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Foreword

This technical document has been produced within the Verizon 5G TF.

1 Scope

The present document establishes a test plan for the air interface of the 5G trial systems. In this specification, a single 5G NB shall operate with a single 5G UE in a lab environment.

The objectives and scopes of the document are as follows:

- It provides test setups, procedures, test metrics, and pass/fail conditions of the 5G air interface
- It covers inter-operability tests of layer 1 baseband functions, but layers 2/3 may be implicitly involved when high-layer message needs to be monitored
    - More rely on L1 messages if possible, but higher layer messages may be considered due to diagnostic monitor (DM) message reliability
    - Both 5G NB and 5G UE DM messages can be taken into account
- Good channel conditions are assumed in AWGN as a baseline, but fading channel may be considered depending on test cases
    - Wireless connection i.e., pseudo wireline (close enough) is assumed as a baseline if wireline connection is not available in the test frequency

2 References

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

[1] “TS V5G.211 v1.4”, 5GTF

[2] “TS V5G.212 v1.3”, 5GTF

[3] “TS V5G.213 v1.1”, 5GTF

3 Definitions, Symbols and Abbreviations

3.1 Symbols

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

$N_{\text{symb}}^{\text{DL}}$ Number of OFDM symbols in a downlink slot

$N_{\mathrm{symb}}^{\mathrm{UL}}$	Number of OFDMA symbols in an uplink slot
$N_{\mathrm{sc}}^{\mathrm{RB}}$	Resource block size in the frequency domain, expressed as a number of subcarriers
N_{TA}	Timing offset between uplink and downlink radio frames at the UE, expressed in units of T_s
$N_{\mathrm{TA\ offset}}$	Fixed timing advance offset, expressed in units of T_s
T_{f}	Radio frame duration
T_s	Basic time unit
T_{slot}	Slot duration
Δf	Subcarrier spacing

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply.

BSI	Beam-State Information
BRI	Bream-Refinement Information
CSI	Channel-State Information
CQI	Channel-Quality Information
DCI	Downlink Control Information
DM	Diagnostic Monitor
DM-RS	Demodulation Reference Signal
DUT	Device Under Test
5GARFCN	5G Absolute Radio-Frequency Channel
ICCID	Integrated Circuit Card Identifier
IMSI	International Mobile Subscriber Identity
MSISDN	Mobile Subscriber ISDN Number
PCRS	Phase Compensation Reference Signal
PRB	Physical Resource Block
PMI	Precoding Matrix Index
PUK	PIN and Unblocking Key

RB	Resource Block
RI	Rank Indication
RSRP	Reference Signal Received Power
RSRQ	Reference Signal Received Quality
TB	Transport Block
UCI	Uplink Control Information
UICC	Universal Integrated Circuit Card

4 Background

4.1 Band Definitions for 5G Trial

The 5G trial is determined to be carried out on 28GHz band, and up to 8 carrier components of 100 MHz each as specified in the section 5.6.

4.2 5G Air Interface

The air interface defined in Verizon 5G TF relates closely to 3GPP release 13 specification for LTE, and is a natural evolution from it.

4.2.1 Beamforming

The nature of high propagation loss from high frequency electromagnetic waves calls for the utilization of beamforming, which by applying certain phase and gain adjustments on waveform transmitted by an array of antenna elements, a larger gain is achieved in the desired direction of transmission. Beamforming is thus an essential part of any commercial radio access networks that are deployed on a higher frequency in order to provide a sufficient coverage.

There are three types of realization for beamforming:

- Digital beamforming, which provides the largest degree of freedom in controlling the shape of a beam. The numbers of beams can be formed at a time is directly related to the number of transmitting antenna elements. This is also the most costly way for implementing beamforming.
- Analog beamforming, in which the beam is formed by analog components and only allows one beam to be active for a given OFDM symbol, it would be possible to apply different beams for different OFDM symbols.
- Hybrid beamforming, in which the beam is formed by analog components as in analog beamforming, but with multiple of such RF chains it is possible to have multiple beams formed at

any given OFDM symbol. Along with digital domain processing such as precoding which further enhanced the system's ability for supporting MIMO.

