [9]	[14] [15]
Propagation channel			AWGN	AWGN
Antenna configuration			2×2 with static channel specified in [Annex B.1]	2×2 with static channel specified in [Annex B.1]
Beamforming Model			As specified in Section [Annex TBD]	As specified in Section [Annex TBD]
ZP CSI-RS configuration	CSI-RS resource Type		*Periodic*	*Periodic*
	Number of CSI-RS ports (*X*)		4	4
	CDM Type		*FD-CDM2*	*FD-CDM2*
	Density (ρ)		1	1
	First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		8	8
	First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		13	13
	CSI-RS periodicity and offset	slot	8/1	8/1
NZP CSI-RS for CSI acquisition	CSI-RS resource Type		*Periodic*	*Periodic*
	Number of CSI-RS ports (*X*)		2	2
	CDM Type		*fd-CDM2*	*fd-CDM2*
	Density (ρ)		1	1
	First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		6	6
	First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		13	13
	NZP CSI-RS-timeConfig periodicity and offset	slot	8/1	8/1
CSI-IM configuration	CSI-IM RE pattern		1	1
	CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(8, 13)	(8, 13)
	CSI-IM timeConfig periodicity and offset	slot	8/1	8/1
ReportConfigType			*Periodic*	*Periodic*
CQI-table			Table 1	Table 1
reportQuantity			*cri-RI-PMI-CQI*	*cri-RI-PMI-CQI*
timeRestrictionForChannelMeasurements			*Not configured*	*Not configured*
timeRestrictionForInterferenceMeasurements			*Not configured*	*Not configured*
cqi-FormatIndicator			*Wideband*	*Wideband*
pmi-FormatIndicator			*Wideband*	*Wideband*
Sub-band Size		RB	[8]	[8]
csi-ReportingBand			[111111111]	[111111111]
CSI-Report periodicity and offset		slot	8/1	8/1
aperiodicTriggeringOffset			*Not configured*	*Not configured*
Codebook configuration	Codebook Type		*typeI-SinglePanel*	*typeI-SinglePanel*
	Codebook Mode		1	1
	(CodebookConfig-N1,CodebookConfig-N2)		*Not configured*	*Not configured*
	CodebookSubsetRestriction		[010000]	[010000]
	RI Restriction		[N/A]	[N/A]
Physical channel for CSI report			[PUCCH]	[PUCCH]
CQI/RI/PMI delay		ms	[8.375]	[8.375]
Maximum number of HARQ transmission			1	1
Measurement channel			As specified in Table	As specified in Table

		A.4-1, TBS.1-2	A.4-1, TBS.1-2

8.2.2.2.2 CQI reporting under fading conditions

8.2.2.2.2.1 Minimum requirement for wideband CQI reporting

<Editor's note: Open issues to be resolved:

- *SNR levels*
- *Test parameters*
- *Requirements values (BLER, α, γ)>*

The purpose of the requirements is to verify that the UE is tracking the channel variations and selecting the largest transport format possible according to the prevailing channel state for the frequency non-selective scheduling.

The reporting accuracy of CQI under frequency non-selective fading conditions is determined by the reporting variance, the relative increase of the throughput obtained when the transport format is indicated by the reported CQI compared to the throughput obtained when a fixed transport format is configured according to the reported median CQI, and a minimum BLER using the transport formats indicated by the reported CQI. To account for sensitivity of the input SNR the CQI reporting under frequency non-selective fading conditions is considered to be verified if the reporting accuracy is met for at least one of two SNR levels separated by an offset of [1] dB.

For the parameters specified in Table 8.2.2.2.2.1-1 and using the downlink physical channels specified in Annex C.5.1, the minimum requirements are specified by the following:

a) a CQI index not in the set {median CQI -1, median CQI, median CQI +1} shall be reported at least α % of the time, where α% is specified in Table 8.2.2.2.2.1-2;

b) the ratio of the throughput obtained when transmitting the transport format indicated by each reported wideband CQI index and that obtained when transmitting a fixed transport format configured according to the wideband CQI median shall be ≥ γ, where γ is specified in Table 8.2.2.2.2.1-2;

c) when transmitting the transport format indicated by each reported wideband CQI index, the average BLER for the indicated transport formats shall be greater or equal to [0.01].

Table 8.2.2.2.2.1-1 Test parameters

Parameter		Unit	Test 1	Test 2
Bandwidth		MHz	100	100
Duplex Mode			TDD	TDD
TDD Slot Configuration			FR2.120-2 [Annex A.1.3]	FR2.120-2 [Annex A.1.3]
DL BWP configuration #1	First PRB		0	0
	Number of contiguous PRB		66	66
	Subcarrier spacing	kHz	120	120
SNR_{BB}		dB	6 | 7	12 | 13
Propagation channel			[TDLA30-35]	[TDLA30-35]
Antenna configuration			2×2 [ULA High]	2×2 [ULA High]
Beamforming Model			As specified in Section [Annex TBD]	As specified in Section [Annex TBD]
ZP CSI-RS configuration	CSI-RS resource Type		*Aperiodic*	*Aperiodic*
	Number of CSI-RS ports (*X*)		4	4
	CDM Type		*FD-CDM2*	*FD-CDM2*
	Density (ρ)		1	1
	First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		8	8
	First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		13	13
	CSI-RS interval and offset	slot	[8/1]	[8/1]
NZP CSI-RS for CSI acquisition	CSI-RS resource Type		*Aperiodic*	*Aperiodic*
	Number of CSI-RS ports (*X*)		2	2
	CDM Type		*fd-CDM2*	*fd-CDM2*
	Density (ρ)		1	1
	First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		6	6
	First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		13	13
	NZP CSI-RS-timeConfig interval and offset	slot	[8/1]	[8/1]
CSI-IM configuration	CSI-IM RE pattern		1	1
	CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(8, 13)	(8, 13)
	CSI-IM timeConfig interval and offset	slot	[8/1]	[8/1]
ReportConfigType			*Aperiodic*	*Aperiodic*
CQI-table			Table 1	Table 1
reportQuantity			*cri-RI-PMI-CQI*	*cri-RI-PMI-CQI*
timeRestrictionForChannelMeasurements			*Not configured*	*Not configured*
timeRestrictionForInterferenceMeasurements			*Not configured*	*Not configured*
cqi-FormatIndicator			*Wideband*	*Wideband*
pmi-FormatIndicator			*Wideband*	*Wideband*
Sub-band Size		RB	[8]	[8]
csi-ReportingBand			[111111111]	[111111111]
CSI-Report periodicity and offset		slot	8/1	8/1
aperiodicTriggeringOffset			*Not configured*	*Not configured*
Codebook configuration	Codebook Type		*typeI-SinglePanel*	*typeI-SinglePanel*
	Codebook Mode		1	1
	(CodebookConfig-N1,CodebookConfig-N2)		*Not configured*	*Not configured*
	CodebookSubsetRestriction		[000001]	[000001]
	RI Restriction		[N/A]	[N/A]
Physical channel for CSI report			[PUSCH]	[PUSCH]
CQI/RI/PMI delay		ms	[1.375]	[1.375]
Maximum number of HARQ transmission			1	1
Measurement channel			As specified in Table A.4-1, TBS.1-1	As specified in Table A.4-1, TBS.1-1

Table 8.2.2.2.2.1-2 Minimum requirements

	Test 1	Test 2
α [%]	[2]	[2]
γ	[1.05]	[1.05]

8.3 Reporting of Precoding Matrix Indicator (PMI)

The minimum performance requirements of PMI reporting are defined based on the precoding gain, expressed as the relative increase in throughput when the transmitter is configured according to the UE reports compared to the case when the transmitter is using random precoding, respectively. When the transmitter uses random precoding, for each PDSCH allocation a precoder is randomly generated and applied to the PDSCH. A fixed transport format (FRC) is configured for all requirements.

The requirements for transmission mode 1 with 2TX and higher layer parameter *codebookType* set to 'typeI-SinglePanel' are specified in terms of the ratio

$$\gamma = \frac{t_{ue}}{t_{rnd}}$$

In the definition of γ, for 2TX PMI requirements, t_{ue} is [90] % of the maximum throughput obtained at SNR_{ue} using the precoders configured according to the UE reports, and t_{rnd} is the throughput measured at SNR_{ue} with random precoding.

8.3.1 1RX requirements

(Void)

8.3.2 2RX requirements

8.3.2.1 FDD

(Void)

8.3.2.2 TDD

8.3.2.2.1 Single PMI with 2TX TypeI-SinglePanel Codebook

For the parameters specified in Table 8.3.2.2.1-1, and using the downlink physical channels specified in Annex C.5.1, the minimum requirements are specified in Table 8.3.2.2.1-2.

Table 8.3.2.2.1-1: Test parameters (single layer)

Parameter		Unit	Test 1	Test 2
Bandwidth		MHz	100	100
TDD DL-UL configuration			FR2.120-2 as specified in Annex A	FR2.120-2 as specified in Annex A
DL BWP configuration #1	First PRB		0	0
	Number of contiguous PRB		66	66
	Subcarrier spacing	kHz	120	120
Propagation channel			[TDLA30-35]	
Antenna configuration			2 x 2 [ULA Low]	2 x 2 [ULA Low]
Beamforming Model			TBD	
ZP CSI-RS configuration	CSI-RS resource Type		Aperiodic	Aperiodic
	Number of CSI-RS ports (*X*)		4	4
	CDM Type		FD-CDM2	FD-CDM2
	Density (ρ)		1	1
	First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 4, (8,-)	Row 4, (8,-)
	First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(13,-)	(13,-)
	CSI-RS interval and offset	slot	8/1	5/1
NZP CSI-RS for CSI acquisition	CSI-RS resource Type		Aperiodic	Aperiodic
	Number of CSI-RS ports (*X*)		2	2
	CDM Type		FD-CDM2	FD-CDM2
	Density (ρ)		1	1
	First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 3, (6,-)	Row 3, (6,-)
	First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(13,-)	(13,-)
	CSI-RS interval and offset	slot	8/1	8/1
CSI-IM configuration	CSI-IM RE pattern		Patten 0	Patten 0
	CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(8,13)	(8,13)
	CSI-IM timeConfig interval and offset	slot	8/1	5/1
ReportConfigType			Aperiodic	Aperiodic
CQI-table			Table 1	Table 1
reportQuantity			cri-RI-PMI-CQI	cri-RI-PMI-CQI
timeRestrictionForChannelMeasurements			Not configured	Not configured
timeRestrictionForInterferenceMeasurements			Not configured	Not configured
cqi-FormatIndicator			Wideband	Wideband
pmi-FormatIndicator			Wideband	Wideband

Sub-band Size		RB	[8]	[8]
csi-ReportingBand			[111111111]	[111111111]
CSI-Report interval and offset		slot	8/1	5/1
aperiodicTriggeringOffset			0	0
Codebook configuration	Codebook Type		typeI-SinglePanel	typeI-SinglePanel
	Codebook Mode		1	1
	(CodebookConfig-N1,CodebookConfig-N2)		N/A	N/A
	CodebookSubsetRestriction		001111	001111
	RI Restriction		N/A	N/A
Physical channel for CSI report			PUSCH	PUSCH
CQI/RI/PMI delay		ms	1.375	1.75
Maximum number of HARQ transmission			4	4
Measurement channel			R.PDSCH.5-8.1 TDD	R.PDSCH.5-7.1 TDD
Note 1: For random precoder selection, the precoder shall be updated in each slot (0.125 ms granularity). Note 2: If the UE reports in an available uplink reporting instance at slot#n based on PMI estimation at a downlink slot not later than slot#[(n-4)], this reported PMI cannot be applied at the eNB downlink before slot#[(n+4)]. Note 3: Randomization of the principle beam direction shall be used as specified in TBD.				

Table 8.3.2.2.1-2: Minimum requirement

Parameter	Test 1	Test 2
γ	[1.05]	[1.05]

8.4 Reporting of Rank Indicator (RI)

The purpose of this test is to verify that the reported rank indicator accurately represents the channel rank. The accuracy of RI reporting is determined by the relative increase of the throughput obtained when transmitting based on the reported rank compared to the case for which a fixed rank is used for transmission.

8.4.1 1RX requirements

(Void)

8.4.2 2RX requirements

8.4.2.1 FDD

(Void)

8.4.2.2 TDD

The minimum performance requirement in Table 8.4.2.2-2 is defined as

a) The ratio of the throughput obtained when transmitting based on UE reported RI and that obtained when transmitting with fixed rank 1 shall be $\geq \gamma_1$;

b) The ratio of the throughput obtained when transmitting based on UE reported RI and that obtained when transmitting with fixed rank 2 shall be $\geq \gamma_2$;

For the parameters specified in Table 8.4.2.2-1, and using the downlink physical channels specified in Annex C.5.1, the minimum requirements are specified in Table 8.4.2.2-2.

Table 8.4.2.2-1: RI Test (TDD)

Parameter			Unit	Test 1	Test 2	Test 3
Bandwidth			MHz	100	100	100
Duplex Mode				TDD	TDD	TDD
TDD Slot Configuration				FR1.120-2	FR1.120-2	FR1.120-2
DL BWP configuration #1		First PRB		0	0	0
		Number of contiguous PRB		66	66	66
		Subcarrier spacing	kHz	120	120	120
SNR			dB	[0]	[20]	[20]
Propagation channel				[TDLA30-35]	[TDLA30-35]	[TDLA30-35]
Antenna configuration				ULA Low 2x2	ULA Low 2x2	XP High 2x2
Beamforming Model				As defined in Annex B.4.1	As defined in Annex B.4.1	As defined in Annex B.4.1
ZP CSI-RS configuration		CSI-RS resource Type		Aperiodic	Aperiodic	Aperiodic
		Number of CSI-RS ports (*X*)		4	4	4
		CDM Type		FD-CDM2	FD-CDM2	FD-CDM2
		Density (ρ)		1	1	1
		First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 4, (8,-)	Row 4, (8,-)	Row 4, (8,-)
		First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(13,-)	(13,-)	(13,-)
		CSI-RS interval and offset	slot	8/1	8/1	8/1
NZP CSI-RS for CSI acquisition		CSI-RS resource Type		Aperiodic	Aperiodic	Aperiodic
		Number of CSI-RS ports (*X*)		2	2	2
		CDM Type		FD-CDM2	FD-CDM2	FD-CDM2
		Density (ρ)		1	1	1
		First subcarrier index in the PRB used for CSI-RS (k_0, k_1)		Row 3 (6,-)	Row 3 (6,-)	Row 3 (6,-)
		First OFDM symbol in the PRB used for CSI-RS (l_0, l_1)		(13,-)	(13,-)	(13,-)
		NZP CSI-RS-timeConfig interval and offset	slot	8/1	8/1	8/1
CSI-IM configuration		CSI-IM RE pattern		Pattern 1	Pattern 1	Pattern 1
		CSI-IM Resource Mapping (k_{CSI-IM},l_{CSI-IM})		(8,13)	(8,13)	(8,13)
		CSI-IM timeConfig interval and offset	slot	8/1	8/1	8/1
ReportConfigType				Aperiodic	Aperiodic	Aperiodic
CQI-table				Table 1	Table 1	Table 1
reportQuantity				cri-RI-PMI-CQI	cri-RI-PMI-CQI	cri-RI-PMI-CQI
timeRestrictionForChannelMeasurements				not configured	not configured	not configured
timeRestrictionForInterferenceMeasurements				not configured	not configured	not configured
cqi-FormatIndicator				Wideband	Wideband	Wideband
pmi-FormatIndicator				Wideband	Wideband	Wideband
Sub-band Size			RB	[8]	[8]	[8]
csi-ReportingBand				[111111111]	[111111111]	[111111111]
CSI-Report interval and offset			slot	8/1	8/1	8/1
aperiodicTriggeringOffset				0	0	0
Codebook configuration		Codebook Type		typeI-SinglePanel	typeI-SinglePanel	typeI-SinglePanel
		Codebook Mode		1	1	1
		(CodebookConfig-N1,CodebookConfig-N2)		N/A	N/A	N/A
		CodebookSubsetRestriction		[010000 for fixed rank 2, 010011 for following rank]	[000011 for fixed rank 1, 010011 for following rank]	[000011 for fixed rank 1, 010011 for following rank]
		RI Restriction		N/A	N/A	N/A

Physical channel for CSI report		PUSCH	PUSCH	PUSCH
CQI/RI/PMI delay	ms	1.375	1.375	1.375
Maximum number of HARQ transmission		1	1	1
RI Configuration		Fixed RI = 2 and follow RI	Fixed RI = 1 and follow RI	Fixed RI = 1 and follow RI

Table 8.4.2.2-2: Minimum requirement (TDD)

	Test 1	Test 2	Test 3
γ_1	N/A	[1.05]	[1.05]
γ_2	[1.0]	N/A	N/A

9 Demodulation performance requirements for interworking

9.1 General

This clause covers the UE demodulation performance requirements for EN-DC, NE-DC, inter-band NR-DC between FR1 and FR2, and inter-band NR CA between FR1 and FR2.

9.1.1 Applicability of requirements

The following applicability rules are specified for demodulation performance requirements for interworking:

- For UEs supporting both SA and NSA,
  - The performance requirements specified in Section 5 will be verified only for SA except for the sustained downlink data rate test specified in Section 5.5 and 5.5A.
  - The performance requirements specified in Section 7 will be verified only for SA except for the sustained downlink data rate test specified in Section 7.5.
  - The sustained downlink data rate tests specified in Sections 5.5, 5.5A and 7.5 for SA and in Section 9.4B for NSA are verified separately.
- The FR1 EN-DC test cases with the NR TDD DL-UL configurations which are not aligned with LTE's can be tested on the corresponding EN-DC band combinations where UE supports simultaneous transmission and reception.

9.1.2 LTE Pcell setup

This sub-clause provides the parameters for LTE Pcell during the demodulation performance test for EN-DC unless otherwise stated. For EN-DC with multiple LTE carriers or bands, randomly selected one carrier or band that can be used for Pcell as LTE Pcell for the connection setup.

9.1.2.1 FDD

The parameters specified in Table 9.1.2.1-1 and Table 9.1.2.1-2 are used to setup an LTE Pcell. One of test setup in Table 9.1.2.1-2 will be selected for the LTE Pcell depending on the maximum bandwidth of an LTE carrier for all the EN-DC band combinations supported by the UE.

The measurement channels in Table 9.1.2.1-2 and OCNG pattern OP.1 FDD are specified in TS 36.101 [4]. The physical channel setup with downlink power allocation is according to TS36.101 [4, Annex C.3.2].

Table 9.1.2.1-1: Common Test Parameters (FDD)

Parameter	Unit	Value
Cyclic prefix		Normal
Physical Cell ID		0
Number of PDCCH symbols	symbols	1
PHICH Ng (Note 1)		1
PHICH duration		Normal
Number of HARQ processes per component carrier	Processes	[8]
Maximum number of HARQ transmission		[4]
Redundancy version coding sequence		{0,0,1,2} for [64QAM]
Propagation condition		Static propagation condition No external noise sources are applied
Transmission mode		[3]
Transmission time difference between LTE cell and NR cell(s)	μs	0
Antenna configuration		2x2
Codebook subset restriction		[10]
Symbols for all unused Res		OCNG in Annex A.5

Table 9.1.2.1-2: Specific Test Parameters (FDD [64QAM])

Test setup	Bandwidth (MHz)	Downlink power allocation (dB)		
		ρ_A	ρ_B	σ
1	5	-3	-3	0
2	10	-3	-3	0
3	15	-3	-3	0
4	20	-3	-3	0

9.1.2.2 TDD

The parameters specified in Table 9.1.2.2-1 and Table 9.1.2.2-2 are used to setup an LTE Pcell. One of test setup in Table 9.1.2.2-2 will be selected for the LTE Pcell depending on the maximum bandwidth of an LTE carrier for all the EN-DC band combinations supported by the UE.

The measurement channels in Table 9.1.2.2-2 and OCNG pattern OP.1 TDD are specified in TS36.101 [4]. The physical channel setup with downlink power allocation is according to TS36.101 [4, Annex C.3.2].

Table 9.1.2.2-1: Common Test Parameters (TDD)

Parameter	Unit	Value
UL DL configuration		2 (Note1)
Special subframe configuration		7
Number of PDCCH symbols	symbols	1
PHICH Ng (Note 3)		1
PHICH duration		Normal
Cyclic prefix		Normal
Cell ID		0
Maximum number of HARQ transmission		[4]
Redundancy version coding sequence		{0,0,1,2} for [64QAM]
Propagation condition		Static propagation condition No external noise sources are applied
Transmission mode		[3]
Transmission time difference between LTE cell and NR cell(s)	μs	0
Antenna configuration		2x2
Codebook subset restriction		[10]
Symbols for all unused Res		OCNG in Annex A.5
NOTE 1: The start of transmission of LTE frame is delayed by 2 LTE subframes with respect to the start of transmission of NR frame when TDD-TDD EN-DC configuration is configured during the test.		

Table 9.1.2.2-2: Specific Test Parameters (FDD [64QAM])

Test setup	Bandwidth (MHz)	Downlink power allocation (dB)		
		ρ_A	ρ_B	σ
1	10	-3	-3	0
2	15	-3	-3	0
3	20	-3	-3	0

9.2 Void

9.2A PDSCH demodulation for CA

9.2A.1 NR CA between FR1 and FR2

9.2B PDSCH demodulation for DC

9.2B.1 EN-DC

<Editor note: which NR PDSCH test case(s) will be selected for EN-DC test need FFS.>

9.2B.1.1 EN-DC within FR1

9.2B.1.1.1 PDSCH

The test setup for LTE Pcell is specified in Section 9.1.2. The NR PDSCH demodulation performance requirements for NR are specified in Section 5.2. During the test, only the PDSCH performance on the NR cell(s) shall be verified.

9.2B.1.2 EN-DC including FR2 NR carrier only

9.2B.1.2.1 PDSCH

The test setup for LTE Pcell is specified in Section 9.1.2. The NR PDSCH demodulation performance requirements for NR are specified in Section 7.2. During the test, only the PDSCH performance on the NR cell(s) on FR2 carriers shall be verified.

9.2B.1.3 EN-DC including FR1 and FR2 NR carriers

The demodulation performance requirements are verified according to Section 9.2B.1.1 for EN-DC with FR1 NR carrier only and Section 9.2B.1.2 for EN-DC with FR2 NR carrier only. During the test for EN-DC with FR2 NR carriers, only demodulation performance requirements on the FR2 carriers are verified. No demodulation requirement for FR1 NR or LTE carriers is specified for EN-DC including FR2 carrier(s).

9.2B.2 NR DC between FR1 and FR2

9.3 Void

9.3A PDCCH demodulation for CA

9.3A.1 NR CA between FR1 and FR2

During the test, only the demodulation performance requirements on FR2 carriers are verified. The demodulation performance requirements for NR FR2 are specified in Section 7.3.

9.3B PDCCH demodulation for DC

9.3B.1 EN-DC

<Editor note: which NR PDCCH test case(s) will be selected for EN-DC test need FFS.>

9.3B.1.1 EN-DC within FR1

9.3B.1.1.1 PDCCH

The test setup for LTE Pcell is specified in Section 9.1.2. The NR PDCCH demodulation performance requirements for NR are specified in Section 5.3. During the test, only the PDCCH performance on the single NR cell shall be verified.

9.3B.1.2 EN-DC including FR2 NR carrier only

9.3B.1.2.1 PDCCH

The test setup for LTE Pcell is specified in Section 9.1.2. The NR PDCCH demodulation performance requirements are specified in Section 7.3. During the test, only the PDCCH performance on the single NR cell shall be verified.

9.3B.1.3 EN-DC including FR1 and FR2 NR carriers

The demodulation performance requirements are verified according to Section 9.3B.1.1 for EN-DC with FR1 NR carrier only and Section 9.3B.1.2 for EN-DC with FR2 NR carrier only. During the test for EN-DC with FR2 NR carriers, only demodulation performance requirements on the FR2 carriers are verified. No demodulation requirement for FR1 NR or LTE carriers is specified for EN-DC including FR2 carrier(s).

9.3B.2 NR DC between FR1 and FR2

9.4 Void

9.4A SDR test for CA

9.4A.1 NR CA between FR1 and FR2

During the test, only the demodulation performance requirements on FR2 carriers are verified. The demodulation performance requirements for FR2 are specified in Section 7.5.

9.4B SDR test for DC

9.4B.1 EN-DC

<Editor note: which NR SDR test case(s) will be selected for EN-DC test need FFS.>

9.4B.1.1 EN-DC within FR1

9.4B.1.1.1 SDR test

The test setup for LTE Pcell is specified in Section 9.1.2. The NR SDR tests are specified in Section 5.5. During the test, the PDSCH performance on both the NR cell(s) and LTE cell(s) shall be verified.

9.4B.1.2 EN-DC including FR2 NR carrier

9.4B.1.2.1 SDR test

The test setup for LTE Pcell is specified in Section 9.1.2. The NR PDSCH SDR tests are specified in Section 7.5. During the test, only the PDSCH performance on the NR cell(s) on FR2 carriers is verified.

9.4B.1.3 EN-DC including FR1 and FR2 NR carriers

The SDR tests are verified according to Section 9.4B.1.1 for EN-DC with FR1 NR carrier only and Section 9.4B.1.2 for EN-DC with FR2 NR carrier only. During the test for EN-DC with FR2 NR carriers, only SDR tests on the FR2 carriers are verified. No SDR requirement for FR1 NR or LTE carriers is tested for EN-DC including FR2 carrier(s).

9.4B.2 NR DC between FR1 and FR2

10 CSI reporting requirements for interworking

10.1 General

This clause specifies CSI performance requirements for EN-DC, NE-DC, inter-band NR-DC between FR1 and FR2, and inter-band NR CA between FR1 and FR2.

The definition of frequency ranges (FR1 and FR2) are specified in TS38.101-3 [8, table 5.1-1].

10.1.1 Applicability of requirements

<TBA>

10.2 Void

10.2A Reporting of Channel Quality Indicator (CQI) for CA

10.2B Reporting of Channel Quality Indicator (CQI) for DC

10.2B.1 EN-DC

<Editor's note: FFS which test cases from SA will be applied for EN-DC >

10.2B.1.1 EN-DC within FR1

Unless otherwise stated, the configuration of LTE Pcell specified in [X] applies to LTE carrier.

Unless otherwise stated, NR CQI requirements and test configurations defined in Subclause 6.2 apply to NR cell(s).

Unless otherwise stated, only NR requirements on NR cell(s) shall be verified during test.

10.2B.1.2 EN-DC including FR2 NR carrier

Unless otherwise stated, the configuration of LTE Pcell specified in [X] applies to LTE carrier.

Unless otherwise stated, NR CQI requirements and test configurations defined in Subclause 8.2 apply to NR cell(s).

Unless otherwise stated, only NR requirements on NR cell(s) shall be verified during test.

10.2B.1.3 EN-DC including FR1 and FR2 NR carriers

10.3 Void

10.3A Reporting of Precoding Matrix Indicator (PMI) for CA

10.3B Reporting of Precoding Matrix Indicator (PMI) for DC

10.3B.1 EN-DC

<Editor's note: FFS which test cases from SA will be applied for EN-DC >

10.3B.1.1 EN-DC within FR1

Unless otherwise stated, the configuration of LTE Pcell specified in [X] applies to LTE carrier.

Unless otherwise stated, NR PMI requirements and test configurations defined in Subclause 6.3 apply to NR cell(s).

Unless otherwise stated, only NR requirements on NR carrier(s) shall be verified during test.

10.3B.1.2 EN-DC including NR FR2 carrier

Unless otherwise stated, the configuration of LTE Pcell specified in [X] applies to LTE carrier.

Unless otherwise stated, NR PMI requirements and test configurations defined in Subclause 8.3 apply to NR cell(s).

Unless otherwise stated, only NR requirements on NR cell(s) shall be verified during test.

10.3B.1.3 EN-DC including FR1 and FR2 NR carriers

10.4 Void

10.4A Reporting of Rank Indicator (RI) for CA

10.4B Reporting of Rank Indicator (RI) for DC

10.4B.1 EN-DC

<Editor's note: FFS which test cases from SA will be applied for EN-DC >

10.4B.1.1 EN-DC within FR1

Unless otherwise stated, the configuration of LTE Pcell specified in [X] applies to LTE carrier.

Unless otherwise stated, NR RI requirements and test configurations defined in Subclause 6.4 apply to NR cell(s).

Unless otherwise stated, only NR requirements on NR cell(s) shall be verified during test.

10.4B.1.2 EN-DC including NR FR2 carrier

Unless otherwise stated, the configuration of LTE Pcell specified in [X] applies to LTE carrier.

Unless otherwise stated, NR RI requirements and test configurations defined in Subclause 8.4 apply to NR cell(s) for EN-DC operation with NR carrier(s) in FR2.

Unless otherwise stated, only NR requirements on NR cell(s) shall be verified during test.

10.4B.1.3 EN-DC including FR1 and FR2 NR carriers

Annex A (normative): Measurement channels

A.1 General

A.1.1 Throughput definition

The throughput values defined in the measurement channels specified in Annex A, are calculated and are valid per codeword. For multi-codeword transmissions, the throughput referenced in the minimum requirements is the sum of throughputs of all codewords.

A.1.2 TDD UL-DL patterns for FR1

TDD UL-DL patterns configurations for performance requirements are provided in Tables A.1.2-1, A.1.2-2, and A.1.2-3.

Table A.1.2-1: TDD UL-DL pattern for SCS 15 kHz

Parameter		Unit	UL-DL pattern
			FR1.15-1
TDD Slot Configuration pattern (Note 1)			DDDSU
Special Slot Configuration (Note 2)			10D+2G+2U
UL-DL configuration (*tdd-UL-DL-ConfigurationCommon*)	*referenceSubcarrierSpacing*	kHz	15
	dl-UL-TransmissionPeriodicity	ms	5
	nrofDownlinkSlots		3
	nrofDownlinkSymbols		10
	nrofUplinkSlot		1
	nrofUplinkSymbols		2
K1 value (PDSCH-to-HARQ-timing-indicator)			[4] if mod(I,5) = 0 [3] if mod(i,5) = 1 [2] if mod(i,5) = 2 [6] if mod(i,5) = 3
Note 1: D denotes a slot with all DL symbols; S denotes a slot with a mix of DL, UL and guard symbols; U denotes a slot with all UL symbols. The field is for information. Note 2: D, G, U denote DL, guard and UL symbols, respectively. The field is for information. Note 3: i is the slot index per frame; i = {0,…,9}			

Table A.1.2-2: TDD UL-DL pattern for SCS 30 kHz

Parameter		Unit	UL-DL pattern					
			FR1.30-1	**FR1.30-2**	**FR1.30-3**	**FR1.30-4**	**FR1.30-5**	**FR1.30-6**
TDD Slot Configuration pattern (Note 1)			7DS2U	DDDSU	DDDSUDDSUU	SU	DDSU	DS_1S_2U
Special Slot Configuration (Note 2)			6D+4G+4U	10D+2G+2U	10D+2G+2U	12D+2G+0U	10D+2G+2U	S1: 10D+2G+2U S2: 12D+2G+0U
UL-DL configuration (*tdd-UL-DL-ConfigurationCommon*)	*referenceSubcarrierSpacing*	kHz	30	30	30	30	30	30
	dl-UL-TransmissionPeriodicity	ms	5	2.5	2.5	1	2	1
	nrofDownlinkSlots		7	3	3	0	2	1
	nrofDownlinkSymbols		6	10	10	12	10	10
	nrofUplinkSlot		2	1	1	1	1	0
	nrofUplinkSymbols		4	2	2	0	2	2
UL-DL configuration2 (*tdd-UL-DL-ConfigurationCommon2*)	*referenceSubcarrierSpacing*	kHz	N/A	N/A	30	N/A	N/A	30
	dl-UL-TransmissionPeriodicity	ms	N/A	N/A	2.5	N/A	N/A	1
	nrofDownlinkSlots		N/A	N/A	2	N/A	N/A	0
	nrofDownlinkSymbols		N/A	N/A	10	N/A	N/A	12
	nrofUplinkSlot		N/A	N/A	2	N/A	N/A	1
	nrofUplinkSymbols		N/A	N/A	2	N/A	N/A	0
K1 value (PDSCH-to-HARQ-timing-indicator)			[7] if mod(i,10) = 0 [6] if mod(i,10) = 1 [5] if mod(i,10) = 2 [5] if mod(i,10) = 3 [4] if mod(i,10) = 4 [3] if mod(i,10) = 5 [3] if mod(i,10) = 6 [2] if mod(i,10) = 7	[4] if mod(i,5) = 0 [3] if mod(i,5) = 1 [2] if mod(i,5) = 2 [6] if mod(i,5) = 3	[4] if mod(i,10) = 0 [3] if mod(i,10) = 1 [2] if mod(i,10) = 2 [5] if mod(i,10) = 3 [3] if mod(i,10) = 5 [3] if mod(i,10) = 6 [2] if mod(i,10) = 7	[3] if mod(i,2) = 0	[3] if mod(i,4) = 0 [2] if mod(i,4) = 1 [5] if mod(i,4) = 3	[3] if mod(i,4) = 0 [2] if mod(i,4) = 1 [3] if mod(i,4) = 3

Note 1: D denotes a slot with all DL symbols; S denotes a slot with a mix of DL, UL and guard symbols; U denotes a slot with all UL symbols. The field is for information.
Note 2: D, G, U denote DL, guard and UL symbols, respectively. The field is for information.
Note 3: i is the slot index per frame; i = {0,…,19}

A.1.3 TDD UL-DL patterns for FR2

TDD UL-DL patterns configurations for performance requirements are provided in Tables A.1.3-1, A.1.3-2.

Table A.1.3-1: TDD UL-DL pattern for SCS 60 kHz

Parameter		Unit	UL-DL pattern
			FR2.60-1
TDD Slot Configuration pattern (Note 1)			DDSU
Special Slot Configuration (Note 2)			11D+3G+0U
UL-DL configuration (*tdd-UL-DL-ConfigurationCommon*)	*referenceSubcarrierSpacing*	kHz	60
	dl-UL-TransmissionPeriodicity	ms	1
	nrofDownlinkSlots		2
	nrofDownlinkSymbols		11
	nrofUplinkSlot		1
	nrofUplinkSymbols		0
K1 value (PDSCH-to-HARQ-timing-indicator)			K1 = [3] if mod(i,4) = 0 K1 = [2] if mod(i,4) = 1 K1 = [5] if mod(i,4) = 3
Note 1: D denotes a slot with all DL symbols; S denotes a slot with a mix of DL, UL and guard symbols; U denotes a slot with all UL symbols. The field is for information. Note 2: D, G, U denote DL, guard and UL symbols, respectively. The field is for information. Note 3: i is the slot index per frame; i = {0,…,39}			

Table A.3.1-5: TDD UL-DL pattern for SCS 120 kHz

Parameter		Unit	UL-DL pattern	
			FR2.120-1	FR2.120-2
TDD Slot Configuration pattern (Note 1)			DDDSU	DDSU
Special Slot Configuration (Note 2)			10D+2G+2U	11D+3G+0U
UL-DL configuration (*tdd-UL-DL-ConfigurationCommon*)	*referenceSubcarrierSpacing*	kHz	120	120
	dl-UL-TransmissionPeriodicity	ms	0.625	0.5
	nrofDownlinkSlots		3	2
	nrofDownlinkSymbols		10	11
	nrofUplinkSlot		1	1
	nrofUplinkSymbols		2	0
K1 value (PDSCH-to-HARQ-timing-indicator)			K1 = [4] if mod(i,5) = 0 K1 = [3] if mod(i,5) = 1 K1 = [2] if mod(i,5) = 2 K1 = [6] if mod(i,5) = 3	K1 = [3] if mod(i,4) = 0 K1 = [2] if mod(i,4) = 1 K1 = [5] if mod(i,4) = 3
Note 1: D denotes a slot with all DL symbols; S denotes a slot with a mix of DL, UL and guard symbols; U denotes a slot with all UL symbols. The field is for information. Note 2: D, G, U denote DL, guard and UL symbols, respectively. The field is for information. Note 3: i is the slot index per frame; i = {0,…,79}				

A.2 Void

<Editor's note: Clause A.2 is a placeholder for UL Measurement channels>

A.3 DL reference measurement channels

A.3.1 General

The transport block size (TBS) determination procedure is described in TS 38.214 [12, Section 5.1.3.2].

[Unless otherwise stated, no user data is scheduled on slot #0 within 20 ms in order to avoid SSB and PDSCH transmissions in one slot and simplify test configuration.]

A.3.2 Reference measurement channels for PDSCH performance requirements

For PDSCH reference channels if more than one Code Block is present, an additional CRC sequence of L = 24 Bits is attached to each Code Block (otherwise L = 0 Bit).

A.3.2.1 FDD

A.3.2.1.1 Reference measurement channels for SCS 15 kHz FR1

Table A.3.2.1.1-1: PDSCH Reference Channel for FDD (QPSK)

Parameter	Unit	Value				
Reference channel		R.PDSCH.1-1.1 FDD	R.PDSCH.1-1.2 FDD	R.PDSCH.1-1.3 FDD	R.PDSCH.1-1.4 FDD	R.PDSCH.1-1.5 FDD
Channel bandwidth	MHz	10	10	10	10	10
Subcarrier spacing	kHz	15	15	15	15	15
Number of allocated resource blocks	PRBs	52	6	52	52	52
Number of consecutive PDSCH symbols		12	12	7	9	11
Allocated slots per 2 frames	Slots	19	19	19	19	19
MCS table		64QAM	64QAM	64QAM	64QAM	64QAM
MCS index		4	4	4	4	4
Modulation		QPSK	QPSK	QPSK	QPSK	QPSK
Target Coding Rate		0.30	0.30	0.30	0.30	0.30
Number of MIMO layers		1	1	1	1	1
Number of DMRS rEs		18	12	12	12	12
Overhead for TBS determination		0	0	0	18	18
Information Bit Payload per Slot						
For Slot i = 0	Bits	N/A	N/A	N/A	N/A	N/A
For Slots i = 1,…, 19	Bits	3904	480	2280	2472	3240
Transport block CRC per Slot						
For Slot i = 0	Bits	N/A	N/A	N/A	N/A	N/A
For Slots i = 1,…, 19	Bits	24	16	16	16	16
Number of Code Blocks per Slot						
For Slot i = 0	CBs	N/A	N/A	N/A	N/A	N/A
For Slots i = 1,…, 19	CBs	1	1	1	1	1
Binary Channel Bits Per Slot						
For Slot i = 0	Bits	N/A	N/A	N/A	N/A	N/A
For Slots i = 10, 11	Bits	12480	1512	6864	7760	10256
For Slots i = 3,…, 9, 12, …, 19	Bits	13104	1584	7488	8384	10880
Max. Throughput averaged over 2 frames	Mbps	3.709	0.456	2.166	2.348	3.078
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames						

Table A.3.2.1.1-2: PDSCH Reference Channel for FDD (16QAM)

Parameter	Unit	Value				
Reference channel		R.PDSCH.1-2.1 FDD	R.PDSCH.1-2.2 FDD	R.PDSCH.1-2.3 FDD	R.PDSCH.1-2.4 FDD	
Channel bandwidth	MHz	10	10	10	10	
Subcarrier spacing	kHz	15	15	15	15	
Number of allocated resource blocks	PRBs	52	52	52	52	
Number of consecutive PDSCH symbols		12	12	12	12	
Allocated slots per 2 frames	Slots	19	19	19	19	
MCS table		64QAM	64QAM	64QAM	64QAM	
MCS index		13	13	13	13	
Modulation		16QAM	16QAM	16QAM	16QAM	
Target Coding Rate		0.48	0.48	0.48	0.48	
Number of MIMO layers		1	2	3	4	
Number of DMRS rEs		12	12	24	24	
Overhead for TBS determination		0	0	0	0	
Information Bit Payload per Slot						
For Slot i = 0	Bits	N/A	N/A	N/A	N/A	
For Slots i = 1,…, 19	Bits	13064	26120	35856	48168	
Transport block CRC per Slot						
For Slot i = 0	Bits	N/A	N/A	N/A	N/A	
For Slots i = 1,…, 19	Bits	24	24	24	24	
Number of Code Blocks per Slot						
For Slot i = 0	CBs	N/A	N/A	N/A	N/A	
For Slots i = 1,…, 19	CBs	2	4	5	6	
Binary Channel Bits Per Slot						
For Slot i = 0	Bits	N/A	N/A	N/A	N/A	
For Slots i = 10, 11	Bits	26208	52416	71136	94848	
For Slots i = 1,…, 9, 12, …, 19	Bits	27456	54912	74880	99840	
Max. Throughput averaged over 2 frames	Mbps	12.411	24.814	34.063	45.760	
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames						

Table A.3.2.1.1-3: PDSCH Reference Channel for FDD (64QAM)

Parameter	Unit	Value				
Reference channel		R.PDSCH. 1-3.1 FDD				
Channel bandwidth	MHz	10				
Subcarrier spacing	kHz	15				
Number of allocated resource blocks	PRBs	52				
Number of consecutive PDSCH symbols		12				
Allocated slots per 2 frames	Slots	19				
MCS table		64QAM				
MCS index		19				
Modulation		64QAM				
Target Coding Rate		0.51				
Number of MIMO layers		2				
Number of DMRS rEs		12				
Overhead for TBS determination		0				
Information Bit Payload per Slot						
For Slot i = 0	Bits	N/A				
For Slots i = 1,…, 19	Bits	42016				
Transport block CRC per Slot						
For Slot i = 0	Bits	N/A				
For Slots i = 1,…, 19	Bits	24				
Number of Code Blocks per Slot						
For Slot i = 0	CBs	N/A				
For Slots i = 1,…, 19	CBs	5				
Binary Channel Bits Per Slot						
For Slot i = 0	Bits	N/A				
For Slots i = 10, 11	Bits	78624				
For Slots i = 1,…, 9, 12, …, 19	Bits	82368				
Max. Throughput averaged over 2 frames	Mbps	39.915				
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames						

Table A.3.2.1.1-4: PDSCH Reference Channel for FDD (256QAM)