Members of Verizon 5G TF have agreed on adopting hybrid beamforming as the technology for realizing the next generation radio access network to be developed for its advantage in relatively flexible beamforming at a reasonable implementation cost, as well as ability to support both SU-MIMO and MU-MIMO [1-3].

4.2.2 Frame Structure

Verizon 5G air interface is designed to provide service with extremely low latency and flexibility for adopting to different traffic models.

Five times the sampling rate comparing to LTE gives $T_s = 1/(75000 \times 2048)$ seconds. Each radio frame of 10 ms consists of 100 slots of length $T_{\mathrm{slot}} = 15360 \cdot \mathrm{T_s} = 0.1\,\mathrm{ms}$. Two consecutive slots form a subframe and there are four subframe types supported:

- Subframe including DL control channel and DL data channel,
- Subframe including DL control channel, DL data channel and UL control channel,
- Subframe including DL control channel and UL data channel,
- Subframe including DL control channel, UL data channel and UL control channel.

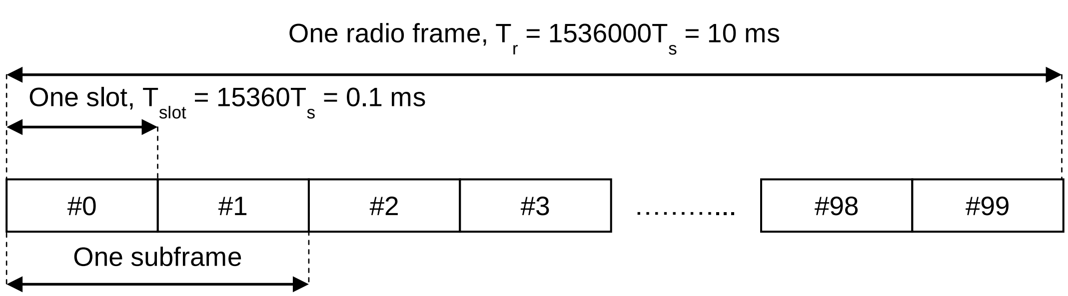

Figure 4.2.2-1: Frame Structure

4.2.3 Slot Structure

Both uplink and downlink share the same slot structure.

Each slot consists of 7 OFDM symbols in time domain as well as 100 PRBs in frequency domain. Each PRB consists of 12 subcarriers with the spacing of 75 KHz.

Table 4.2.3-1: Uplink Physical Resource Blocks Parameters

Configuration		N_{sc}^{RB}	N_{symb}^{UL}
Normal cyclic prefix	$\Delta f = 75\,\text{kHz}$	12	7

Table 4.2.3-2: Downlink Physical Resource Blocks Parameters

Configuration		N_{sc}^{RB}	N_{symb}^{DL}
Normal cyclic prefix	$\Delta f = 75\,\text{kHz}$	12	7

4.2.4 Physical Channels and Signals

Given the physical characteristic of higher frequency millimeter wave i.e. high propagation loss, beamforming is absolutely necessary for supporting a typical carrier grade RAN. Unlike current LTE system, where beamforming is only needed for traffic channels, in Verizon 5G RAN system, beamforming is needed for all physical layer channels and signals. And as a result, the following physical layer channels and signals are defined for Verizon 5G air interface [1].

- Uplink Physical channels
  - Physical Uplink Shared Channel, xPUSCH
  - Physical Uplink Control Channel, xPUCCH
  - Physical Random Access Channel, xPRACH
- Uplink Physical signals
  - Demodulation reference signal, associated with transmission of xPUCCH
  - Demodulation reference signal, associated with transmission of xPUSCH
  - Sounding reference signal, not associated with transmission of xPUSCH or xPUCCH
  - Phase noise reference signal, associated with transmission of xPUSCH
- Downlink Physical channels
  - Physical Downlink Shared Channel, xPDSCH
  - Physical Broadcast Channel, xPBCH
  - Extended physical broadcast channel, ePBCH
  - Physical Downlink Control Channel, xPDCCH
- Downlink Physical signals