Parameter	Unit	Value				
Reference channel		R.PDSCH. 1-4.1 FDD				
Channel bandwidth	MHz	10				
Subcarrier spacing	kHz	15				
Number of allocated resource blocks	PRBs	52				
Number of consecutive PDSCH symbols		12				
Allocated slots per 2 frames	Slots	19				
MCS table		256QAM				
MCS index		24				
Modulation		256QAM				
Target Coding Rate		0.82				
Number of MIMO layers		1				
Number of DMRS rEs		12				
Overhead for TBS determination		0				
Information Bit Payload per Slot						
For Slot i = 0	Bits	N/A				
For Slots i = 1,…, 19	Bits	45096				
Transport block CRC per Slot						
For Slot i = 0	Bits	N/A				
For Slots i = 1,…, 19	Bits	24				
Number of Code Blocks per Slot						
For Slot i = 0	CBs	N/A				
For Slots i = 1,…, 19	CBs	6				
Binary Channel Bits Per Slot						
For Slot i = 0	Bits	N/A				
For Slots i = 10, 11	Bits	52416				
For Slots i = 1,…, 9, 12, …, 19	Bits	54912				
Max. Throughput averaged over 2 frames	Mbps	42.841				
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames						

Table A.3.2.1.1-5: PDSCH Reference Channel for FDD and CSI-RS overlapped with PDSCH

Parameter	Unit	Value				
Reference channel		R.PDSCH. 1-5.1 FDD				
Channel bandwidth	MHz	10				
Subcarrier spacing	kHz	15				
Number of allocated resource blocks	PRBs	52				
Number of consecutive PDSCH symbols		12				
Allocated slots per 2 frames	Slots	19				
MCS table		64QAM				
MCS index		13				
Modulation		16QAM				
Target Coding Rate		0.48				
Number of MIMO layers		2				
Number of DMRS rEs		12				
Overhead for TBS determination		0				
Information Bit Payload per Slot						
For Slot i = 0	Bits	N/A				
For Slots i = 1,…, 19	Bits	26120				
Transport block CRC per Slot						
For Slot i = 0	Bits	N/A				
For Slots i = 1,…, 19	Bits	24				
Number of Code Blocks per Slot						
For Slot i = 0	CBs	N/A				
For Slots i = 1,…, 19	CBs	4				
Binary Channel Bits Per Slot						
For Slot i = 0	Bits	N/A				
For Slots i = 5, 15	Bits	50752				
For Slots i = 10	Bits	48256				
For Slots i = 11	Bits	52416				
For Slots i = 1,…,4,6,…, 9,12,…14,16,…,19	Bits	54912				
Max. Throughput averaged over 2 frames	Mbps	24.814				
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames						

Table A.3.2.1.1-6: PDSCH Reference Channel for FDD PMI reporting requirements

Parameter	Unit	Value				
Reference channel		R.PDSCH.1-6.1 FDD	R.PDSCH.1-6.2 FDD			
Channel bandwidth	MHz	10	10			
Subcarrier spacing	kHz	15	15			
Number of allocated resource blocks	PRBs	52	52			
Number of consecutive PDSCH symbols		12	12			
Allocated slots per 2 frames	Slots	15	15			
MCS table		64QAM	64QAM			
MCS index		13	13			
Modulation		16QAM	16QAM			
Target Coding Rate		0.48	0.48			
Number of MIMO layer		1	2			
Number of DMRS rEs (Note 3)		24	24			
Overhead for TBS determination		0	0			
Information Bit Payload per Slot						
For Slot i = 0	Bits	N/A	N/A			
For CSI Slots i, if mod (i,5) =1, i={0,…,19}		N/A	N/A			
For Non CSI-RS Slot i, if mod (i,5) ={0,2,3,4}, i={1,..19}	Bits	12040	24072			
Transport block CRC per Slot						
For Slot i = 0	Bits	N/A	N/A			
For CSI Slots i, if mod (i,5) =1, i={0,…,19}		N/A	N/A			
For Non CSI-RS Slot i, if mod (i,5) ={0,2,3,4}, i={1,..19}	Bits	24	24			
Number of Code Blocks per Slot						
For Slot i = 0	CBs	N/A	N/A			
For CSI Slots i, if mod (i,5) =1, i={0,…,19}		N/A	N/A			
For Non CSI-RS Slot i, if mod (i,5) ={0,2,3,4}, i={1,..,19}	CBs	2	3			
Binary Channel Bits Per Slot						
For Slot i = 0	Bits	N/A	N/A			
For CSI Slots i, if mod (i,5) =1, i={0,…,19}		N/A	N/A			
For Slots i = 10	Bits	23712	47424			
For Non CSI-RS Slot i, if mod (i,5) ={0,2,3,4}, i={1,..9,11,…,19}	Bits	24960	49920			
Max. Throughput averaged over 2 frames	Mbps	9.030	18.054			
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames Note 3: Number of DMRS rEs includes the overhead of the DM-RS CDM groups without data						

A.3.2.1.2 Reference measurement channels for SCS 30 kHz FR1

Table A.3.2.1.2-1: PDSCH Reference Channel for FDD (64QAM)

Parameter	Unit	Value				
Reference channel		R.PDSCH. 2-1.1 FDD				
Channel bandwidth	MHz	20				
Subcarrier spacing	kHz	30				
Number of allocated resource blocks	PRBs	51				
Number of consecutive PDSCH symbols		12				
Allocated slots per 2 frames	Slots	39				
MCS table		64QAM				
MCS index		19				
Modulation		64QAM				
Target Coding Rate		0.51				
Number of MIMO layers		2				
Number of DMRS rEs		12				
Overhead for TBS determination		0				
Information Bit Payload per Slot						
For Slot i = 0	Bits	N/A				
For Slots i = 1,…, 19	Bits	40976				
Transport block CRC per Slot						
For Slot i = 0	Bits	N/A				
For Slots i = 1,…, 19	Bits	24				
Number of Code Blocks per Slot						
For Slot i = 0	CBs	N/A				
For Slots i = 1,…, 19	CBs	5				
Binary Channel Bits Per Slot						
For Slot i = 0	Bits	N/A				
For Slots i = 10, 11	Bits	77112				
For Slots i = 1,…, 9, 12, …, 19	Bits	80784				
Max. Throughput averaged over 2 frames	Mbps	79.903				
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames						

A.3.2.2 TDD

A.3.2.2.1 Reference measurement channels for SCS 15 kHz FR1

A.3.2.2.2 Reference measurement channels for SCS 30 kHz FR1

Table A.3.2.2.2-1: PDSCH Reference Channel for TDD UL-DL pattern FR1.30-1 (QPSK)

Parameter	Unit	Value				
Reference channel		R.PDSCH.2-1.1 TDD	R.PDSCH.2-1.2 TDD	R.PDSCH.2-1.3 TDD		
Channel bandwidth	MHz	40	40	40		
Subcarrier spacing	kHz	30	30	30		
Allocated resource blocks	PRBs	106	6	106		
Number of consecutive PDSCH symbols						
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}		4	4	N/A		
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,39}		12	12	7		
Allocated slots per 2 frames		31	31	27		
MCS table		64QAM	64QAM	64QAM		
MCS index		4	4	4		
Modulation		QPSK	QPSK	QPSK		
Target Coding Rate		0.30	0.30	0.30		
Number of MIMO layers		1	1	1		
Number of DMRS rEs						
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}		6	6	N/A		
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,39}		18	12	12		
Overhead for TBS determination		0	0	0		
Information Bit Payload per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {8,9} for i from {0,…,39}	Bits	N/A	N/A	N/A		
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}	Bits	2664	144	N/A		
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,39}	Bits	8064	480	4608		
Transport block CRC per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {8,9} for i from {0,…,39}	Bits	N/A	N/A	N/A		
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}	Bits	16	16	N/A		
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,39}	Bits	24	16	24		
Number of Code Blocks per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {8,9} for i from {0,…,39}	CBs	N/A	N/A	N/A		
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}	CBs	1	1	N/A		
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,39}	CBs	1	1	1		
Binary Channel Bits Per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {8,9} for i from {0,…,39}	Bits	N/A	N/A	N/A		
For Slots i = 20, 21	Bits	25440	1512	13992		
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}	Bits	8904	504	N/A		
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,19,22,…,39}	Bits	26712	1584	15264		
Max. Throughput averaged over 2 frames	Mbps	11.419	0.677	6.221		
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames						

Table A.3.2.2.2-2: PDSCH Reference Channel for TDD UL-DL pattern FR1.30-1 (16QAM)

Parameter	Unit	Value				
Reference channel		R.PDSCH.2-2.1 TDD	R.PDSCH.2-2.2 TDD	R.PDSCH.2-2.3 TDD	R.PDSCH.2-2.4 TDD	
Channel bandwidth	MHz	40	40	40	40	
Subcarrier spacing	kHz	30	30	30	30	
Allocated resource blocks	PRBs	106	106	106	106	
Number of consecutive PDSCH symbols						
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}		4	4	4	4	
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,39}		12	12	12	12	
Allocated slots per 2 frames		31	31	31	31	
MCS table		64QAM	64QAM	64QAM	64QAM	
MCS index		13	13	13	13	
Modulation		16QAM	16QAM	16QAM	16QAM	
Target Coding Rate		0.48	0.48	0.48	0.48	
Number of MIMO layers		1	2	3	4	
Number of DMRS rEs						
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}		6	6	12	12	
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,39}		12	12	24	24	
Overhead for TBS determination		0	0	0	0	
Information Bit Payload per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {8,9} for i from {0,…,39}	Bits	N/A	N/A	N/A	N/A	
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}	Bits	8456	16896	22032	29192	
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,39}	Bits	26632	53288	73776	98376	
Transport block CRC per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {8,9} for i from {0,…,39}	Bits	N/A	N/A	N/A	N/A	
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}	Bits	24	24	24	24	
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,39}	Bits	24	24	24	24	
Number of Code Blocks per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {8,9} for i from {0,…,39}	CBs	N/A	N/A	N/A	N/A	
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}	CBs	2	3	3	4	
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,39}	CBs	4	7	9	12	
Binary Channel Bits Per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {8,9} for i from {0,…,39}	Bits	N/A	N/A	N/A	N/A	
For Slots i = 20, 21	Bits	53424	106848	144008	193344	
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}	Bits	17808	35616	45792	61056	
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,19,22,…,39}	Bits	55968	111936	152640	203520	
Max. Throughput averaged over 2 frames	Mbps	37.644	75.318	104.719	138.646	
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames						

Table A.3.2.2.2-3: PDSCH Reference Channel for TDD UL-DL pattern FR1.30-1 (64QAM)

Parameter	Unit	Value				
Reference channel		R.PDSCH.2-3.1 TDD	R.PDSCH.2-3.2 TDD			
Channel bandwidth	MHz	40	20			
Subcarrier spacing	kHz	30	30			
Allocated resource blocks	PRBs	106	51			
Number of consecutive PDSCH symbols						
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}		4	4			
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,39}		12	12			
Allocated slots per 2 frames		31	31			
MCS table		64QAM	64QAM			
MCS index		19	19			
Modulation		64QAM	64QAM			
Target Coding Rate		0.51	0.51			
Number of MIMO layers		2	2			
Number of DMRS rEs						
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}		6	6			
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,39}		12	12			
Overhead for TBS determination		0	0			
Information Bit Payload per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {8,9} for i from {0,…,39}	Bits	N/A	N/A			
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}	Bits	27144	13064			
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,39}	Bits	83976	40976			
Transport block CRC per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {8,9} for i from {0,…,39}	Bits	N/A	N/A			
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}	Bits	24	24			
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,39}	Bits	24	24			
Number of Code Blocks per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {8,9} for i from {0,…,39}	CBs	N/A	N/A			
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}	CBs	4	2			
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,39}	CBs	10	5			
Binary Channel Bits Per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {8,9} for i from {0,…,39}	Bits	N/A	N/A			
For Slots i = 20, 21	Bits	160272	77112			
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}	Bits	53424	25704			
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,19,22,…,39}	Bits	167904	80784			
Max. Throughput averaged over 2 frames	Mbps	118.796	57.930			
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames						

Table A.3.2.2.2-4: PDSCH Reference Channel for TDD UL-DL pattern FR1.30-1 (256QAM)

Parameter	Unit	Value				
Reference channel		R.PDSCH.2-4.1 TDD				
Channel bandwidth	MHz	40				
Subcarrier spacing	kHz	30				
Allocated resource blocks	PRBs	106				
Number of consecutive PDSCH symbols						
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}		4				
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,39}		12				
Allocated slots per 2 frames		31				
MCS table		256QAM				
MCS index		24				
Modulation		256QAM				
Target Coding Rate		0.82				
Number of MIMO layers		1				
Number of DMRS rEs						
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}		6				
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,39}		12				
Overhead for TBS determination		0				
Maximum number of HARQ transmissions		4				
Information Bit Payload per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {8,9} for i from {0,…,39}	Bits	N/A				
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}	Bits	29192				
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,39}	Bits	92200				
Transport block CRC per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {8,9} for i from {0,…,39}	Bits	N/A				
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}	Bits	24				
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,39}	Bits	24				
Number of Code Blocks per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {8,9} for i from {0,…,39}	CBs	N/A				
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}	CBs	4				
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,39}	CBs	11				
Binary Channel Bits Per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {8,9} for i from {0,…,39}	Bits	N/A				
For Slots i = 20, 21	Bits	106848				
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}	Bits	35616				
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,19,22,…,39}	Bits	111936				
Max. Throughput averaged over 2 frames	Mbps	130.308				
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames						

Table A.3.2.2.2-5: PDSCH Reference Channel for TDD UL-DL pattern FR1.30-2

Parameter	Unit	Value				
Reference channel		R.PDSCH.2-5.1 TDD				
Channel bandwidth	MHz	40				
Subcarrier spacing	kHz	30				
Allocated resource blocks	PRBs	106				
Number of consecutive PDSCH symbols						
For Slot i, if mod(i, 5) = 3 for i from {0,…,39}		8				
For Slot i, if mod(i, 5) = {0,1,}) for i from {1,…,39}		12				
Allocated slots per 2 frames		31				
MCS table		64QAM				
MCS index		4				
Modulation		QPSK				
Target Coding Rate		0.30				
Number of MIMO layers		1				
Number of DMRS rEs						
For Slot i, if mod(i, 5) = 3 for i from {0,…,39}		12				
For Slot i, if mod(i, 5) = {0,1,}) for i from {1,…,39}		12				
Overhead for TBS determination		0				
Information Bit Payload per Slot						
For Slot 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,39}	Bits	N/A				
For Slot i, if mod(i, 5) = 3 for i from {0,…,39}	Bits	5376				
For Slot i, if mod(i, 5) = {0,1,}) for i from {1,…,39}	Bits	8456				
Transport block CRC per Slot						
For Slot 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,39}	Bits	N/A				
For Slot i, if mod(i, 5) = 3 for i from {0,…,39}	Bits	24				
For Slot i, if mod(i, 5) = {0,1,}) for i from {1,…,39}	Bits	24				
Number of Code Blocks per Slot						
For Slot 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,39}	CBs	N/A				
For Slot i, if mod(i, 5) = 3 for i from {0,…,39}	CBs	1				
For Slot i, if mod(i, 5) = {0,1,}) for i from {1,…,39}	CBs	2				
Binary Channel Bits Per Slot						
For Slot 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,39}	Bits	N/A				
For Slot i = 20, 21	Bits	26712				
For Slot i, if mod(i, 5) = 3 for i from {0,…,39}	Bits	17808				
For Slot i, if mod(i, 5) = {0,1,}) for i from {1,…,19,22,…,39}	Bits	27984				
Max. Throughput averaged over 2 frames	Mbps	11.875				
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames						

Table A.3.2.2.2-6: PDSCH Reference Channel for TDD UL-DL pattern FR1.30-3

Parameter	Unit	Value				
Reference channel		R.PDSCH.2-6.1 TDD				
Channel bandwidth	MHz	40				
Subcarrier spacing	kHz	30				
Allocated resource blocks	PRBs	106				
Number of consecutive PDSCH symbols						
For Slot i, if mod(i, 10) = {3,7} for i from {0,…,39}		8				
For Slot i, if mod(i, 10) = {0,1,2,5,}) for i from {1,…,39}		12				
Allocated slots per 2 frames		27				
MCS table		64QAM				
MCS index		4				
Modulation		QPSK				
Target Coding Rate		0.30				
Number of MIMO layers		1				
Number of DMRS rEs						
For Slot i, if mod(i, 10) = {3,7} for i from {0,…,39}		12				
For Slot i, if mod(i, 10) = {0,1,2,5,}) for i from {1,…,39}		12				
Overhead for TBS determination		0				
Maximum number of HARQ transmissions		4				
Information Bit Payload per Slot						
For Slot 0 and Slot i, if mod(i, 10) = {4,8,9} for i from {0,…,39}	Bits	N/A				
For Slot i, if mod(i, 10) = {3,7} for i from {0,…,39}	Bits	5376				
For Slot i, if mod(i, 10) = {0,1,2,5,}) for i from {1,…,39}	Bits	8456				
Transport block CRC per Slot						
For Slot 0 and Slot i, if mod(i, 10) = {4,8,9} for i from {0,…,39}	Bits	N/A				
For Slot i, if mod(i, 10) = {3,7} for i from {0,…,39}	Bits	24				
For Slot i, if mod(i, 10) = {0,1,2,5,}) for i from {1,…,39}	Bits	24				
Number of Code Blocks per Slot						
For Slot 0 and Slot i, if mod(i, 10) = {4,8,9} for i from {0,…,39}	CBs	N/A				
For Slot i, if mod(i, 10) = {3,7} for i from {0,…,39}	CBs	1				
For Slot i, if mod(i, 10) = {0,1,2,5,}) for i from {1,…,39}	CBs	2				
Binary Channel Bits Per Slot						
For Slot 0 and Slot i, if mod(i, 10) = {4,8,9} for i from {0,…,39}	Bits	N/A				
For Slot i = 20, 21	Bits	26712				
For Slot i, if mod(i, 10) = {3,7} for i from {0,…,39}	Bits	17808				
For Slot i, if mod(i, 10) = {0,1,2,5,}) for i from {1,…,19,22,…,39}	Bits	27984				
Max. Throughput averaged over 2 frames	Mbps	10.184				
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames						

Table A.3.2.2.2-7: PDSCH Reference Channel for TDD UL-DL pattern FR1.30-1 and CSI-RS overlapped with PDSCH

Parameter	Unit	Value				
Reference channel		R.PDSCH.2-7.1 TDD				
Channel bandwidth	MHz	40				
Subcarrier spacing	kHz	30				
Allocated resource blocks	PRBs	106				
Number of consecutive PDSCH symbols						
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}		4				
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,39}		12				
Allocated slots per 2 frames		31				
MCS table		64QAM				
MCS index		13				
Modulation		16QAM				
Target Coding Rate		0.48				
Number of MIMO layers		2				
Number of DMRS rEs						
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}		6				
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,39}		12				
Overhead for TBS determination		0				
Information Bit Payload per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {8,9} for i from {0,…,39}	Bits	N/A				
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}	Bits	16896				
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,39}	Bits	53288				
Transport block CRC per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {8,9} for i from {0,…,39}	Bits	N/A				
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}	Bits	24				
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,39}	Bits	24				
Number of Code Blocks per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {8,9} for i from {0,…,39}	CBs	N/A				
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}	CBs	3				
For Slot i, if mod(i, 10) = {0,1,2,3,4,5,}) for i from {1,…,39}	CBs	7				
Binary Channel Bits Per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {8,9} for i from {0,…,39}	Bits	N/A				
For Slot i, if mod(i, 10) = {0,}) for i from {1,…,19,22,…,39}	Bits	103456				
For Slots i = 20	Bits	98368				
For Slots i = 21	Bits	106848				
For Slot i, if mod(i, 10) = 7 for i from {0,…,39}	Bits	35616				
For Slot i, if mod(i, 10) = {1,2,3,4,}) for i from {1,…,19,22,…,39}	Bits	111936				
Max. Throughput averaged over 2 frames	Mbps	75.318				
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames						

Table A.3.2.2.2-8: PDSCH Reference Channel for TDD PMI reporting requirements with UL-DL pattern FR1.30-1 (16QAM)