    - UE-specific Reference Signal (DM-RS) associated with xPDSCH
    - UE-specific Reference Signal (DM-RS) associated with xPDCCH
    - CSI Reference Signal (CSI-RS)
    - Beam measurement Reference Signal (BRS)
    - Beam Refinement Reference Signal (BRRS)
    - Phase noise reference signal, associated with transmission of xPDSCH
    - Reference Signal (DM-RS) associated with ePBCH
- Synchronization signals
    - Primary synchronization signal, PSS
    - Secondary synchronization signal, SSS
    - Extended synchronization signal, ESS

4.2.5 Modulation

Modulation schemes for the physical channels are listed in table 4.2.5-1 below.

Table 4.2.5-1: Modulation Schemes of Physical Channels

Physical channel	Modulation schemes
xPUSCH	QPSK, 16QAM, 64QAM
xPUCCH	QPSK
xPDSCH	QPSK, 16QAM, 64QAM
xPBCH	QPSK
ePBCH	QPSK
xPDCCH	QPSK

4.2.6 Random Access

The parameters xPRACH are defined to be sufficient to support random access of up to 1 Km. There are up to 2 subframes within each radio frame that are dedicated for random access. Each of the random access subframes is consist of 5 or 4 random access opportunities each has a length of 2 symbols (due to extended cyclic prefix used, there are only 10 symbols in the random access subframe)

Table 4.2.6-1: Random Access Preamble Parameters

Preamble format	T_{GP1}	T_{CP}	T_{SEQ}	N_{SYM}	T_{GP2}
0	2224*T_s	656*T_s	2048*T_s	10	1456*T_s
1	2224*T_s	1344*T_s	2048*T_s	8	1360*T_s

Table 4.2.6-2: Random Access Configuration

PRACH configuration	System Frame Number	Subframe Number
0	Any	15, 40
1	Any	15

4.2.7 UL Timing Advance

A 5G UE shall transmit $(N_{\mathrm{TA}} + N_{\mathrm{TA\ offset}}) \times T_s$ seconds before the corresponding downlink frame for offsetting the propagation delay, where $0 \leq N_{\mathrm{TA}} \leq 1200$ and $N_{\mathrm{TA\ offset}} = 768$.

4.2.8 Channel Coding

LDPC (Low Density Parity Check) and Turbo coding are selected for sending unicast traffic whereas Tail Biting Convolutional Coding (TBCC) and Reed-Muller (RM) Coding is used for broadcasting and control information.

Table 4.2.8-1: Usage of Channel Coding Scheme and Coding Rate for Traffic Channels.

Transport Channel	Coding scheme	Coding rate
UL-SCH	LDPC coding Turbo coding (optional)	Variable 1/3
DL-SCH		
BCH	TBCC	1/3

Table 4.2.8-2: Usage of Channel Coding Scheme and Coding Rate for Control Information

Control Information	Coding scheme	Coding rate
DCI	TBCC	1/3
UCI	RM	Variable

4.3 Summary of Key System Parameters

Table 4.3-1 below provides a summary of key system parameters for the Verizon 5G air interface design.

Table 4.3-1: Key 5G System Parameters

Parameters	Values
Frequency Band (GHz)	28
Bandwidth (MHz)	100
Subcarrier Spacing	75 KHz

Cyclic Prefix Length	First OFDM Symbol	160Ts
	Remaining OFDM Symbol	144Ts
Rank		up to 2 per transmission point
Modulation	DL	up to 64 QAM
	UL	up to 64 QAM
Timing Advance	Min	0Ts
	Max	1200Ts
	TA_{offset}	768Ts

5 Test Configuration

5.1 Lab Configuration

Figure 5-1 shows a recommended lab configuration. Any variations from this or any specific configurations are described in each of the test case sections. A 5G UE is connected to a 5G NB via over the air transmission or wired connection during testing, and test application servers may be required for traffic generations.