Parameter	Unit	Value				
Reference channel		R.PDSCH.2-8.1 TDD	R.PDSCH.2-8.2 TDD			
Channel bandwidth	MHz	40	40			
Subcarrier spacing	kHz	30	30			
Allocated resource blocks	PRBs	106	106			
Number of consecutive PDSCH symbols		12	12			
Allocated slots per 2 frames		23	23			
MCS table		64QAM	64QAM			
MCS index		13	13			
Modulation		16QAM	16QAM			
Target Coding Rate		0.48	0.48			
Number of MIMO layers		1	2			
Number of DMRS rEs (Note 3)		24	24			
Overhead for TBS determination		0	0			
Information Bit Payload per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {7,8,9} for i from {0,…,39}	Bits	N/A	N/A			
For CSI-RS Slot i, if mod(i,10) =1 for i from {0,…,39}	Bits	N/A	N/A			
For Slot i = 20	Bits	24576	49176			
For Slot i, if mod(i, 10) = {0,2,3,4,5,6} for i from {1,…,19,22,…,39}		24576	49176			
Transport block CRC per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {7,8,9} for i from {0,…,39}	Bits	N/A	N/A			
For CSI-RS Slot i, if mod(i,10) =1 for i from {0,…,39}		N/A	N/A			
For Slot i = 20	Bits	24	24			
For Slot i, if mod(i, 10) = {0,2,3,4,5,6} for i from {1,…,19,22,…,39}	Bits	24	24			
Number of Code Blocks per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {7,8,9} for i from {0,…,39}	CBs	N/A	N/A			
For CSI-RS Slot i, if mod(i,10) =1 for i from {0,…,39}		N/A	N/A			
For Slot i = 20	CBs	3	6			
For Slot i, if mod(i, 10) = {0,2,3,4,5,6} for i from {1,…,19,22,…,39}	CBs	3	6			
Binary Channel Bits Per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {7,8,9} for i from {0,…,39}	Bits	N/A	N/A			
For CSI-RS Slot i, if mod(i,10) =1 for i from {0,…,39}	Bits	N/A	N/A			
For Slot i = 20	Bits	48336	96672			
For Slot i, if mod(i, 10) = {0,2,3,4,5,6} for i from {1,…,19,22,…,39}	Bits	50880	101760			
Max. Throughput averaged over 2 frames	Mbps	28.2624	56.5524			
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames Note 3: Number of DMRS rEs includes the overhead of the DM-RS CDM groups without data						

A.3.2.2.3 Reference measurement channels for SCS 60 kHz FR1

A.3.2.2.4 Reference measurement channels for SCS 60 kHz FR2

Table A.3.2.2.4-1: PDSCH Reference Channel for TDD UL-DL pattern FR2.60-1 (16QAM)

Parameter	Unit	Value				
Reference channel		R.PDSCH. 4-1.1 TDD				
Channel bandwidth	MHz	50				
Subcarrier spacing	kHz	60				
Allocated resource blocks	PRBs	66				
Number of consecutive PDSCH symbols						
For Slot i, if mod(i, 4) = 2 for i from {1,…, 79}		10				
For Slot i, if mod(i, 4) = {0,}) for i from {1,…,79}		13				
Allocated slots per 2 frames		59				
MCS table		64QAM				
MCS index		13				
Modulation		16QAM				
Target Coding Rate		0.48				
Number of MIMO layers		2				
Number of DMRS rEs						
For Slot i, if mod(i, 4) = 2 for i from {1,…, 79}		12				
For Slot i, if mod(i, 4) = {0,}) for i from {1,…,79}		12				
Overhead for TBS determination		6				
Information Bit Payload per Slot						
For Slots 0 and Slot i, if mod(i, 4) = 3 for i from {0,…,79}	Bits	N/A				
For Slot i, if mod(i, 4) = 2 for i from {1,…, 79}	Bits	25608				
For Slot i, if mod(i, 4) = {0,}) for i from {1,…,79}	Bits	34816				
Transport block CRC per Slot						
For Slots 0 and Slot i, if mod(i, 4) = 3 for i from {0,…,79}	Bits	N/A				
For Slot i, if mod(i, 4) = 2 for i from {1,…, 79}	Bits	24				
For Slot i, if mod(i, 4) = {0,}) for i from {1,…,79}	Bits	24				
Number of Code Blocks per Slot						
For Slots 0 and Slot i, if mod(i, 4) = 3 for i from {0,…,79}	CBs	N/A				
For Slot i, if mod(i, 4) = 2 for i from {1,…, 79}	CBs	4				
For Slot i, if mod(i, 4) = {0,}) for i from {1,…,79}	CBs	5				
Binary Channel Bits Per Slot						
For Slots 0 and Slot i, if mod(i, 4) = 3 for i from {0,…,79}	Bits	N/A				
For Slot i = 40, 41	Bits	69960				
For Slot i, if mod(i, 4) = 2 for i from {4,…, 79}	Bits	54912				
For Slot i, if mod(i, 4) = {0,}) for i from {1,…,39,42,…,79}	Bits	73128				
Max. Throughput averaged over 2 frames	Mbps	93.499				
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames						

A.3.2.2.5 Reference measurement channels for SCS 120 kHz FR2

Table A.3.2.2.5-1: PDSCH Reference Channel for TDD UL-DL pattern FR2.120-1 (QPSK)

Parameter	Unit	Value				
Reference channel		R.PDSCH.5-1.1 TDD				
Channel bandwidth	MHz	100				
Subcarrier spacing	kHz	120				
Allocated resource blocks	PRBs	66				
Number of consecutive PDSCH symbols						
For Slot i, if mod(i, 5) = 3 for i from {0,…, 159}		9				
For Slot i, if mod(i, 5) = {0,1,}) for i from {1,…,159}		13				
Allocated slots per 2 frames		127				
MCS table		64QAM				
MCS index		4				
Modulation		QPSK				
Target Coding Rate		0.30				
Number of MIMO layers		1				
Number of DMRS rEs						
For Slot i, if mod(i, 5) = 3 for i from {0,…, 159}		12				
For Slot i, if mod(i, 5) = {0,1,}) for i from {1,…,159}		12				
Overhead for TBS determination		6				
Information Bit Payload per Slot						
For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159}	Bits	N/A				
For Slot i, if mod(i, 5) = 3 for i from {0,…, 159}	Bits	3624				
For Slot i, if mod(i, 5) = {0,1,}) for i from {1,…,159}	Bits	5504				
Transport block CRC per Slot						
For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159}	Bits	N/A				
For Slot i, if mod(i, 5) = 3 for i from {0,…, 159}	Bits	16				
For Slot i, if mod(i, 5) = {0,1,}) for i from {1,…,159}	Bits	24				
Number of Code Blocks per Slot						
For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159}	CBs	N/A				
For Slot i, if mod(i, 5) = 3 for i from {0,…, 159}	CBs	1				
For Slot i, if mod(i, 5) = {0,1,}) for i from {1,…,159}	CBs	1				
Binary Channel Bits Per Slot						
For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159}	Bits	N/A				
For Slots i = 80, 81	Bits	17490				
For Slot i, if mod(i, 5) = 3 for i from {0,…, 159}	Bits	12210				
For Slot i, if mod(i, 5) = {0,1,}) for i from {1,…,79,82,…,159}	Bits	18282				
Max. Throughput averaged over 2 frames	Mbps	31.942				
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames						

Table A.3.2.2.5-2: PDSCH Reference Channel for TDD UL-DL pattern FR2.120-1 (16QAM)

Parameter	Unit	Value				
Reference channel		R.PDSCH.5-2.1 TDD	R.PDSCH.5-2.2 TDD	R.PDSCH.5-2.3 TDD		
Channel bandwidth	MHz	100	100	200		
Subcarrier spacing	kHz	120	120	120		
Allocated resource blocks	PRBs	66	66	132		
Number of consecutive PDSCH symbols						
For Slot i, if mod(i, 5) = 3 for i from {0,…, 159}		9	9	9		
For Slot i, if mod(i, 5) = {0,1,}) for i from {1,…,159}		13	13	13		
Allocated slots per 2 frames		127	127	127		
MCS table		64QAM	64QAM	64QAM		
MCS index		13	13	13		
Modulation		16QAM	16QAM	16QAM		
Target Coding Rate		0.48	0.48	0.48		
Number of MIMO layers		1	2	2		
Number of DMRS rEs						
For Slot i, if mod(i, 5) = 3 for i from {0,…, 159}		12	12	12		
For Slot i, if mod(i, 5) = {0,1,}) for i from {1,…,159}		12	12	12		
Overhead for TBS determination		6	6	6		
Information Bit Payload per Slot						
For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159}	Bits	N/A	N/A	N/A		
For Slot i, if mod(i, 5) = 3 for i from {0,…, 159}	Bits	11272	22536	45096		
For Slot i, if mod(i, 5) = {0,1,}) for i from {1,…,159}	Bits	17424	34816	69672		
Transport block CRC per Slot						
For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159}	Bits	N/A	N/A	N/A		
For Slot i, if mod(i, 5) = 3 for i from {0,…, 159}	Bits	24	24	24		
For Slot i, if mod(i, 5) = {0,1,}) for i from {1,…,159}	Bits	24	24	24		
Number of Code Blocks per Slot						
For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159}	CBs	N/A	N/A	N/A		
For Slot i, if mod(i, 5) = 3 for i from {0,…, 159}	CBs	2	3	6		
For Slot i, if mod(i, 5) = {0,1,}) for i from {1,…,159}	CBs	3	5	9		
Binary Channel Bits Per Slot						
For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159}	Bits	N/A	N/A	N/A		
For Slots i = 80, 81	Bits	34980	69960	139920		
For Slot i, if mod(i, 5) = 3 for i from {0,…, 159}	Bits	24420	48840	97680		
For Slot i, if mod(i, 5) = {0,1,}) for i from {1,…,79,82,…,159}	Bits	36564	73128	146256		
Max. Throughput averaged over 2 frames	Mbps	100.799	201.434	403.096		
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames						

Table A.3.2.2.5-3: PDSCH Reference Channel for TDD UL-DL pattern FR2.120-1 (64QAM)

Parameter	Unit	Value				
Reference channel		R.PDSCH.5-3.1 TDD				
Channel bandwidth	MHz	100				
Subcarrier spacing	kHz	120				
Allocated resource blocks	PRBs	66				
Number of consecutive PDSCH symbols						
For Slot i, if mod(i, 5) = 3 for i from {0,…, 159}		9				
For Slot i, if mod(i, 5) = {0,1,}) for i from {1,…,159}		13				
Allocated slots per 2 frames		127				
MCS table		64QAM				
MCS index		18				
Modulation		64QAM				
Target Coding Rate		0.46				
Number of MIMO layers		1				
Number of DMRS rEs						
For Slot i, if mod(i, 5) = 3 for i from {0,…, 159}		12				
For Slot i, if mod(i, 5) = {0,1,}) for i from {1,…,159}		12				
Overhead for TBS determination		6				
Information Bit Payload per Slot						
For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159}	Bits	N/A				
For Slot i, if mod(i, 5) = 3 for i from {0,…, 159}	Bits	16136				
For Slot i, if mod(i, 5) = {0,1,}) for i from {1,…,159}	Bits	25104				
Transport block CRC per Slot						
For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159}	Bits	N/A				
For Slot i, if mod(i, 5) = 3 for i from {0,…, 159}	Bits	24				
For Slot i, if mod(i, 5) = {0,1,}) for i from {1,…,159}	Bits	24				
Number of Code Blocks per Slot						
For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159}	CBs	N/A				
For Slot i, if mod(i, 5) = 3 for i from {0,…, 159}	CBs	2				
For Slot i, if mod(i, 5) = {0,1,}) for i from {1,…,159}	CBs	3				
Binary Channel Bits Per Slot						
For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159}	Bits	N/A				
For Slots i = 80, 81	Bits	52470				
For Slot i, if mod(i, 5) = 3 for i from {0,…, 159}	Bits	36630				
For Slot i, if mod(i, 5) = {0,1,}) for i from {1,…,79,82,…,159}	Bits	54846				
Max. Throughput averaged over 2 frames	Mbps	145.062				
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames						

Table A.3.2.2.5-4: PDSCH Reference Channel for TDD UL-DL pattern FR2.120-2 (QPSK)

Parameter	Unit	Value				
Reference channel		R.PDSCH.5-4.1 TDD				
Channel bandwidth	MHz	100				
Subcarrier spacing	kHz	120				
Allocated resource blocks	PRBs	6				
Number of consecutive PDSCH symbols						
For Slot i, if mod(i, 4) = 2 for i from {1,…, 159}		10				
For Slot i, if mod(i, 4) = {0,}) for i from {1,…,159}		13				
Allocated slots per 2 frames		119				
MCS table		64QAM				
MCS index		4				
Modulation		QPSK				
Target Coding Rate		0.30				
Number of MIMO layers		2				
Number of DMRS rEs						
For Slot i, if mod(i, 4) = 2 for i from {1,…, 159}		12				
For Slot i, if mod(i, 4) = {0,}) for i from {1,…,159}		12				
Overhead for TBS determination		6				
Information Bit Payload per Slot						
For Slots 0 and Slot i, if mod(i, 4) = 3 for i from {0,…,159}	Bits	N/A				
For Slot i, if mod(i, 4) = 2 for i from {1,…, 159}	Bits	736				
For Slot i, if mod(i, 4) = {0,}) for i from {1,…,159}	Bits	1032				
Transport block CRC per Slot						
For Slots 0 and Slot i, if mod(i, 4) = 3 for i from {0,…,159}	Bits	N/A				
For Slot i, if mod(i, 4) = 2 for i from {1,…, 159}	Bits	16				
For Slot i, if mod(i, 4) = {0,}) for i from {1,…,159}	Bits	16				
Number of Code Blocks per Slot						
For Slots 0 and Slot i, if mod(i, 4) = 3 for i from {0,…,159}	CBs	N/A				
For Slot i, if mod(i, 4) = 2 for i from {1,…, 159}	CBs	1				
For Slot i, if mod(i, 4) = {0,}) for i from {1,…,159}	CBs	1				
Binary Channel Bits Per Slot						
For Slots 0 and Slot i, if mod(i, 4) = 3 for i from {0,…,159}	Bits	N/A				
For Slot i = 80, 81	Bits	3180				
For Slot i, if mod(i, 4) = 2 for i from {4,…, 159}	Bits	2496				
For Slot i, if mod(i, 4) = {0,}) for i from {1,…,79,82,…,159}	Bits	3324				
Max. Throughput averaged over 2 frames	Mbps	5.548				
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames						

Table A.3.2.2.5-5: PDSCH Reference Channel for TDD UL-DL pattern FR2.120-2 (16QAM)

Parameter	Unit	Value				
Reference channel		R.PDSCH.5-5.1 TDD	R.PDSCH.5-5.2 TDD			
Channel bandwidth	MHz	100	50			
Subcarrier spacing	kHz	120	120			
Allocated resource blocks	PRBs	66	32			
Number of consecutive PDSCH symbols						
For Slot i, if mod(i, 4) = 2 for i from {1,…, 159}		10	10			
For Slot i, if mod(i, 4) = {0,}) for i from {1,…,159}		13	13			
Allocated slots per 2 frames		119	119			
MCS table		64QAM	64QAM			
MCS index		13	13			
Modulation		16QAM	16QAM			
Target Coding Rate		0.48	0.48			
Number of MIMO layers		2	2			
Number of DMRS rEs						
For Slot i, if mod(i, 4) = 2 for i from {1,…, 159}		12	12			
For Slot i, if mod(i, 4) = {0,}) for i from {1,…,159}		12	12			
Overhead for TBS determination		6	6			
Information Bit Payload per Slot						
For Slots 0 and Slot i, if mod(i, 4) = 3 for i from {0,…,159}	Bits	N/A	N/A			
For Slot i, if mod(i, 4) = 2 for i from {1,…, 159}	Bits	25608	12552			
For Slot i, if mod(i, 4) = {0,}) for i from {1,…,159}	Bits	34816	16896			
Transport block CRC per Slot						
For Slots 0 and Slot i, if mod(i, 4) = 3 for i from {0,…,159}	Bits	N/A	N/A			
For Slot i, if mod(i, 4) = 2 for i from {1,…, 159}	Bits	24	24			
For Slot i, if mod(i, 4) = {0,}) for i from {1,…,159}	Bits	24	24			
Number of Code Blocks per Slot						
For Slots 0 and Slot i, if mod(i, 4) = 3 for i from {0,…,159}	CBs	N/A	N/A			
For Slot i, if mod(i, 4) = 2 for i from {1,…, 159}	CBs	4	2			
For Slot i, if mod(i, 4) = {0,}) for i from {1,…,159}	CBs	5	3			
Binary Channel Bits Per Slot						
For Slots 0 and Slot i, if mod(i, 4) = 3 for i from {0,…,159}	Bits	N/A	N/A			
For Slot i = 80, 81	Bits	69960	33920			
For Slot i, if mod(i, 4) = 2 for i from {4,…, 159}	Bits	54912	26624			
For Slot i, if mod(i, 4) = {0,}) for i from {1,…,79,82,…,159}	Bits	73128	35456			
Max. Throughput averaged over 2 frames	Mbps	188.739	91.843			
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames						

Table A.3.2.2.5-6: PDSCH Reference Channel for TDD UL-DL pattern FR2.120-2 (64QAM)

Parameter	Unit	Value				
Reference channel		R.PDSCH.5-6.1 TDD				
Channel bandwidth	MHz	100				
Subcarrier spacing	kHz	120				
Allocated resource blocks	PRBs	66				
Number of consecutive PDSCH symbols						
For Slot i, if mod(i, 4) = 2 for i from {1,…, 159}		10				
For Slot i, if mod(i, 4) = {0,}) for i from {1,…,159}		13				
Allocated slots per 2 frames		119				
MCS table		64QAM				
MCS index		17				
Modulation		64QAM				
Target Coding Rate		0.43				
Number of MIMO layers		2				
Number of DMRS rEs						
For Slot i, if mod(i, 4) = 2 for i from {1,…, 159}		12				
For Slot i, if mod(i, 4) = {0,}) for i from {1,…,159}		12				
Overhead for TBS determination		6				
Information Bit Payload per Slot						
For Slots 0 and Slot i, if mod(i, 4) = 3 for i from {0,…,159}	Bits	N/A				
For Slot i, if mod(i, 4) = 2 for i from {1,…, 159}	Bits	34816				
For Slot i, if mod(i, 4) = {0,}) for i from {1,…,159}	Bits	47112				
Transport block CRC per Slot						
For Slots 0 and Slot i, if mod(i, 4) = 3 for i from {0,…,159}	Bits	N/A				
For Slot i, if mod(i, 4) = 2 for i from {1,…, 159}	Bits	24				
For Slot i, if mod(i, 4) = {0,}) for i from {1,…,159}	Bits	24				
Number of Code Blocks per Slot						
For Slots 0 and Slot i, if mod(i, 4) = 3 for i from {0,…,159}	CBs	N/A				
For Slot i, if mod(i, 4) = 2 for i from {1,…, 159}	CBs	5				
For Slot i, if mod(i, 4) = {0,}) for i from {1,…,159}	CBs	6				
Binary Channel Bits Per Slot						
For Slots 0 and Slot i, if mod(i, 4) = 3 for i from {0,…,159}	Bits	N/A				
For Slot i = 80, 81	Bits	114940				
For Slot i, if mod(i, 4) = 2 for i from {4,…, 159}	Bits	82368				
For Slot i, if mod(i, 4) = {0,}) for i from {1,…,79,82,…,159}	Bits	109692				
Max. Throughput averaged over 2 frames	Mbps	255.724				
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames						

Table A.3.2.2.5-7: PDSCH Reference Channel for TDD PMI reporting requirements with UL-DL pattern FR2.120-1 (16QAM)

Parameter	Unit	Value				
Reference channel		R.PDSCH.5-7.1 TDD				
Channel bandwidth	MHz	100				
Subcarrier spacing	kHz	120				
Allocated resource blocks	PRBs	66				
Number of consecutive PDSCH symbols		12				
Allocated slots per 2 frames		63				
MCS table		64QAM				
MCS index		13				
Modulation		16QAM				
Target Coding Rate		0.48				
Number of MIMO layers		1				
Number of DMRS rEs (Note 3)		6				
Overhead for TBS determination		4				
Information Bit Payload per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {7,8,9} for i from {0,…,39}	Bits	N/A				
For CSI-RS Slot i, if mod(i,10) =1 for i from {0,…,39}	Bits	14344				
For Slot i = 20	Bits	N/A				
For Slot i, if mod(i, 10) = {0,2,3,4,5,6} for i from {1,…,19,22,…,39}		14344				
Transport block CRC per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {7,8,9} for i from {0,…,39}	Bits	N/A				
For CSI-RS Slot i, if mod(i,10) =1 for i from {0,…,39}		24				
For Slot i = 20	Bits	N/A				
For Slot i, if mod(i, 10) = {0,2,3,4,5,6} for i from {1,…,19,22,…,39}	Bits	24				
Number of Code Blocks per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {7,8,9} for i from {0,…,39}	CBs	N/A				
For CSI-RS Slot i, if mod(i,10) =1 for i from {0,…,39}		2				
For Slot i = 20	CBs	N/A				
For Slot i, if mod(i, 10) = {0,2,3,4,5,6} for i from {1,…,19,22,…,39}	CBs	2				
Binary Channel Bits Per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {7,8,9} for i from {0,…,39}	Bits	N/A				
For CSI-RS Slot i, if mod(i,10) =1 for i from {0,…,39}	Bits	28776				
For Slot i = 20	Bits	N/A				
For Slot i, if mod(i, 10) = {0,2,3,4,5,6}for i from {1,…,19,22,…,39}	Bits	30360				
Max. Throughput averaged over 2 frames	Mbps	45.1836				
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames Note 3: Number of DMRS rEs includes the overhead of the DM-RS CDM groups without data						

Table A.3.2.2.5-8: PDSCH Reference Channel for TDD PMI reporting requirements with UL-DL pattern FR2.120-2 (16QAM)

Parameter	Unit	Value				
Reference channel		R.PDSCH.5-8.1 TDD				
Channel bandwidth	MHz	100				
Subcarrier spacing	kHz	120				
Allocated resource blocks	PRBs	66				
Number of consecutive PDSCH symbols		12				
Allocated slots per 2 frames		59				
MCS table		64QAM				
MCS index		13				
Modulation		16QAM				
Target Coding Rate		0.48				
Number of MIMO layers		1				
Number of DMRS rEs (Note 3)		6				
Overhead for TBS determination		4				
Information Bit Payload per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {7,8,9} for i from {0,…,39}	Bits	N/A				
For CSI-RS Slot i, if mod(i,10) =1 for i from {0,…,39}	Bits	14344				
For Slot i = 20	Bits	N/A				
For Slot i, if mod(i, 10) = {0,2,3,4,5,6} for i from {1,…,19,22,…,39}		14344				
Transport block CRC per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {7,8,9} for i from {0,…,39}	Bits	N/A				
For CSI-RS Slot i, if mod(i,10) =1 for i from {0,…,39}		24				
For Slot i = 20	Bits	N/A				
For Slot i, if mod(i, 10) = {0,2,3,4,5,6} for i from {1,…,19,22,…,39}	Bits	24				
Number of Code Blocks per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {7,8,9} for i from {0,…,39}	CBs	N/A				
For CSI-RS Slot i, if mod(i,10) =1 for i from {0,…,39}		2				
For Slot i = 20	CBs	N/A				
For Slot i, if mod(i, 10) = {0,2,3,4,5,6} for i from {1,…,19,22,…,39}	CBs	2				
Binary Channel Bits Per Slot						
For Slots 0 and Slot i, if mod(i, 10) = {7,8,9} for i from {0,…,39}	Bits	N/A				
For CSI-RS Slot i, if mod(i,10) =1 for i from {0,…,39}	Bits	28776				
For Slot i = 20	Bits	N/A				
For Slot i, if mod(i, 10) = {0,2,3,4,5,6}for i from {1,…,19,22,…,39}	Bits	30360				
Max. Throughput averaged over 2 frames	Mbps	42.3148				
Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms Note 2: Slot i is slot index per 2 frames Note 3: Number of DMRS rEs includes the overhead of the DM-RS CDM groups without data						

A.3.3 Reference measurement channels for PDCCH performance requirements

A.3.3.1 FDD

A.3.3.1.1 Reference measurement channels for SCS 15 kHz FR1

Table A.3.3.1.1-1: PDCCH Reference Channels (Time domain allocation 1 symbol)

Parameter	Unit	Value					
Reference channel		R.PDCCH.1-1.1 FDD	R.PDCCH.1-1.2 FDD	R.PDCCH.1-1.3 FDD			
Subcarrier spacing	kHz	15	15	15			
CORESET frequency domain allocation		48	48	48			
CORESET time domain allocation		1	1	1			
Aggregation level		4	4	8			
DCI Format		1_0	1_1	1_1			
Payload (without CRC)	Bits	39	52	52			

Table A.3.3.1.1-2: PDCCH Reference Channel (Time domain allocation 2 symbols)

Parameter	Unit	Value					
Reference channel		R.PDCCH.1-2.1 FDD	R.PDCCH.1-2.2 FDD	R.PDCCH.1-2.3 FDD	R.PDCCH.1-2.4 FDD	R.PDCCH.1-2.5 FDD	R.PDCCH.1-2.6 FDD
Subcarrier spacing	kHz	15	15	15	15	15	15
CORESET frequency domain allocation		24	24	24	48	48	48
CORESET time domain allocation		2	2	2	2	2	2
Aggregation level		2	4	2	4	8	16
DCI Format		1_0	1_0	1_1	1_1	1_1	1_0
Payload (without CRC)	Bits	39	39	512	52	52	39

A.3.3.1.2 Reference measurement channels for SCS 30 kHz FR1

Table A.3.3.1.2-1: PDCCH Reference Channels (Time domain allocation 1 symbol)

Parameter	Unit	Value					
Reference channel		R.PDCCH.2-1.1 FDD	R.PDCCH.2-1.2 FDD	R.PDCCH.2-1.3 FDD			
Subcarrier spacing	kHz	30	30	30			
CORESET frequency domain allocation		[102]	[102]	90			
CORESET time domain allocation		1	1	1			
Aggregation level		2	4	8			
DCI Format		1_0	1_1	1_1			
Payload (without CRC)	Bits	41	53	53			

Table A.3.3.1.2-2: PDCCH Reference Channel (Time domain allocation 2 symbols)

Parameter	Unit	Value					
Reference channel		R.PDCCH.2-2.1 FDD					
Subcarrier spacing	kHz	30					
CORESET frequency domain allocation		48					
CORESET time domain allocation		2					
Aggregation level		16					
DCI Format		1_0					
Payload (without CRC)	Bits	41					

A.3.3.2 TDD

A.3.3.2.1 Reference measurement channels for SCS 15 kHz FR1

Table A.3.3.2.1-1: PDCCH Reference Channels (Time domain allocation 1 symbol)

Parameter	Unit	Value					
Reference channel		R.PDCCH.1-1.1 TDD	R.PDCCH.1-1.2 TDD	R.PDCCH.1-1.3 TDD			
Subcarrier spacing	kHz	15	15	15			
CORESET frequency domain allocation		48	48	48			
CORESET time domain allocation		1	1	1			
Aggregation level		4	4	8			
DCI Format		1_0	1_1	1_1			
Payload (without CRC)	Bits	39	52	52			

Table A.3.3.2.1-2: PDCCH Reference Channel (Time domain allocation 2 symbols)

Parameter	Unit	Value					
Reference channel		R.PDCCH.1-2.1 TDD	R.PDCCH.1-2.2 TDD	R.PDCCH.1-2.3 TDD	R.PDCCH.1-2.4 TDD	R.PDCCH.1-2.5 TDD	R.PDCCH.1-2.6 TDD
Subcarrier spacing	kHz	15	15	15	15	15	15
CORESET frequency domain allocation		24	24	24	48	48	48
CORESET time domain allocation		2	2	2	2	2	2
Aggregation level		2	4	2	4	8	16
DCI Format		1_0	1_0	1_1	1_1	1_1	1_0
Payload (without CRC)	Bits	39	39	52	52	52	39

A.3.3.2.2 Reference measurement channels for SCS 30 kHz FR1

Table A.3.3.2.2-1: PDCCH Reference Channels (Time domain allocation 1 symbol)

Parameter	Unit	Value					
Reference channel		R.PDCCH.2-1.1 TDD	R.PDCCH.2-1.2 TDD	R.PDCCH.2-1.3 TDD			
Subcarrier spacing	kHz	30	30	30			
CORESET frequency domain allocation		[102]	[102]	90			
CORESET time domain allocation		1	1	1			
Aggregation level		2	4	8			
DCI Format		1_0	1_1	1_1			
Payload (without CRC)	Bits	41	53	53			

Table A.3.3.2.2-2: PDCCH Reference Channel (Time domain allocation 2 symbols)

Parameter	Unit	Value					
Reference channel		R.PDCCH.2-2.1 TDD					
Subcarrier spacing	kHz	30					
CORESET frequency domain allocation		48					
CORESET time domain allocation		2					
Aggregation level		16					
DCI Format		1_0					
Payload (without CRC)	Bits	41					

A.3.3.2.3 Reference measurement channels for SCS 60 kHz FR1

A.3.3.2.4 Reference measurement channels for SCS 60 kHz FR2

A.3.3.2.5 Reference measurement channels for SCS 120 kHz FR2

Table A.3.3.2.5-1: PDCCH Reference Channels (Time domain allocation 1 symbol)

Parameter	Unit	Value					
Reference channel		R.PDCCH.5-1.1 TDD	R.PDCCH.5-1.2 TDD	R.PDCCH.5-1.3 TDD			
Subcarrier spacing	kHz	120	120	120			
CORESET frequency domain allocation		60	60	60			
CORESET time domain allocation		1	1	1			
Aggregation level		2	4	8			
DCI Format		1_0	1_1	1_1			
Payload (without CRC)	Bits	40	56	56			

Table A.3.3.2.5-2: PDCCH Reference Channel (Time domain allocation 2 symbols)

Parameter	Unit	Value					
Reference channel		R.PDCCH. 5-2.1 TDD					
Subcarrier spacing	kHz	120					
CORESET frequency domain allocation		60					
CORESET time domain allocation		2					
Aggregation level		16					
DCI Format		1_0					
Payload (without CRC)	Bits	40					

A.3.4 Reference measurement channels for PBCH demodulation requirements

A.3.4.1 Reference measurement channels for FR1

Table A.3.4.1-1: PBCH Reference Channel

Parameter	Unit	Value	
Reference channel		[R.PBCH.1]	[R.PBCH.2]
SS/PBCH block subcarrier spacing	kHz	15	30
Modulation		QPSK	QPSK
Target coding rate		56/864	56/864
Payload (without CRC and timing related PBCH payload bits)	bits	24	24

A.3.4.2 Reference measurement channels for FR2

Table A.3.4.2-1: PBCH Reference Channel

Parameter	Unit	Value	
Reference channels		[R.PBCH.5]	[R.PBCH.6]
SS/PBCH block subcarrier spacing	kHz	120	240
Modulation		QPSK	QPSK
Target coding rate		56/864	56/864
Payload (without CRC and timing related PBCH payload bits)	bits	24	24

A.4 CSI reference measurement channels

This section defines the DL signal applicable to the reporting of channel status information (Clause X).

Tables in this section specifies the mapping of CQI index to Information Bit payload, which complies with the CQI definition specified in TS 38.214 [12, Section 5.2.2.1] and with MCS definition specified in TS 38.214 [12, Section 5.1.3].

Table A.4-1: Mapping of CQI Index to Information Bit payload (CQI table 1)

TBS Scheme				TBS.1-1	TBS.1-2				
MCS table				64QAM					
Number of allocated PDSCH resource blocks				66	66				
Number of consecutive PDSCH symbols				12	12				
Number of PDSCH MIMO layers				1	2				
Number of DMRS rEs (Note 1)				24	24				
Overhead for TBS determination				6	6				
Available RE-s				7920	7920				
CQI index	Spectral efficiency	MCS index	Modulation	Information Bit Payload per Slot					
0	OOR	OOR	OOR	N/A	N/A				
1	0.1523	0	QPSK	1800	3624				
2	0.2344	0		1800	3624				
3	0.3770	2		2856	5640				
4	0.6016	4		4480	8968				
5	0.8770	6		6528	13064				
6	1.1758	8		8712	17928				
7	1.4766	11	16QAM	11016	22032				
8	1.9141	13		14343	28680				
9	2.4063	15		17928	35856				
10	2.7305	18	64QAM	20496	40976				
11	3.3223	20		25104	50184				
12	3.9023	22		29192	58384				
13	4.5234	24		33816	67584				
14	5.1152	26		38936	77896				
15	5.5547	28		42016	83976				
Note 1: Number of DMRS rEs includes the overhead of the DM-RS CDM groups without data									

Table A.4-2: Mapping of CQI Index to Information Bit payload (CQI table 2)

TBS Scheme				TBS.2-1	TBS.2-2	TBS.2-3	TBS.2-4		
MCS table				256QAM					
Number of allocated PDSCH resource blocks				52	52	106	106		
Number of consecutive PDSCH symbols				12	12	12	12		
Number of PDSCH MIMO layers				1	2	1	2		
Number of DMRS rEs (Note 1)				24	24	24	24		
Overhead for TBS determination				0	0	0	0		
Available RE-s for PDSCH				7920	7920	12720	12720		
CQI index	Spectral efficiency	MCS index	Modulation	Information Bit Payload per Slot					
0	OOR	OOR	OOR	N/A	N/A	N/A	N/A		
1	0.1523	0	QPSK	1480	2976	2976	5896		
2	0.3770	1		2408	4744	4744	9480		
3	0.8770	3		5504	11016	11016	22536		
4	1.4766	5	16QAM	9224	18432	18960	37896		
5	1.9141	7		12040	24072	24576	49176		
6	2.4063	9		15112	30216	30728	61480		
7	2.7305	11	64QAM	16896	33816	34816	69672		
8	3.3223	13		20496	40976	42016	83976		
9	3.9023	15		24576	49176	49176	98376		
10	4.5234	17		28168	56368	57376	114776		
11	5.1152	19		31752	63528	65576	131176		
12	5.5547	21	256QAM	34816	69672	69672	139376		
13	6.2266	23		38936	77896	79896	159880		
14	6.9141	25		43032	86040	88064	176208		
15	7.4063	27		46104	92200	94248	188576		
Note 1: Number of DMRS rEs includes the overhead of the DM-RS CDM groups without data									

A.5 OFDMA Channel Noise Generator (OCNG)

A.5.1 OCNG Patterns for FDD

A.5.1.1 OCNG FDD pattern 1: Generic OCNG FDD Pattern for all unused rEs

Table A.5.1.1-1: OP.1 FDD: Generic OCNG FDD Pattern for all unused rEs

OCNG Appliance / OCNG Parameters	Control Region (CORESET)	Data Region
Resources allocated	All unused rEs (Note 1)	All unused rEs (Note 2)
Structure	PDCCH	PDSCH
Content	Uncorrelated pseudo random QPSK modulated data	Uncorrelated pseudo random QPSK modulated data
Transmission scheme for multiple antennas ports transmission	Single Tx port transmission	Spatial multiplexing using any precoding matrix with dimensions same as the precoding matrix for PDSCH
Subcarrier Spacing	Same as for RMC PDCCH in the active BWP	Same as for RMC PDSCH in the active BWP
Power Level	Same as for RMC PDCCH	Same as for RMC PDSCH
Note 1: All unused rEs in the active CORESETS appointed by the search spaces in use. Note 2: Unused available rEs refer to rEs in PRBs not allocated for any physical channels, CORESETs, synchronization signals or reference signals in channel bandwidth.		

A.5.2 OCNG Patterns for TDD

A.5.2.1 OCNG TDD pattern 1: Generic OCNG TDD Pattern for all unused rEs

Table A.5.2.1-1: OP.1 TDD: Generic OCNG TDD Pattern for all unused rEs

OCNG Appliance / OCNG Parameters	Control Region (CORESET)	Data Region
Resources allocated	All unused rEs (Note 1)	All unused rEs (Note 2)
Structure	PDCCH	PDSCH
Content	Uncorrelated pseudo random QPSK modulated data	Uncorrelated pseudo random QPSK modulated data
Transmission scheme for multiple antennas ports transmission	Single Tx port transmission	Spatial multiplexing using any precoding matrix with dimensions same as the precoding matrix for PDSCH
Subcarrier Spacing	Same as for RMC PDCCH in the active BWP	Same as for RMC PDSCH in the active BWP
Power Level	Same as for RMC PDCCH	Same as for RMC PDSCH
Note 1: All unused rEs in the active CORESETS appointed by the search spaces in use. Note 2: Unused available rEs refer to rEs in PRBs not allocated for any physical channels, CORESETs, synchronization signals or reference signals in channel bandwidth.		

Annex B (normative): Propagation conditions

B.1 Static propagation condition

B.1.1 UE Receiver with 2Rx

For 1 port transmission the channel matrix is defined in the frequency domain by

$$\mathbf{H} = \begin{pmatrix} 1 \\ 1 \end{pmatrix}.$$

For 2 port transmission the channel matrix is defined in the frequency domain by

$$\mathbf{H} = \begin{pmatrix} 1 & j \\ 1 & -j \end{pmatrix}.$$

For 4 port transmission the channel matrix is defined in the frequency domain by

$$\mathbf{H} = \begin{bmatrix} 1 & 1 & j & j \\ 1 & 1 & -j & -j \end{bmatrix}$$

For 8 port transmission the channel matrix is defined in the frequency domain by

$$\mathbf{H} = \begin{bmatrix} 1 & 1 & 1 & 1 & j & j & j & j \\ 1 & 1 & 1 & 1 & -j & -j & -j & -j \end{bmatrix}$$

B.1.2 UE Receiver with 4Rx

For 1 port transmission the channel matrix is defined in the frequency domain by

$$\mathbf{H} = \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \end{bmatrix}.$$

For 2 port transmission the channel matrix is defined in the frequency domain by

$$\mathbf{H} = \begin{bmatrix} 1 & j \\ 1 & -j \\ 1 & j \\ 1 & -j \end{bmatrix}.$$

For 4 port transmission the channel matrix is defined in the frequency domain by

$$\mathbf{H} = \begin{bmatrix} 1 & 1 & j & j \\ 1 & 1 & -j & -j \\ 1 & -1 & j & -j \\ 1 & -1 & -j & j \end{bmatrix}.$$

For 8 port transmission the channel matrix is defined in the frequency domain by

$$\mathbf{H} = \begin{bmatrix} 1 & 1 & 1 & 1 & j & j & j & j \\ 1 & 1 & 1 & 1 & -j & -j & -j & -j \\ 1 & 1 & -1 & -1 & j & j & -j & -j \\ 1 & 1 & -1 & -1 & -j & -j & j & j \end{bmatrix}$$

B.2 Multi-path fading propagation conditions

The multipath propagation conditions consist of several parts:

- A delay profile in the form of a "tapped delay-lin", characterized by a number of taps at fixed positions on a sampling grid. The profile can be further characterized by the r.m.s. delay spread and the maximum delay spanned by the taps.
- A combination of channel model parameters that include the Delay profile and the Doppler spectrum that is characterized by a classical spectrum shape and a maximum Doppler frequency.
- Different models are used for FR1 (below 6 GHz) and FR2 (above 6 GHz).

B.2.1 Delay profiles

The delay profiles are simplified from the TR 38.901 [5] TDL models. The simplification steps are shown below for information. These steps are only used when new delay profiles are created. Otherwise, the delay profiles specified in B.2.1.1 and B.2.1.2 can be used as such.

Step 1: Use the original TDL model from TR 38.901[5].

Step 2: Re-order the taps in ascending delays

Step 3: Perform delay scaling according to the procedure described in subclause 7.7.3 in TR 38.901 [5].

Step 4: Apply the quantization to the delay resolution 5 ns. This is done simply by rounding the tap delays to the nearest multiple of the delay resolution.

Step 5: If multiple taps are rounded to the same delay bin, merge them by calculating their linear power sum.

Step 6: If there are more than 12 taps in the quantized model, merge the taps as follows

- Find the weakest tap from all taps (both merged and unmerged taps are considered)
  - If there are two or more taps having the same value and are the weakest, select the tap with the smallest delay as the weakest tap.
- When the weakest tap is the first delay tap, merge taps as follows
  - Update the power of the first delay tap as the linear power sum of the weakest tap and the second delay tap.
  - Remove the second delay tap.
- When the weakest tap is the last delay tap, merge taps as follows
  - Update the power of the last delay tap as the linear power sum of the second-to-last tap and the last tap.
  - Remove the second-to-last tap.
- Otherwise
  - For each side of the weakest tap, identify the neighbour tap that has the smaller delay difference to the weakest tap.

- When the delay difference between the weakest tap and the identified neighbour tap on one side equals the delay difference between the weakest tap and the identified neighbour tap on the other side.
    - Select the neighbour tap that is weaker in power for merging.
- Otherwise, select the neighbour tap that has smaller delay difference for merging.

- To merge, the power of the merged tap is the linear sum of the power of the weakest tap and the selected tap.
- When the selected tap is the first tap, the location of the merged tap is the location of the first tap. The weakest tap is removed.
- When the selected tap is the last tap, the location of the merged tap is the location of the last tap. The weakest tap is removed.
- Otherwise, the location of the merged tap is based on the average delay of the weakest tap and selected tap. If the average delay is on the sampling grid, the location of the merged tap is the average delay. Merge two parallel taps with different delays (average delay, sum power) starting from the weakest ones. Otherwise, the location of the merged tap is rounded towards the direction of the selected tap (e.g. 10 ns & 20 ns → 15 ns, 10 ns & 25 ns → 20 ns, if 25 ns had higher or equal power; 15 ns, if 10 ns had higher power). The weakest tap and the selected tap are removed.

- Repeat step 6 until the final number of taps is 12.

Step 7: Round the amplitudes of taps to one decimal (e.g. -8.78 dB → -8.8 dB)

Step 8: If the delay spread has slightly changed due to the tap merge, adjust the final delay spread by increasing or decreasing the power of the last tap so that the delay spread is corrected.

Step 9: Re-normalize tap powers such that the strongest tap is at 0dB.

Note: Some values of the delay profile created by the simplification steps may differ from the values in tables B.2.1.1-2, B.2.1.1-3, B.2.1.1-4, B.2.1.2-2, and B.2.1.1-3 for the corresponding model.

B.2.1.1 Delay profiles for FR1

The delay profiles for FR1 are selected to be representative of low, medium and high delay spread environment. The resulting model parameters are specified in B.2.1.1-1 and the tapped delay line models are specified in Tables B.2.1.1-2 ~ Table B.2.1.1-4.