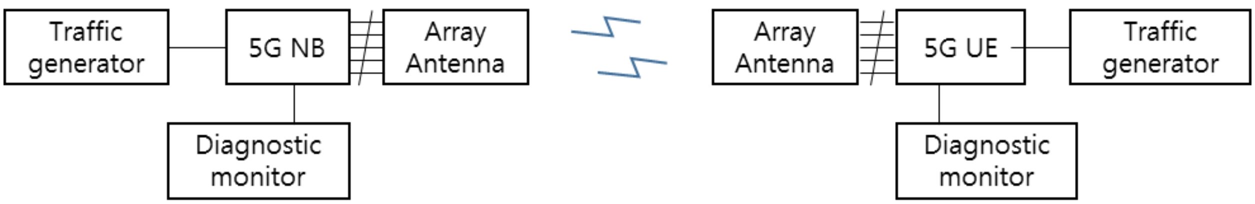

Figure 5.1-1: Lab Configuration

In each of the test cases, the test procedures contain instructions to control the RF power of the 5G NB. It is acceptable to turn the power down low enough to ensure that the 5G UE loses the RF connection, but the lab environment must confirm that the 5G UE actually lost the RF connection during the test execution.

5.2 UICC Configuration

The lab UICC is based on most current Verizon Wireless LTE commercial UICC. It is programmed for a simulated network environment and is not intended to access commercial networks.

- The lab UICC contains static values, including --
- Access conditions (PIN, PUK, ADM, etc.)
- Authentication values (Milenage keys)
- Identifiers (ICCID, IMSI)
- Subscription values (MSISDN, PLMN-related files, etc.)

Vendors are required to request for pre-approval from VZ in order to directly acquire UICC from VZ-approved UICC vendors.

5.3 5G UE Configuration

The device shall support a test mode in which the device is configured for Single RAT only operation (e.g. 5G only mode). In this test mode, the device shall disable any other radio access technologies supported in the device, and the device shall not perform any inter-RAT functions while attached to the test network. By default, this test mode shall be disabled, i.e. by default the device is configured for normal operation. This test mode shall be enabled and disabled using a non-volatile memory setting.

5.4 5G NB Configuration

The 5G NB shall support testability functionality, allowing observation of the current entity state and state transitions during normal operation. This functionality shall enable successful test result determination of all test cases included in this document (i.e. unambiguous failure due to underlying defects, or success due to lack of defects - both with desired, agreed level of certainty).

For the purpose of this activity 5G NB shall support mentioned functionality for 5G RAN.

5.5 Test Tool

This section describes the settings on tools that are used in the execution of this test plan.

5.5.1 Traffic Generator

Traffic generator is required to measure throughput and verify other test cases' operability. If internal traffic generator (e.g. MAC padding) is available, L1 peak throughput can be measured using this function. Otherwise, various tests which depend on measuring performance using UDP shall be executed using iPerf (iPerf is an open source tool available at http://sourceforge.net/projects/iperf). Details on the configuration of iPerf in both the server and client are described below:

Details on the configuration of iPerf in both the server and client are described below:

- Type of transport protocol used: UDP (-u); otherwise it is FTP
- Packet size: 1418 bytes for IPv4 and 1300 for IPv6 (-l) to avoid fragmentation
- Transmit Time: 65 Seconds (-t)
- UDP Bandwidth: Will be adjusted per case to avoid packet loss (-b)
- Bidirectional testing where applicable (-d)
- Report Interval: 1 sec (-i)

- Format: Kilobits (-f)
- IP: -V is used for IPv6; if not, then IPv4
- For example for IPv4: iperf -c <Server IP Address> -u -i 1 -p <Server Port> -l 1418.0B -f k -b <UDP BW> -t 65
- For example for IPv6: iperf –c <server IP Address> -i 5 –t 300 –l 1300 –u –b 5m -V

In the test cases listed in this document, pass/fail criteria are often listed in terms of the average data rate (e.g. Mbps). The tools used in executing these tests often provide the amount of time it takes for a file to be transmitted from the source to the destination (and it is a simple calculation to determine the transmission rate). In this document, the term "throughput" is the measure for a part of pass/fail criteria and it is acceptable to calculate this based on the output of the tools.