Table B.2.1.1-1: Delay profiles for NR channel models

Model	Number of channel taps	Delay spread (r.m.s.)	Maximum excess tap delay (span)	Delay resolution
TDLA30	12	30 ns	290 ns	5 ns
TDLB100	12	100 ns	480 ns	5 ns
TDLC300	12	300 ns	2595 ns	5 ns

Table B.2.1.1-2 TDLA30 (DS = 30 ns)

Tap #	Delay [ns]	Power [dB]	Fading distribution
1	0	-15.5	Rayleigh
2	10	0	Rayleigh
3	15	-5.1	Rayleigh
4	20	-5.1	Rayleigh
5	25	-9.6	Rayleigh
6	50	-8.2	Rayleigh
7	65	-13.1	Rayleigh
8	75	-11.5	Rayleigh
9	105	-11.0	Rayleigh
10	135	-16.2	Rayleigh
11	150	-16.6	Rayleigh
12	290	-26.2	Rayleigh

Table B.2.1.1-3 TDLB100 (DS = 100ns)

Tap #	Delay [ns]	Power [dB]	Fading distribution
1	0	0	Rayleigh
2	10	-2.2	Rayleigh
3	20	-0.6	Rayleigh
4	30	-0.6	Rayleigh
5	35	-0.3	Rayleigh
6	45	-1.2	Rayleigh
7	55	-5.9	Rayleigh
8	120	-2.2	Rayleigh
9	170	-0.8	Rayleigh
10	245	-6.3	Rayleigh
11	330	-7.5	Rayleigh
12	480	-7.1	Rayleigh

Table B.2.1.1-4 TDLC300 (DS = 300 ns)

Tap #	Delay [ns]	Power [dB]	Fading distribution
1	0	-6.9	Rayleigh
2	65	0	Rayleigh
3	70	-7.7	Rayleigh
4	190	-2.5	Rayleigh
5	195	-2.4	Rayleigh
6	200	-9.9	Rayleigh
7	240	-8.0	Rayleigh
8	325	-6.6	Rayleigh
9	520	-7.1	Rayleigh
10	1045	-13.0	Rayleigh
11	1510	-14.2	Rayleigh
12	2595	-16.0	Rayleigh

B.2.1.2 Delay profiles for FR2

The delay profiles for FR2 are specified in B.2.1.2-1 and the tapped delay line models are specified in Tables B.2.1.2-2 and table B.2.1.2-3.

Table B.2.1.2-1: Delay profiles for NR channel models

Model	Number of channel taps	Delay spread (r.m.s.)	Maximum excess tap delay (span)	Delay resolution
TDLA30	12	30 ns	290 ns	5 ns
TDLC60	12	60 ns	520 ns	5 ns

Table B.2.1.2-2 TDLA30 (DS = 30 ns)

Tap #	Delay [ns]	Power [dB]	Fading distribution
1	0	-15.5	Rayleigh
2	10	0	Rayleigh
3	15	-5.1	Rayleigh
4	20	-5.1	Rayleigh
5	25	-9.6	Rayleigh
6	50	-8.2	Rayleigh
7	65	-13.1	Rayleigh
8	75	-11.5	Rayleigh
9	105	-11.0	Rayleigh
10	135	-16.2	Rayleigh
11	150	-16.6	Rayleigh
12	290	-26.2	Rayleigh

Table B.2.1.2-3 TDLC60 (DS = 60 ns)

Tap #	Delay [ns]	Power [dB]	Fading distribution
1	0	-7.8	Rayleigh
2	15	-0.3	Rayleigh
3	40	0	Rayleigh
4	50	-8.9	Rayleigh
5	55	-14.5	Rayleigh
6	75	-8.5	Rayleigh
7	80	-10.2	Rayleigh
8	130	-12.1	Rayleigh
9	210	-13.9	Rayleigh
10	300	-15.2	Rayleigh
11	360	-16.9	Rayleigh
12	520	-19.4	Rayleigh

B.2.2 Combinations of channel model parameters

The propagation conditions used for the performance measurements in multi-path fading environment are indicated as a combination of a channel model name and a maximum Doppler frequency, i.e., TDLA<DS>-<Doppler>, TDLB<DS>-<Doppler> or TDLC<DS>-<Doppler> where '<DS>' indicates the desired delay spread and '<Doppler>' indicates the maximum Doppler frequency (Hz).

Table B.2.2-1 and Table B.2.2-2 show the propagation conditions that are used for the performance measurements in multi-path fading environment for low, medium and high Doppler frequencies for FR1 and FR2, respectively.

Table B.2.2-1 Channel model parameters for FR1

Combination name	Model	Maximum Doppler frequency
TDLA30-5	TDLA30	5 Hz
TDLA30-10	TDLA30	10 Hz
TDLB100-400	TDLB100	400 Hz
TDLC300-100	TDLC300	100 Hz

Table B.2.2-2 Channel model parameters for FR2

Combination name	Model	Maximum Doppler frequency
TDLA30-35	TDLA30	35 Hz
TDLA30-75	TDLA30	75 Hz
TDLA30-300	TDLA30	300 Hz
TDLC60-300	TDLC60	300 Hz

B.2.3 MIMO Channel Correlation Matrices

The MIMO channel correlation matrices defined in B.2.3 apply for the antenna configuration using uniform linear arrays at both gNB and UE and for the antenna configuration using cross polarized antennas.

B.2.3.1 MIMO Correlation Matrices using Uniform Linear Array (ULA)

The MIMO channel correlation matrices defined in B.2.3.1 apply for the antenna configuration using uniform linear array (ULA) at both gNB and UE.

B.2.3.1.1 Definition of MIMO Correlation Matrices

Table B.2.3.1.1-1 defines the correlation matrix for the gNB.

Table B.2.3.1.1-1 gNB correlation matrix

	One antenna	Two antennas	Four antennas
gNB Correlation	$R_{gNB}=1$	$R_{gNB}=\begin{pmatrix}1 & \alpha\\ \alpha^{*} & 1\end{pmatrix}$	$R_{gNB}=\begin{pmatrix}1 & \alpha^{1/9} & \alpha^{4/9} & \alpha\\ \alpha^{1/9*} & 1 & \alpha^{1/9} & \alpha^{4/9}\\ \alpha^{4/9*} & \alpha^{1/9*} & 1 & \alpha^{1/9}\\ \alpha^{*} & \alpha^{4/9*} & \alpha^{1/9*} & 1\end{pmatrix}$

Table B.2.3.1.1-2 defines the correlation matrix for the UE:

Table B.2.3.1.1-2 UE correlation matrix

	One antenna	Two antennas	Four antennas
UE Correlation	$R_{UE}=1$	$R_{UE}=\begin{pmatrix}1 & \beta\\ \beta^{*} & \mathbf{1}\end{pmatrix}$	$R_{UE}=\begin{pmatrix}1 & \beta^{1/9} & \beta^{4/9} & \beta\\ \beta^{1/9*} & 1 & \beta^{1/9} & \beta^{4/9}\\ \beta^{4/9*} & \beta^{1/9*} & 1 & \beta^{1/9}\\ \beta^{*} & \beta^{4/9*} & \beta^{1/9*} & 1\end{pmatrix}$

Table B.2.3.1.1-3 defines the channel spatial correlation matrix R_{spat} . The parameters, α and β in Table B.2.3.1-3 defines the spatial correlation between the antennas at the gNB and UE.

Table B.2.3.1.1-3: R_{spat} correlation matrices

1x2 case	$R_{spat} = R_{UE} = \begin{bmatrix} 1 & \beta \\ \beta^* & 1 \end{bmatrix}$
1x4 case	$R_{spat} = R_{UE} = \begin{pmatrix} 1 & \beta^{1/9} & \beta^{4/9} & \beta \\ \beta^{1/9*} & 1 & \beta^{1/9} & \beta^{4/9} \\ \beta^{4/9*} & \beta^{1/9*} & 1 & \beta^{1/9} \\ \beta^* & \beta^{4/9*} & \beta^{1/9*} & 1 \end{pmatrix}$
2x1 case	$R_{spat} = R_{gNB} = \begin{bmatrix} 1 & \alpha \\ \alpha^* & 1 \end{bmatrix}$
2x2 case	$R_{spat} = R_{gNB} \otimes R_{UE} = \begin{bmatrix} 1 & \alpha \\ \alpha^* & 1 \end{bmatrix} \otimes \begin{bmatrix} 1 & \beta \\ \beta^* & 1 \end{bmatrix} = \begin{bmatrix} 1 & \beta & \alpha & \alpha\beta \\ \beta^* & 1 & \alpha\beta^* & \alpha \\ \alpha^* & \alpha^*\beta & 1 & \beta \\ \alpha^*\beta^* & \alpha^* & \beta^* & 1 \end{bmatrix}$
2x4 case	$R_{spat} = R_{gNB} \otimes R_{UE} = \begin{bmatrix} 1 & \alpha \\ \alpha^* & 1 \end{bmatrix} \otimes \begin{bmatrix} 1 & \beta^{1/9} & \beta^{4/9} & \beta \\ \beta^{1/9*} & 1 & \beta^{1/9} & \beta^{4/9} \\ \beta^{4/9*} & \beta^{1/9*} & 1 & \beta^{1/9} \\ \beta^* & \beta^{4/9*} & \beta^{1/9*} & 1 \end{bmatrix}$
4x1 case	$R_{spat} = R_{gNB} = \begin{bmatrix} 1 & \alpha^{1/9} & \alpha^{4/9} & \alpha \\ \alpha^{1/9*} & 1 & \alpha^{1/9} & \alpha^{4/9} \\ \alpha^{4/9*} & \alpha^{1/9*} & 1 & \alpha^{1/9} \\ \alpha^* & \alpha^{4/9*} & \alpha^{1/9*} & 1 \end{bmatrix}$
4x2 case	$R_{spat} = R_{gNB} \otimes R_{UE} = \begin{bmatrix} 1 & \alpha^{1/9} & \alpha^{4/9} & \alpha \\ \alpha^{1/9*} & 1 & \alpha^{1/9} & \alpha^{4/9} \\ \alpha^{4/9*} & \alpha^{1/9*} & 1 & \alpha^{1/9} \\ \alpha^* & \alpha^{4/9*} & \alpha^{1/9*} & 1 \end{bmatrix} \otimes \begin{bmatrix} 1 & \beta \\ \beta^* & 1 \end{bmatrix}$
4x4 case	$R_{spat} = R_{gNB} \otimes R_{UE} = \begin{bmatrix} 1 & \alpha^{1/9} & \alpha^{4/9} & \alpha \\ \alpha^{1/9*} & 1 & \alpha^{1/9} & \alpha^{4/9} \\ \alpha^{4/9*} & \alpha^{1/9*} & 1 & \alpha^{1/9} \\ \alpha^* & \alpha^{4/9*} & \alpha^{1/9*} & 1 \end{bmatrix} \otimes \begin{pmatrix} 1 & \beta^{1/9} & \beta^{4/9} & \beta \\ \beta^{1/9*} & 1 & \beta^{1/9} & \beta^{4/9} \\ \beta^{4/9*} & \beta^{1/9*} & 1 & \beta^{1/9} \\ \beta^* & \beta^{4/9*} & \beta^{1/9*} & 1 \end{pmatrix}$

For cases with more antennas at either gNB or UE or both, the channel spatial correlation matrix can still be expressed as the Kronecker product of R_{gNB} and R_{UE} according to $R_{spat} = R_{gNB} \otimes R_{UE}$.

B.2.3.1.2 MIMO Correlation Matrices at High, Medium and Low Level

The α and β for different correlation types are given in Table B.2.3.1.2-1.

Table B.2.3.1.2-1: The α and β parameters for ULA MIMO correlation matrices

Correlation Model	α	β
Low correlation	0	0
Medium Correlation	0.3	0.9
Medium Correlation A	0.3	0.3874
High Correlation	0.9	0.9

The correlation matrices for high, medium, medium A and low correlation are defined in Table B.2.3.1.2-2, B.2.3.1.2-3, B.2.3.1.2-4 and B.2.3.1.2-5 as below.

The values in Table B.2.3.1.2-2 have been adjusted for the 4x2 and 4x4 high correlation cases to insure the correlation matrix is positive semi-definite after round-off to 4 digit precision. This is done using the equation:

$$R_{high} = [R_{spat} + aI_n]/(1+a)$$

Where the value "*a*" is a scaling factor such that the smallest value is used to obtain a positive semi-definite result. For the 4x2 high correlation case, a=0.00010. For the 4x4 high correlation case, a=0.00012.

The same method is used to adjust the 2x4 and 4x4 medium correlation matrix in Table B.2.3.1.2-3 to insure the correlation matrix is positive semi-definite after round-off to 4 digit precision with a = 0.00010 and a = 0.00012.

Table B.2.3.1.2-2: MIMO correlation matrices for high correlation

1x2 case

$$R_{high} = \begin{pmatrix} 1 & 0.9 \\ 0.9 & 1 \end{pmatrix}$$

2x1 case

$$R_{high} = \begin{pmatrix} 1 & 0.9 \\ 0.9 & 1 \end{pmatrix}$$

2x2 case

$$R_{high} = \begin{pmatrix} 1 & 0.9 & 0.9 & 0.81 \\ 0.9 & 1 & 0.81 & 0.9 \\ 0.9 & 0.81 & 1 & 0.9 \\ 0.81 & 0.9 & 0.9 & 1 \end{pmatrix}$$

4x2 case

$$R_{high} = \begin{bmatrix} 1.0000 & 0.8999 & 0.9883 & 0.8894 & 0.9542 & 0.8587 & 0.8999 & 0.8099 \\ 0.8999 & 1.0000 & 0.8894 & 0.9883 & 0.8587 & 0.9542 & 0.8099 & 0.8999 \\ 0.9883 & 0.8894 & 1.0000 & 0.8999 & 0.9883 & 0.8894 & 0.9542 & 0.8587 \\ 0.8894 & 0.9883 & 0.8999 & 1.0000 & 0.8894 & 0.9883 & 0.8587 & 0.9542 \\ 0.9542 & 0.8587 & 0.9883 & 0.8894 & 1.0000 & 0.8999 & 0.9883 & 0.8894 \\ 0.8587 & 0.9542 & 0.8894 & 0.9883 & 0.8999 & 1.0000 & 0.8894 & 0.9883 \\ 0.8999 & 0.8099 & 0.9542 & 0.8587 & 0.9883 & 0.8894 & 1.0000 & 0.8999 \\ 0.8099 & 0.8999 & 0.8587 & 0.9542 & 0.8894 & 0.9883 & 0.8999 & 1.0000 \end{bmatrix}$$

4x4 case

$$R_{high} = \begin{bmatrix} 1.0000 & 0.9882 & 0.9541 & 0.8999 & 0.9882 & 0.9767 & 0.9430 & 0.8894 & 0.9541 & 0.9430 & 0.9105 & 0.8587 & 0.8999 & 0.8894 & 0.8587 & 0.8099 \\ 0.9882 & 1.0000 & 0.9882 & 0.9541 & 0.9767 & 0.9882 & 0.9767 & 0.9430 & 0.9430 & 0.9541 & 0.9430 & 0.9105 & 0.8894 & 0.8999 & 0.8894 & 0.8587 \\ 0.9541 & 0.9882 & 1.0000 & 0.9882 & 0.9430 & 0.9767 & 0.9882 & 0.9767 & 0.9105 & 0.9430 & 0.9541 & 0.9430 & 0.8587 & 0.8894 & 0.8999 & 0.8894 \\ 0.8999 & 0.9541 & 0.9882 & 1.0000 & 0.8894 & 0.9430 & 0.9767 & 0.9882 & 0.8587 & 0.9105 & 0.9430 & 0.9541 & 0.8099 & 0.8587 & 0.8894 & 0.8999 \\ 0.9882 & 0.9767 & 0.9430 & 0.8894 & 1.0000 & 0.9882 & 0.9541 & 0.8999 & 0.9882 & 0.9767 & 0.9430 & 0.8894 & 0.9541 & 0.9430 & 0.9105 & 0.8587 \\ 0.9767 & 0.9882 & 0.9767 & 0.9430 & 0.9882 & 1.0000 & 0.9882 & 0.9541 & 0.9767 & 0.9882 & 0.9767 & 0.9430 & 0.9430 & 0.9541 & 0.9430 & 0.9105 \\ 0.9430 & 0.9767 & 0.9882 & 0.9767 & 0.9541 & 0.9882 & 1.0000 & 0.9882 & 0.9430 & 0.9767 & 0.9882 & 0.9767 & 0.9105 & 0.9430 & 0.9541 & 0.9430 \\ 0.8894 & 0.9430 & 0.9767 & 0.9882 & 0.8999 & 0.9541 & 0.9882 & 1.0000 & 0.8894 & 0.9430 & 0.9767 & 0.9882 & 0.8587 & 0.9105 & 0.9430 & 0.9541 \\ 0.9541 & 0.9430 & 0.9105 & 0.8587 & 0.9882 & 0.9767 & 0.9430 & 0.8894 & 1.0000 & 0.9882 & 0.9541 & 0.8999 & 0.9882 & 0.9767 & 0.9430 & 0.8894 \\ 0.9430 & 0.9541 & 0.9430 & 0.9105 & 0.9767 & 0.9882 & 0.9767 & 0.9430 & 0.9882 & 1.0000 & 0.9882 & 0.9541 & 0.9767 & 0.9882 & 0.9767 & 0.9430 \\ 0.9105 & 0.9430 & 0.9541 & 0.9430 & 0.9430 & 0.9767 & 0.9882 & 0.9767 & 0.9541 & 0.9882 & 1.0000 & 0.9882 & 0.9430 & 0.9767 & 0.9882 & 0.9767 \\ 0.8587 & 0.9105 & 0.9430 & 0.9541 & 0.8894 & 0.9430 & 0.9767 & 0.9882 & 0.8999 & 0.9541 & 0.9882 & 1.0000 & 0.8894 & 0.9430 & 0.9767 & 0.9882 \\ 0.8999 & 0.8894 & 0.8587 & 0.8099 & 0.9541 & 0.9430 & 0.9105 & 0.8587 & 0.9882 & 0.9767 & 0.9430 & 0.8894 & 1.0000 & 0.9882 & 0.9541 & 0.8999 \\ 0.8894 & 0.8999 & 0.8894 & 0.8587 & 0.9430 & 0.9541 & 0.9430 & 0.9105 & 0.9767 & 0.9882 & 0.9767 & 0.9430 & 0.9882 & 1.0000 & 0.9882 & 0.9541 \\ 0.8587 & 0.8894 & 0.8999 & 0.8894 & 0.9105 & 0.9430 & 0.9541 & 0.9430 & 0.9430 & 0.9767 & 0.9882 & 0.9767 & 0.9541 & 0.9882 & 1.0000 & 0.9882 \\ 0.8099 & 0.8587 & 0.8894 & 0.8999 & 0.8587 & 0.9105 & 0.9430 & 0.9541 & 0.8894 & 0.9430 & 0.9767 & 0.9882 & 0.8999 & 0.9541 & 0.9882 & 1.0000 \end{bmatrix}$$

Table B.2.3.1.2-3: MIMO correlation matrices for medium correlation

1x2 case	N/A
2x1 case	N/A
2x2 case	$R_{medium} = \begin{pmatrix} 1 & 0.9 & 0.3 & 0.27 \\ 0.9 & 1 & 0.27 & 0.3 \\ 0.3 & 0.27 & 1 & 0.9 \\ 0.27 & 0.3 & 0.9 & 1 \end{pmatrix}$
2x4 case	$R_{medium} = \begin{pmatrix} 1.0000 & 0.9882 & 0.9541 & 0.8999 & 0.3000 & 0.2965 & 0.2862 & 0.2700 \\ 0.9882 & 1.0000 & 0.9882 & 0.9541 & 0.2965 & 0.3000 & 0.2965 & 0.2862 \\ 0.9541 & 0.9882 & 1.0000 & 0.9882 & 0.2862 & 0.2965 & 0.3000 & 0.2965 \\ 0.8999 & 0.9541 & 0.9882 & 1.0000 & 0.2700 & 0.2862 & 0.2965 & 0.3000 \\ 0.3000 & 0.2965 & 0.2862 & 0.2700 & 1.0000 & 0.9882 & 0.9541 & 0.8999 \\ 0.2965 & 0.3000 & 0.2965 & 0.2862 & 0.9882 & 1.0000 & 0.9882 & 0.9541 \\ 0.2862 & 0.2965 & 0.3000 & 0.2965 & 0.9541 & 0.9882 & 1.0000 & 0.9882 \\ 0.2700 & 0.2862 & 0.2965 & 0.3000 & 0.8999 & 0.9541 & 0.9882 & 1.0000 \end{pmatrix}$
4x2 case	$R_{medium} = \begin{pmatrix} 1.0000 & 0.9000 & 0.8748 & 0.7873 & 0.5856 & 0.5271 & 0.3000 & 0.2700 \\ 0.9000 & 1.0000 & 0.7873 & 0.8748 & 0.5271 & 0.5856 & 0.2700 & 0.3000 \\ 0.8748 & 0.7873 & 1.0000 & 0.9000 & 0.8748 & 0.7873 & 0.5856 & 0.5271 \\ 0.7873 & 0.8748 & 0.9000 & 1.0000 & 0.7873 & 0.8748 & 0.5271 & 0.5856 \\ 0.5856 & 0.5271 & 0.8748 & 0.7873 & 1.0000 & 0.9000 & 0.8748 & 0.7873 \\ 0.5271 & 0.5856 & 0.7873 & 0.8748 & 0.9000 & 1.0000 & 0.7873 & 0.8748 \\ 0.3000 & 0.2700 & 0.5856 & 0.5271 & 0.8748 & 0.7873 & 1.0000 & 0.9000 \\ 0.2700 & 0.3000 & 0.5271 & 0.5856 & 0.7873 & 0.8748 & 0.9000 & 1.0000 \end{pmatrix}$
4x4 case	$R_{medium} = \begin{pmatrix} 1.0000 & 0.9882 & 0.9541 & 0.8999 & 0.8747 & 0.8645 & 0.8347 & 0.7872 & 0.5855 & 0.5787 & 0.5588 & 0.5270 & 0.3000 & 0.2965 & 0.2862 & 0.2700 \\ 0.9882 & 1.0000 & 0.9882 & 0.9541 & 0.8645 & 0.8747 & 0.8645 & 0.8347 & 0.5787 & 0.5855 & 0.5787 & 0.5588 & 0.2965 & 0.3000 & 0.2965 & 0.2862 \\ 0.9541 & 0.9882 & 1.0000 & 0.9882 & 0.8347 & 0.8645 & 0.8747 & 0.8645 & 0.5588 & 0.5787 & 0.5855 & 0.5787 & 0.2862 & 0.2965 & 0.3000 & 0.2965 \\ 0.8999 & 0.9541 & 0.9882 & 1.0000 & 0.7872 & 0.8347 & 0.8645 & 0.8747 & 0.5270 & 0.5588 & 0.5787 & 0.5855 & 0.2700 & 0.2862 & 0.2965 & 0.3000 \\ 0.8747 & 0.8645 & 0.8347 & 0.7872 & 1.0000 & 0.9882 & 0.9541 & 0.8999 & 0.8747 & 0.8645 & 0.8347 & 0.7872 & 0.5855 & 0.5787 & 0.5588 & 0.5270 \\ 0.8645 & 0.8747 & 0.8645 & 0.8347 & 0.9882 & 1.0000 & 0.9882 & 0.9541 & 0.8645 & 0.8747 & 0.8645 & 0.8347 & 0.5787 & 0.5855 & 0.5787 & 0.5588 \\ 0.8347 & 0.8645 & 0.8747 & 0.8645 & 0.9541 & 0.9882 & 1.0000 & 0.9882 & 0.8347 & 0.8645 & 0.8747 & 0.8645 & 0.5588 & 0.5787 & 0.5855 & 0.5787 \\ 0.7872 & 0.8347 & 0.8645 & 0.8747 & 0.8999 & 0.9541 & 0.9882 & 1.0000 & 0.7872 & 0.8347 & 0.8645 & 0.8747 & 0.5270 & 0.5588 & 0.5787 & 0.5855 \\ 0.5855 & 0.5787 & 0.5588 & 0.5270 & 0.8747 & 0.8645 & 0.8347 & 0.7872 & 1.0000 & 0.9882 & 0.9541 & 0.8999 & 0.8747 & 0.8645 & 0.8347 & 0.7872 \\ 0.5787 & 0.5855 & 0.5787 & 0.5588 & 0.8645 & 0.8747 & 0.8645 & 0.8347 & 0.9882 & 1.0000 & 0.9882 & 0.9541 & 0.8645 & 0.8747 & 0.8645 & 0.8347 \\ 0.5588 & 0.5787 & 0.5855 & 0.5787 & 0.8347 & 0.8645 & 0.8747 & 0.8645 & 0.9541 & 0.9882 & 1.0000 & 0.9882 & 0.8347 & 0.8645 & 0.8747 & 0.8645 \\ 0.5270 & 0.5588 & 0.5787 & 0.5855 & 0.7872 & 0.8347 & 0.8645 & 0.8747 & 0.8999 & 0.9541 & 0.9882 & 1.0000 & 0.7872 & 0.8347 & 0.8645 & 0.8747 \\ 0.3000 & 0.2965 & 0.2862 & 0.2700 & 0.5855 & 0.5787 & 0.5588 & 0.5270 & 0.8747 & 0.8645 & 0.8347 & 0.7872 & 1.0000 & 0.9882 & 0.9541 & 0.8999 \\ 0.2965 & 0.3000 & 0.2965 & 0.2862 & 0.5787 & 0.5855 & 0.5787 & 0.5588 & 0.8645 & 0.8747 & 0.8645 & 0.8347 & 0.9882 & 1.0000 & 0.9882 & 0.9541 \\ 0.2862 & 0.2965 & 0.3000 & 0.2965 & 0.5588 & 0.5787 & 0.5855 & 0.5787 & 0.8347 & 0.8645 & 0.8747 & 0.8645 & 0.9541 & 0.9882 & 1.0000 & 0.9882 \\ 0.2700 & 0.2862 & 0.2965 & 0.3000 & 0.5270 & 0.5588 & 0.5787 & 0.5855 & 0.7872 & 0.8347 & 0.8645 & 0.8747 & 0.8999 & 0.9541 & 0.9882 & 1.0000 \end{pmatrix}$

Table B.2.3.1.2-4: MIMO correlation matrices for medium correlation A

2x4 case	$R_{medium\ A} = \begin{pmatrix} 1.0000 & 0.9000 & 0.6561 & 0.3874 & 0.3000 & 0.2700 & 0.1968 & 0.1162 \\ 0.9000 & 1.0000 & 0.9000 & 0.6561 & 0.2700 & 0.3000 & 0.2700 & 0.1968 \\ 0.6561 & 0.9000 & 1.0000 & 0.9000 & 0.1968 & 0.2700 & 0.3000 & 0.2700 \\ 0.3874 & 0.6561 & 0.9000 & 1.0000 & 0.1162 & 0.1968 & 0.2700 & 0.3000 \\ 0.3000 & 0.2700 & 0.1968 & 0.1162 & 1.0000 & 0.9000 & 0.6561 & 0.3874 \\ 0.2700 & 0.3000 & 0.2700 & 0.1968 & 0.9000 & 1.0000 & 0.9000 & 0.6561 \\ 0.1968 & 0.2700 & 0.3000 & 0.2700 & 0.6561 & 0.9000 & 1.0000 & 0.9000 \\ 0.1162 & 0.1968 & 0.2700 & 0.3000 & 0.3874 & 0.6561 & 0.9000 & 1.0000 \end{pmatrix}$
4x4 case	$R_{medium\ A} = \begin{pmatrix} 1.0000 & 0.9000 & 0.6561 & 0.3874 & 0.8748 & 0.7873 & 0.5739 & 0.3389 & 0.5856 & 0.5270 & 0.3842 & 0.2269 & 0.3000 & 0.2700 & 0.1968 & 0.1162 \\ 0.9000 & 1.0000 & 0.9000 & 0.6561 & 0.7873 & 0.8748 & 0.7873 & 0.5739 & 0.5270 & 0.5856 & 0.5270 & 0.3842 & 0.2700 & 0.3000 & 0.2700 & 0.1968 \\ 0.6561 & 0.9000 & 1.0000 & 0.9000 & 0.5739 & 0.7873 & 0.8748 & 0.7873 & 0.3842 & 0.5270 & 0.5856 & 0.5270 & 0.1968 & 0.2700 & 0.3000 & 0.2700 \\ 0.3874 & 0.6561 & 0.9000 & 1.0000 & 0.3389 & 0.5739 & 0.7873 & 0.8748 & 0.2269 & 0.3842 & 0.5270 & 0.5856 & 0.1162 & 0.1968 & 0.2700 & 0.3000 \\ 0.8748 & 0.7873 & 0.5739 & 0.3389 & 1.0000 & 0.9000 & 0.6561 & 0.3874 & 0.8748 & 0.7873 & 0.5739 & 0.3389 & 0.5856 & 0.5270 & 0.3842 & 0.2269 \\ 0.7873 & 0.8748 & 0.7873 & 0.5739 & 0.9000 & 1.0000 & 0.9000 & 0.6561 & 0.7873 & 0.8748 & 0.7873 & 0.5739 & 0.5270 & 0.5856 & 0.5270 & 0.3842 \\ 0.5739 & 0.7873 & 0.8748 & 0.7873 & 0.6561 & 0.9000 & 1.0000 & 0.9000 & 0.5739 & 0.7873 & 0.8748 & 0.7873 & 0.3842 & 0.5270 & 0.5856 & 0.5270 \\ 0.3389 & 0.5739 & 0.7873 & 0.8748 & 0.3874 & 0.6561 & 0.9000 & 1.0000 & 0.3389 & 0.5739 & 0.7873 & 0.8748 & 0.2269 & 0.3842 & 0.5270 & 0.5856 \\ 0.5856 & 0.5270 & 0.3842 & 0.2269 & 0.8748 & 0.7873 & 0.5739 & 0.3389 & 1.0000 & 0.9000 & 0.6561 & 0.3874 & 0.8748 & 0.7873 & 0.5739 & 0.3389 \\ 0.5270 & 0.5856 & 0.5270 & 0.3842 & 0.7873 & 0.8748 & 0.7873 & 0.5739 & 0.9000 & 1.0000 & 0.9000 & 0.6561 & 0.7873 & 0.8748 & 0.7873 & 0.5739 \\ 0.3842 & 0.5270 & 0.5856 & 0.5270 & 0.5739 & 0.7873 & 0.8748 & 0.7873 & 0.6561 & 0.9000 & 1.0000 & 0.9000 & 0.5739 & 0.7873 & 0.8748 & 0.7873 \\ 0.2269 & 0.3842 & 0.5270 & 0.5856 & 0.3389 & 0.5739 & 0.7873 & 0.8748 & 0.3874 & 0.6561 & 0.9000 & 1.0000 & 0.3389 & 0.5739 & 0.7873 & 0.8748 \\ 0.3000 & 0.2700 & 0.1968 & 0.1162 & 0.5856 & 0.5270 & 0.3842 & 0.2269 & 0.8748 & 0.7873 & 0.5739 & 0.3389 & 1.0000 & 0.9000 & 0.6561 & 0.3874 \\ 0.2700 & 0.3000 & 0.2700 & 0.1968 & 0.5270 & 0.5856 & 0.5270 & 0.3842 & 0.7873 & 0.8748 & 0.7873 & 0.5739 & 0.9000 & 1.0000 & 0.9000 & 0.6561 \\ 0.1968 & 0.2700 & 0.3000 & 0.2700 & 0.3842 & 0.5270 & 0.5856 & 0.5270 & 0.5739 & 0.7873 & 0.8748 & 0.7873 & 0.6561 & 0.9000 & 1.0000 & 0.9000 \\ 0.1162 & 0.1968 & 0.2700 & 0.3000 & 0.2269 & 0.3842 & 0.5270 & 0.5856 & 0.3389 & 0.5739 & 0.7873 & 0.8748 & 0.3874 & 0.6561 & 0.9000 & 1.0000 \end{pmatrix}$

Table B.2.3.1.2-5: MIMO correlation matrices for low correlation

1x2 case	$R_{low} = \mathbf{I}_2$
1x4 case	$R_{low} = \mathbf{I}_4$
2x1 case	$R_{low} = \mathbf{I}_2$
2x2 case	$R_{low} = \mathbf{I}_4$
2x4 case	$R_{low} = \mathbf{I}_8$
4x1 case	$R_{low} = \mathbf{I}_4$
4x2 case	$R_{low} = \mathbf{I}_8$
4x4 case	$R_{low} = \mathbf{I}_{16}$

In Table B.2.3.1.2-5, $\mathbf{I}_d$ is the $d \times d$ identity matrix.

B.2.3.2 MIMO Correlation Matrices using Cross Polarized Antennas (X-pol)

The MIMO channel correlation matrices defined in B.2.3.2 apply for the antenna configuration using cross polarized (XP/X-pol) antennas at both gNB and UE. The cross-polarized antenna elements with +/-45 degrees polarization slant angles are deployed at gNB and cross-polarized antenna elements with +90/0 degrees polarization slant angles are deployed at UE.

For the 2D cross-polarized antenna array at eNodeB, the N antennas are indexed by (N_1, N_2, P), and total number of antennas is $N = P \cdot N_1 \cdot N_2$, where

- N_1 is the number of antenna elements in first dimension with same polarization,

- N_2 is the number of antenna elements in second dimension with same polarization, and

- P is the number of polarization groups.

For the 2D cross-polarized antennas at gNB, the *N* antennas are labelled such that antennas shall be in increasing order of the second dimension firstly, then the first dimension, and finally the polarization group. For a specific antenna element at *p*-th polarization, n_1-th row, and n_2-th column within the 2D antenna array, the following index number is used for antenna labelling:

$$Index(p,n_1,n_2) = p \cdot N_1 \cdot N_2 + n_1 \cdot N_2 + n_2 + 1; \qquad p = 0,1; \;\; n_1 = 0,\Lambda\ ,N_1 - 1; \;\; n_2 = 0,\Lambda\ ,N_2 - 1.$$

where *N* is the number of transmit antennas, *p* is the polarization group index, n_1 is the row index, and n_2 is the column index of the antenna element.

For the linear (single dimension, 1D) cross-polarized antenna, the *N* antennas are labelled following the above equations with N_2=1.

B.2.3.2.1 Definition of MIMO Correlation Matrices using cross polarized antennas

For the channel spatial correlation matrix, the following is used:

$$R_{spat} = P\left(R_{gNB} \otimes \Gamma \otimes R_{UE}\right)P^T$$

where

- R_{UE} is the spatial correlation matrix at the UE with same polarization,

- R_{gNB} is the spatial correlation matrix at the gNB with same polarization,

- Γ is a polarization correlation matrix, and

- $(\bullet)^T$ denotes transpose.

The matrix Γ is defined as

$$\Gamma = \begin{bmatrix} 1 & 0 & -\gamma & 0 \\ 0 & 1 & 0 & \gamma \\ -\gamma & 0 & 1 & 0 \\ 0 & \gamma & 0 & 1 \end{bmatrix}$$

A permutation matrix P elements are defined as

$$P(a,b) = \begin{cases} 1 & for \quad a = (j-1)Nr + i \quad and \quad b = 2(j-1)Nr + i, \qquad i = 1,\Lambda\ ,Nr,\ j = 1,\Lambda\ Nt/2 \\ 1 & for \quad a = (j-1)Nr + i \quad and \quad b = 2(j - Nt/2)Nr - Nr + i, \quad i = 1,\Lambda\ ,Nr,\ j = Nt/2 + 1,\Lambda\ ,Nt \cdot \\ 0 & otherwise \end{cases}$$

where *Nt* and *Nr* is the number of transmitter and receiver respectively. This is used to map the spatial correlation coefficients in accordance with the antenna element labelling system described in B.2.3.2.

For the 2D cross-polarized antenna array at gNB, the spatial correlation matrix at the gNB is further expressed as following for 2D cross-polarized antenna array at gNB:

$$R_{gNB} = R_{gNB\_Dim,1} \otimes R_{gNB\_Dim,2}$$

where

- - $R_{gNB\_Dim,1}$ is the correlation matrix of antenna elements in first dimension with same polarization, and

- - $R_{gNB\_Dim,2}$ is the correlation matrix of antenna elements in second dimension with same polarization.

For the 2D cross polarized antenna array at gNB side, the spatial correlation matrices in one direction of antenna array are as follows:

- For 1 antenna element with the same polarization in one direction,

$$R_{gNB\_Dim,i} = 1.$$

- For 2 antenna elements with the same polarization in one direction,

$$R_{gNB\_Dim,i} = \begin{pmatrix} 1 & \alpha_i \\ \alpha_i^* & 1 \end{pmatrix}.$$

- For 3 antenna elements with the same polarization in one direction,

$$R_{gNB\_Dim,i} = \begin{pmatrix} 1 & \alpha_i^{1/4} & \alpha_i \\ \alpha_i^{1/4*} & 1 & \alpha_i^{1/4} \\ \alpha_i^* & \alpha_i^{1/4*} & 1 \end{pmatrix}.$$

- For 4 antenna elements with the same polarization in one direction,

$$R_{gNB\_Dim,i} = \begin{pmatrix} 1 & \alpha_i^{1/9} & \alpha_i^{4/9} & \alpha_i \\ \alpha_i^{1/9*} & 1 & \alpha_i^{1/9} & \alpha_i^{4/9} \\ \alpha_i^{4/9*} & \alpha_i^{1/9*} & 1 & \alpha_i^{1/9} \\ \alpha_i^* & \alpha_i^{4/9*} & \alpha_i^{1/9*} & 1 \end{pmatrix}.$$

where the index i = 1,2 stands for first dimension and second dimension respectively.

For the 1D cross-polarized antenna array at gNB, the matrix of R_{gNB} is determined by follow the equations for 2D cross-polarized antenna array and letting $R_{gNB\_Dim,2} = 1$, i.e.,

$$R_{gNB} = R_{gNB\_Dim,1}$$

The spatial correlation matrices at UE side are as follows:

- For 1 antenna element with the same polarization,

$$R_{UE} = 1.$$

- For 2 antenna elements with the same polarization,

$$R_{UE} = \begin{pmatrix} 1 & \beta \\ \beta^* & 1 \end{pmatrix}.$$

B.2.3.2.2 MIMO Correlation Matrices using cross polarized antennas

The values for parameters α, β and γ for the cross polarized antenna models are given in Table B.2.3.2.2-1.

Table B.2.3.2.2-1: The α and β parameters for cross-polarized MIMO correlation matrices

Correlation Model	α_1	α_2	β	γ
Medium Correlation A	0.3	N/A	0.6	0.2
High Correlation	0.9	0.9	0.9	0.3

Note 1: Value of α_1 applies when more than one pair of cross-polarized antenna elements in first dimension at gNB side.
Note 2: Value of α_2 applies when more than one pair of cross-polarized antenna elements in second dimension at gNB side.
Note 3: Value of β applies when more than one pair of cross-polarized antenna elements at UE side.

For the 1D cross polarized antenna array at gNB side, the correlation matrices for high spatial correlation and medium correlation A are defined in Table B.2.3.2.2-2 and Table B.2.3.2.2-3 as below.

The values in Table B.2.3.2.2-2 have been adjusted to insure the correlation matrix is positive semi-definite after round-off to 4 digit precision. This is done using the equation:

$$R_{high} = [R_{spat} + aI_n]/(1+a) \text{ or } R_{mediumA} = [R_{spat} + aI_n]/(1+a)$$

Where the value "a" is a scaling factor such that the smallest value is used to obtain a positive semi-definite result. For the 8x2 high spatial correlation case, a=0.00010.