5.5.2 Diagnostic Monitor

All test cases must be performed while using a Diagnostic Monitor (DM) to capture every test session. Required logging items (common logging items) will be listed in this section, and specific logging item will be listed in each test case section.

Table 5.5.2-1: Required Logging Items

Required Logging Item	5G NB side	5G UE side
Signaling message	All messages	All messages
Received signal strength & quality	Uplink signal strength	DL RSRP, RSRQ
Transmit power	Downlink Tx Power	Uplink Tx Power
Cell information (Serving)	Cell ID/CP/5GARFCN	Cell ID/CP/5GARFCN
xPDSCH or xPUSCH configuration	Number of Antenna Transmission mode Spatial Rank RB allocation PMI index TB size Modulation Scheme	Number of Antenna Transmission mode Spatial Rank RB allocation PMI index TB size Modulation Scheme
Physical Data throughput	Peak, Average throughput BLER	Peak, Average throughput BLER
CSI report	CQI/PMI/RI reported from 5G UE	Measured CQI/PMI/RI
Beam Information	Scheduled Beam Info	Beam ID, BSI, BRI

5.6 Frequency Bands and Channel Arrangement

5.6.1 Operating Bands

5G trial system operating bands defined in Tables 5.6-1, and specific bands for DL and UL will be determined by the Verizon.

Table 5.6.1-1: Operating Bands

Operating Band	Uplink (UL) 5G NB receive UE transmit			Downlink (DL) 5G NB transmit UE receive			Duplex Mode
	F_{UL_low} – F_{UL_high}			F_{DL_low} – F_{DL_high}			
TBD	TBD MHz	–	TBD MHz	TBD MHz	–	TBD MHz	TDD

5.6.2 Channel Spacing

The spacing between carriers will depend on the deployment scenario, the size of the frequency block available and the channel bandwidths. The nominal channel spacing between two adjacent carriers is defined as following:

$$\text{Nominal Channel spacing} = (BW_{Channel(1)} + BW_{Channel(2)})/2,$$

where $BW_{Channel(1)}$ and $BW_{Channel(2)}$ are the the channel bandwidths of the two respective 5GRA carriers. The channel spacing can be adjusted to optimize performance in a particular deployment scenario.

For intra-band contiguous carrier aggregation with two or more component carriers, the nominal channel spacing between two adjacent 5GRA component carriers is defined as the following:

$$\text{Nominal channel spacing} = \left\lfloor \frac{BW_{Channel(1)} + BW_{Channel(2)} - 0.5\left|BW_{Channel(1)} - BW_{Channel(2)}\right|}{3} \right\rfloor 1.5 \quad [\text{MHz}],$$

where $BW_{Channel(1)}$ and $BW_{Channel(2)}$ are the channel bandwidths of the two respective 5GRA component carriers according to Table 5.6.3-1 with values in MHz. The channel spacing for intra-band contiguous carrier aggregation can be adjusted to any multiple of 1.5 MHz less than the nominal channel spacing to optimize performance in a particular deployment scenario.

5.6.3 Channel Bandwidth

Requirements in present document are specified for the channel bandwidths listed in Table 5.6.3-1

Table 5.6.3-1: Transmission Bandwidth Configuration N_{RB} in 5G RA Channel Bandwidths

Configuration Parameters	Values
Channel bandwidth $BW_{Channel}$ [MHz]	100
Transmission bandwidth configuration N_{RB}	100

Figure 5.6.3-1 shows the relation between the Channel bandwidth ($BW_{Channel}$) and the Transmission bandwidth configuration (N_{RB}). The channel edges are defined as the lowest and highest frequencies of the carrier separated by the channel bandwidth, i.e. at F_C +/- $BW_{Channel}$ /2.