Table B.2.3.2.2-2: MIMO correlation matrices for high spatial correlation

4x2 case

$$R_{high} = \begin{bmatrix} 1.0000 & 0.0000 & 0.9000 & 0.0000 & -0.3000 & 0.0000 & -0.2700 & 0.0000 \\ 0.0000 & 1.0000 & 0.0000 & 0.9000 & 0.0000 & 0.3000 & 0.0000 & 0.2700 \\ 0.9000 & 0.0000 & 1.0000 & 0.0000 & -0.2700 & 0.0000 & -0.3000 & 0.0000 \\ 0.0000 & 0.9000 & 0.0000 & 1.0000 & 0.0000 & 0.2700 & 0.0000 & 0.3000 \\ -0.3000 & 0.0000 & -0.2700 & 0.0000 & 1.0000 & 0.0000 & 0.9000 & 0.0000 \\ 0.0000 & 0.3000 & 0.0000 & 0.2700 & 0.0000 & 1.0000 & 0.0000 & 0.9000 \\ -0.2700 & 0.0000 & -0.3000 & 0.0000 & 0.9000 & 0.0000 & 1.0000 & 0.0000 \\ 0.0000 & 0.2700 & 0.0000 & 0.3000 & 0.0000 & 0.9000 & 0.0000 & 1.0000 \end{bmatrix}$$

8x2 case

$$R_{high} = \begin{bmatrix} 1.0000 & 0.0000 & 0.9883 & 0.0000 & 0.9542 & 0.0000 & 0.8999 & 0.0000 & -0.3000 & 0.0000 & -0.2965 & 0.0000 & -0.2862 & 0.0000 & -0.2700 & 0.0000 \\ 0.0000 & 1.0000 & 0.0000 & 0.9883 & 0.0000 & 0.9542 & 0.0000 & 0.8999 & 0.0000 & 0.3000 & 0.0000 & 0.2965 & 0.0000 & 0.2862 & 0.0000 & 0.2700 \\ 0.9883 & 0.0000 & 1.0000 & 0.0000 & 0.9883 & 0.0000 & 0.9542 & 0.0000 & -0.2965 & 0.0000 & -0.3000 & 0.0000 & -0.2965 & 0.0000 & -0.2862 & 0.0000 \\ 0.0000 & 0.9883 & 0.0000 & 1.0000 & 0.0000 & 0.9883 & 0.0000 & 0.9542 & 0.0000 & 0.2965 & 0.0000 & 0.3000 & 0.0000 & 0.2965 & 0.0000 & 0.2862 \\ 0.9542 & 0.0000 & 0.9883 & 0.0000 & 1.0000 & 0.0000 & 0.9883 & 0.0000 & -0.2862 & 0.0000 & -0.2965 & 0.0000 & -0.3000 & 0.0000 & -0.2965 & 0.0000 \\ 0.0000 & 0.9542 & 0.0000 & 0.9883 & 0.0000 & 1.0000 & 0.0000 & 0.9883 & 0.0000 & 0.2862 & 0.0000 & 0.2965 & 0.0000 & 0.3000 & 0.0000 & 0.2965 \\ 0.8999 & 0.0000 & 0.9542 & 0.0000 & 0.9883 & 0.0000 & 1.0000 & 0.0000 & -0.2700 & 0.0000 & -0.2862 & 0.0000 & -0.2965 & 0.0000 & -0.3000 & 0.0000 \\ 0.0000 & 0.8999 & 0.0000 & 0.9542 & 0.0000 & 0.9883 & 0.0000 & 1.0000 & 0.0000 & 0.2700 & 0.0000 & 0.2862 & 0.0000 & 0.2965 & 0.0000 & 0.3000 \\ -0.3000 & 0.0000 & -0.2965 & 0.0000 & -0.2862 & 0.0000 & -0.2700 & 0.0000 & 1.0000 & 0.0000 & 0.9883 & 0.0000 & 0.9542 & 0.0000 & 0.8999 & 0.0000 \\ 0.0000 & 0.3000 & 0.0000 & 0.2965 & 0.0000 & 0.2862 & 0.0000 & 0.2700 & 0.0000 & 1.0000 & 0.0000 & 0.9883 & 0.0000 & 0.9542 & 0.0000 & 0.8999 \\ -0.2965 & 0.0000 & -0.3000 & 0.0000 & -0.2965 & 0.0000 & -0.2862 & 0.0000 & 0.9883 & 0.0000 & 1.0000 & 0.0000 & 0.9883 & 0.0000 & 0.9542 & 0.0000 \\ 0.0000 & 0.2965 & 0.0000 & 0.3000 & 0.0000 & 0.2965 & 0.0000 & 0.2862 & 0.0000 & 0.9883 & 0.0000 & 1.0000 & 0.0000 & 0.9883 & 0.0000 & 0.9542 \\ -0.2862 & 0.0000 & -0.2965 & 0.0000 & -0.3000 & 0.0000 & -0.2965 & 0.0000 & 0.9542 & 0.0000 & 0.9883 & 0.0000 & 1.0000 & 0.0000 & 0.9883 & 0.0000 \\ 0.0000 & 0.2862 & 0.0000 & 0.2965 & 0.0000 & 0.3000 & 0.0000 & 0.2965 & 0.0000 & 0.9542 & 0.0000 & 0.9883 & 0.0000 & 1.0000 & 0.0000 & 0.9883 \\ -0.2700 & 0.0000 & -0.2862 & 0.0000 & -0.2965 & 0.0000 & -0.3000 & 0.0000 & 0.8999 & 0.0000 & 0.9542 & 0.0000 & 0.9883 & 0.0000 & 1.0000 & 0.0000 \\ 0.0000 & 0.2700 & 0.0000 & 0.2862 & 0.0000 & 0.2965 & 0.0000 & 0.3000 & 0.0000 & 0.8999 & 0.0000 & 0.9542 & 0.0000 & 0.9883 & 0.0000 & 1.0000 \end{bmatrix}$$

B.2.3.2.3 Beam steering approach

For the 2D cross-polarized antenna array at gNB, given the channel spatial correlation matrix in B.2.3.2.1 and B.2.3.2.2, the corresponding random channel matrix *H* can be calculated. The signal model for the *k*-th slot is denoted as

$$y = HD_{\theta_{k,1},\theta_{k,2}}Wx + n$$

And the steering matrix is further expressed as following:

$$D_{\theta_{k,1},\theta_{k,2}} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \otimes \left(D_{\theta_{k,1}}(N_1) \otimes D_{\theta_{k,2}}(N_2) \right)$$

where

- *H* is the *Nr*×*Nt* channel matrix per subcarrier.
- $D_{\theta_{k,1},\theta_{k,2}}$ is the steering matrix,
- $D_{\theta_{k,1}}(N_1)$ is the steering matrix in first dimension with same polarization,
- $D_{\theta_{k,2}}(N_2)$ is the steering matrix in second dimension with same polarization,
- N_1 is the number of antenna elements in first dimension with same polarization,
- N_2 is the number of antenna elements in second dimension with same polarization,
- For antenna array with only one direction, number of antenna element in second direction N_2 equals 1.

For 1 antenna element with the same polarization in one direction,

$$D_{\theta_{k,i}}(1) = 1.$$

For 2 antenna elements with the same polarization in one direction,

$$D_{\theta_{k,i}}(2) = \begin{bmatrix} 1 & 0 \\ 0 & e^{j3\theta_{k,i}} \end{bmatrix}.$$

For 3 antenna elements with the same polarization in one direction,

$$D_{\theta_{k,i}}(3) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & e^{j1.5\theta_{k,i}} & 0 \\ 0 & 0 & e^{j3\theta_{k,i}} \end{bmatrix}.$$

For 4 antenna elements with the same polarization in one direction,

$$D_{\theta_{k,i}}(4) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & e^{j\theta_{k,i}} & 0 & 0 \\ 0 & 0 & e^{j2\theta_{k,i}} & 0 \\ 0 & 0 & 0 & e^{j3\theta_{k,i}} \end{bmatrix}.$$

where the index $i = 1,2$ stands for first dimension and second dimension respectively.

- $\theta_{k,i}$ controls the phase variation in first dimension and second dimension respectively, and the phase for k-th subframe is denoted by $\theta_{k,i} = \theta_{0,i} + \Delta\theta \cdot k$, where $\theta_{0,i}$ is the random start value with the uniform distribution, i.e.,

$\theta_{0,i} \in [0,2\pi]$, $\Delta\theta$ is the step of phase variation, which is defined in Table B.2.3B.4-1, and k is the linear increment of $2^{-\mu}$ for every slot throughout the simulation, the index $i = 1,2$ stands for first dimension and second dimension respectively.

- W is the precoding matrix for Nt transmission antennas,
- y is the received signal, x is the transmitted signal, and n is AWGN.
- μ corresponds to subcarrier spacing configuration, $\Delta f = 2^{\mu} \cdot 15$[kHz]

For the 1D cross-polarized antenna array at gNB, the corresponding random channel matrix H can be calculated by letting N_2=1, i.e.,

$$D_{\theta_{k,1}} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \otimes D_{\theta_{k,1}}(N_1)$$

Table B.2.3B.4-1: The step of phase variation

Variation Step	Value (rad/ms)
$\Delta\theta$	1.2566×10^{-3}

B.2.4 Two-tap propagation conditions for CQI tests

For Channel Quality Indication (CQI) tests, the following additional multi-path profile is used:

$$h(t,\tau) = \delta(\tau) + a\exp(-i2\pi f_D t)\delta(\tau - \tau_d)$$

in continuous time (t,τ) representation, with τ_d the delay, a constant value of a and f_D the Doppler frequency. The same $h(t,\tau)$ is used to describe the fading channel between every pair of Tx and Rx.

B.3 High Speed Train Scenario

B.4 Beamforming Model

B.4.1 Generic beamforming model

The transmission on antenna port(s) $p = p_0, p_0 + 1, \ldots, p_0 + N_p - 1$ is defined by using a precoder matrix $W(i)$ of size $N_{ANT} \times N_p$, where N_{ANT} is the number of physical transmit antenna elements configured per test , N_p is the number of ports for a reference signal or physical channel configured per test, and p_0 is the first port for that reference signal or physical channel as defined in clauses 7.3 and 7.4 in TS 38.211 [9]. This precoder takes as an input a block of signals for antenna port(s) $p = p_0, p_0 + 1, \ldots, p_0 + N_p - 1$, $y^{(p)}(i) = \left[y^{(p_0)}(i)\ \ y^{(p_0+1)}(i)\ \ \ldots\ \ y^{(p_0+N_p-1)}(i)\right]^T$, $i = 0,1,\ldots, M^{\text{ap}}_{\text{symb}} - 1$, with $M^{\text{ap}}_{\text{symb}}$ being the number of modulation symbols per antenna port including the reference signal symbols, and generates a block of signals $y^{(q)}_{bf}(i) = \left[y^{(0)}_{bf}(i)\ \ y^{(1)}_{bf}(i)\ \ \ldots\ \ y^{(N_{ANT}-1)}_{bf}(i)\right]^T$ the elements of which are to be mapped onto the frequency-time index pair (k,l) as per the test configuration but transmitted on different physical antenna elements:

$$y^{(q)}_{bf}(i) = W(i)y^{(p)}(i)$$

The precoder matrix $W(i)$ is specific to the test case configuration.

Annex C (normative): Downlink physical channels

C.1 General

This annex specifies the downlink physical channels that are needed for setting a connection and channels that are needed during a connection.

C.2 Setup (Conducted)

Table C.2-1 describes the downlink Physical Channels that are required for connection set up.

Table C.2-1: Downlink Physical Channels required for connection set-up

Physical Channel
PBCH
SSS
PSS
PDCCH
PDSCH
PBCH DMRS
PDCCH DMRS
PDSCH DMRS
CSI-RS

C.3 Connection (Conducted)

The following clauses, describes the downlink Physical Channels that are transmitted during a connection i.e., when measurements are done.

C.3.1 Measurement of Performance requirements

<Editor's note: OCNG for DMRS is FFS in Annex A.>

Table C.3.1-1 is applicable for measurements in which uniform RS-to-EPRE boosting for all downlink physical channels, unless otherwise stated.

Table C.3.1-1: Downlink Physical Channels transmitted during a connection (FDD and TDD)

Parameter	Unit	Value
SSS transmit power	W	Test specific
EPRE ratio of PSS to SSS	dB	0
EPRE ratio of PBCH DMRS to SSS	dB	0
EPRE ratio of PBCH to PBCH DMRS	dB	0
EPRE ratio of PDCCH DMRS to SSS	dB	0
EPRE ratio of PDCCH to PDCCH DMRS	dB	0
EPRE ratio of PDSCH DMRS to SSS	dB	0
EPRE ratio of PDSCH to PDSCH DMRS	dB	0
EPRE ratio of CSI-RS to SSS	dB	0
EPRE ratio of OCNG to SSS	dB	0

C.4 Setup (Radiated)

Table C.4-1 describes the downlink Physical Channels that are required for connection set up.

Table C.4-1: Downlink Physical Channels required for connection set-up

Physical Channel
PBCH
SSS
PSS
PDCCH
PDSCH
PBCH DMRS
PDCCH DMRS
PDSCH DMRS
CSI-RS
PTRS

C.5 Connection (Radiated)

The following clauses, describes the downlink Physical Channels that are transmitted during a connection i.e., when measurements are done.

C.5.1 Measurement of Receiver Characteristics

<Editor's note: OCNG for DMRS is FFS in Annex A.>

Table C.5.1-1 is applicable for measurements in which uniform RS-to-EPRE boosting for all downlink physical channels, unless otherwise stated.

Table C.5.1-1: Downlink Physical Channels transmitted during a connection (TDD)

Parameter	Unit	Value
SSS transmit power	W	Test specific
EPRE ratio of PSS to SSS	dB	0
EPRE ratio of PBCH DMRS to SSS	dB	0
EPRE ratio of PBCH to PBCH DMRS	dB	0
EPRE ratio of PDCCH DMRS to SSS	dB	0
EPRE ratio of PDCCH to PDCCH DMRS	dB	0
EPRE ratio of PDSCH DMRS to SSS	dB	0
EPRE ratio of PDSCH to PDSCH DMRS	dB	0
EPRE ratio of CSI-RS to SSS	dB	0
EPRE ratio of PTRS to PDSCH	dB	Test specific
EPRE ratio of OCNG to SSS	dB	0

Annex D (informative): Void

Annex E (normative): Environmental conditions

E.1 General

This annex specifies the environmental requirements of the UE. Within these limits the requirements of the present documents shall be fulfilled.

E.2 Environmental (Conducted)

The requirements in this clause apply to all types of UE(s).

E.2.1 Temperature

The UE shall fulfil all the requirements in the full temperature range of:

Table E.2.1-1 Temperature conditions

+15°C to +35°C	For normal conditions (with relative humidity of 25 % to 75 %)
-10°C to +55°C	For extreme conditions (see IEC publications 68-2-1 and 68-2-2)

Outside this temperature range the UE, if powered on, shall not make ineffective use of the radio frequency spectrum. In no case shall the UE exceed the transmitted levels as defined in TS 38.101-1 [6, Section 6.2] for extreme operation.

E.2.2 Voltage

The UE shall fulfil all the requirements in the full voltage range, i.e. the voltage range between the extreme voltages.

The manufacturer shall declare the lower and higher extreme voltages and the approximate shutdown voltage. For the equipment that can be operated from one or more of the power sources listed below, the lower extreme voltage shall not be higher, and the higher extreme voltage shall not be lower than that specified below.

Table E.2.2-1 Voltage conditions

Power source	Lower extreme voltage	Higher extreme voltage	Normal conditions voltage
AC mains	0,9 * nominal	1,1 * nominal	nominal
Regulated lead acid battery	0,9 * nominal	1,3 * nominal	1,1 * nominal
Non regulated batteries: Leclanché Lithium Mercury/nickel & cadmium	 0,85 * nominal 0,95 * nominal 0,90 * nominal	 Nominal 1,1 * Nominal	 Nominal 1,1 * Nominal Nominal

Outside this voltage range the UE if powered on, shall not make ineffective use of the radio frequency spectrum. In no case shall the UE exceed the transmitted levels as defined in TS 38.101-1[6, Section 6.2] for extreme operation. In particular, the UE shall inhibit all RF transmissions when the power supply voltage is below the manufacturer declared shutdown voltage.

E.2.3 Vibration

The UE shall fulfil all the requirements when vibrated at the following frequency/amplitudes.

Table E.2.3-1 Vibration conditions

Frequency	ASD (Acceleration Spectral Density) random vibration
5 Hz to 20 Hz	0,96 m^2/s^3
20 Hz to 500 Hz	0,96 m^2/s^3 at 20 Hz, thereafter –3 dB/Octave

Outside the specified frequency range the UE, if powered on, shall not make ineffective use of the radio frequency spectrum. In no case shall the UE exceed the transmitted levels as defined in TS 38.101-1[6] for extreme operation.

E.3 Environmental (Radiated)

The requirements in this clause apply to all types of UE(s).

E.3.1 Temperature

All requirements for UEs operating in FR2 are defined over the air and can only be tested in an OTA chamber.

The UE shall fulfil all the requirements in the temperature range defined in Table E.3.1-1.

Table E.3.1-1: Temperature conditions

+ 25 °C ± 10 °C	For normal (room temperature) conditions with relative humidity of 25% to 75%
-10°C to +55°C	For extreme conditions

Outside this temperature range the UE, if powered on, shall not make ineffective use of the radio frequency spectrum. In no case shall the UE exceed the transmitted levels as defined in TS38.101-2 [7, Section 6.2] for extreme operation.

E.3.2 Voltage

E.3.3 Void

Annex G (informative): Void

Annex H (informative): Void

Annex I (informative): Void

Annex J (informative): Void

Annex K (informative): Void

Annex L (informative): Change history

Change history							
Date	**Meeting**	**tDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2018-07	RAN4 AH18-07	R4-1809554				Draft skeleton	0.0.1
2018-08	RAN4#88	R4-1811357				Skeleton update	0.0.2
2018-10	RAN4#88 bis	R4-1814237				Approved Text Proposal in RAN4#88bis: R4-1814053, “TP on performance specification 38.101-4 Chapter 4 general part” R4-1814054, “TP to TS 38.101-4: FR1 PDSCH demodulation requirements (5.2)” R4-1813924, “TP for introducing FR1 PDCCH requirements in TS 38.101-4 section 5.3” R4-1814058, “TP for 38.101-4 section 6.3 FR1 PMI test cases” R4-1814060, “Draft TP on FR1 Rank Indication Reporting Performance Requirements” R4-1814055, “Draft TP on FR2 PDSCH Demodulation Performance Requirements” R4-1814022, “TP to TS38.101-4 Section 7.3: PDCCH demodulation requirements” R4-1814059, “TP for 38.101-4 section 8.3 FR2 PMI test cases” R4-1814061, “Draft TP on FR2 Rank Indication Reporting Performance Requirements” R4-1813925, “TP for introducing demodulation performance requirements for interworking TS 38.101-4 section 9” R4-1814052, “TP for 38.101-4 section 10 CSI test cases of interworking” R4-1814066, “TP on channel models for TS38.101-4” R4-1814023, “TP to TS38.101-4 Annex C: Downlink physical channels” R4-1814024, “TP to TS38.101-4 Annex E: Environmental conditions”	0.1.0
2018-11	RAN4#89	R4-1816559				Approved Text Proposal in RAN4#89: R4-1814053, “TP on performance specification 38.101-4 Chapter 4 general part” R4-1814487, “TP for TS38.101-4 section 2 (Reference)” R4-1814488, “TP for TS38.101-4 section 3 (Definitions, symbols and abbreviations)” R4-1814579, “TP to TS 38.101-4: Annex A Measurement channels – PDSCH” R4-1814580, “TP to TS 38.101-4: Annex A Measurement channels - DL Control” R4-1814581, “TP to TS 38.101-4: Annex A Measurement channels – CSI” R4-1816395, “FR2 demod: Noc, Band groups and Ref point - TP for TS 38.101-4” R4-1816692, “TP to TS 38.101-4: Requirements applicability” R4-1816693, “TP for performance requirements for interworking (9)” R4-1816694, “TP to TS 38.101-4: FR1 PDSCH demodulation requirements (5.2)” R4-1816695, “Draft TP on FR2 PDSCH Demodulation Performance Requirements” R4-1816697, “TP for updating FR1 PDCCH requirements in TS 38.101-4 section 5.3” R4-1816699, “TP to TS 38.101-4: 5.4 FR1 PBCH demodulation requirements” R4-1816700, “TP to TS 38.101-4: 7.4 FR2 PBCH demodulation requirements” R4-1816701, “TP of introduction of FR1 CQI requirement (6.2)” R4-1816702, “TP to TS 38.101-4: FR2 CQI requirements (8.2)” R4-1816703, “Draft TP on FR1 Rank Indication Reporting Performance Requirements” R4-1816704, “Draft TP on FR2 Rank Indication Reporting Performance Requirements” R4-1816705, “TP for TS 38.101-4 FR1 PMI test requirement” R4-1816706, “TP to TS 38.101-4 FR2 PMI requirements” R4-1816712, “TP to TS 38.101-4: FR1 SDR requirements (5.5)” R4-1816713, “TP to TS38.101-4 Section 7.3: PDCCH demodulation	0.2.0

						requirements" R4-1816714, "TP for propagation conditions in TS 38.104-4(Annex B)"	
2018-12	RAN#82	RP-182408				V1.0.0 is submitted to RAN for 1-step approval	1.0.0
2018-12	RAN#82	RP-182704				V1.0.1 with editorial changes	1.0.1
2018-12	RAN#82					Approved by plenary – Rel-15 spec under change control	15.0.0
2019-03	RAN#83	RP-190403	0001		B	CR on UE demodulation and CSI requirements for 38.101-4 This CR comboines all the endorsed draft CRs as list below: General sections R4-1902427, Draft CR on NR UE demodulation requirements applicability (Intel Corporation) R4-1902576, Draft CR on General Applicability of Requirements (Qualcomm Incorporated) R4-1902412, Editorial cleanup of FR2 Radiated Requirements General section (ANRITSU) PDSCH R4-1902414, Draft CR on FR1 normal PDSCH demodulation requirements (Intel Corporation) R4-1902415, Draft CR on FR2 PDSCH Requirements (Qualcomm Incorporated) R4-1902411, Draft CR on FR1 SDR requirements (Intel Corporation) PDCCH R4-1902416 Draft CR for updating FR1 PDCCH performance requirements in TS38.101-4Huawei, HiSilicon R4-1902423 Draft CR for updating FR2 PDCCH performance requirements in TS38.101-4 section 7.3 CATT PBCH R4-1902420, Draft CR on 2Rx PBCH demodulation requirement for FR1 (CMCC) R4-1902421, Draft CR on 4Rx PBCH demodulation requirements for FR1 (CMCC) R4-1902422, Draft CR on 2Rx PBCH demodulation requirement for FR2 (CMCC) CSI R4-1902418, Draft CR on FR2 CSI Reporting Tests (Qualcomm Incorporated) R4-1902419, Draft CR on FR1 CSI Reporting Tests (Qualcomm Incorporated) R4-1900105, Draft CR on NR CSI reporting (Intel Corporation) R4-1902058, Draft CR for update of FR1 CQI reporting test (Huawei, HiSilicon) R4-1902059, Draft CR for update of FR2 CQI reporting test (Intel) R4-1902426, Draft CR for PMI test cases: 6.2, 8.2, A.3.2.2.2, A.3.2.2.5 (Samsung) R4-1902425, Draft CR for FR1 and FR2 RI test cases (Qualcomm) Annex R4-1900369, Draft CR on PDSCH FRC (Intel Corporation) R4-1900370, Draft CR on PDCCH FRC (Intel Corporation) R4-1902424, Corrections to 38.101-4 subclause B.2.1 Delay profile calculation (Huawei, HiSilicon) R4-1902575, Draft CR on Beamforming Model (Qualcomm) Additional modifications: - Compared to endorsed CR R4-1902414, requirements for several FR1 PDSCH test cases were modified to correct stat error - Correct the format for Annex A.x - Correct table number under PDSCH section 5.2.3.1.3 - Some minor editorial changes Editorial changes after RAN#83 To align the annex numbering with other specifications (TS 38.101-x series), annexes J and K were added and Change history was numbered as annex L.	15.1.0