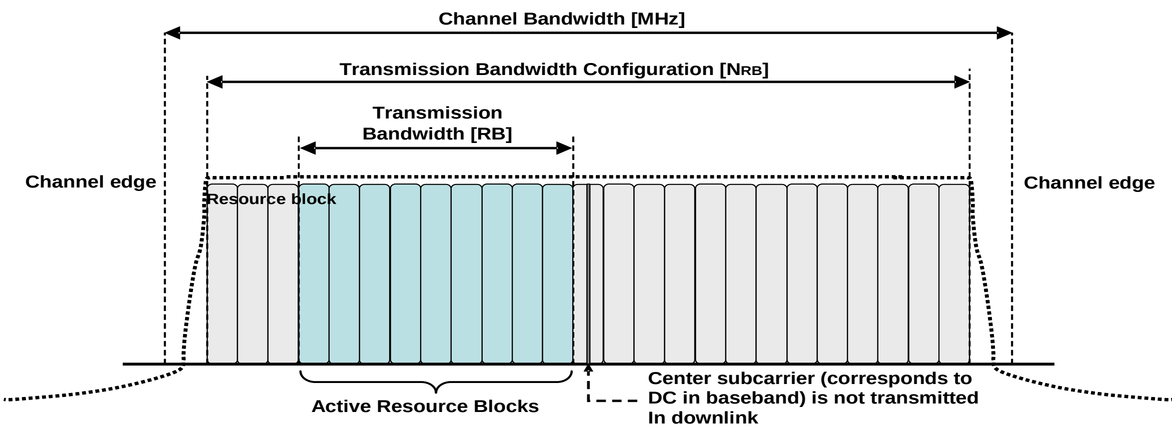

Figure 5.6.3-1: Definition of Channel Bandwidth and Transmission Bandwidth Configuration for a Single 5G RA Carrier

For intra-band contiguous carrier aggregation Aggregated Channel Bandwidth, Aggregated Transmission Bandwidth Configuration and Guard Bands are defined as follows, see Figure 5.6.3-2.

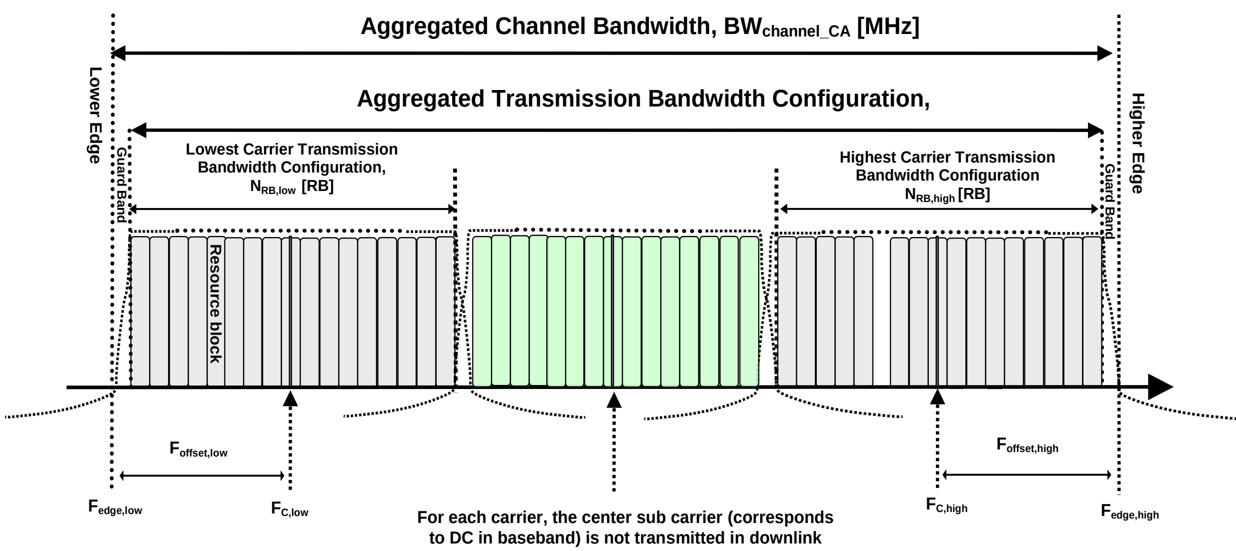

Figure 5.6.3-2: Definition of Aggregated Channel Bandwidth and Aggregated Channel Bandwidth Edges

The aggregated channel bandwidth, $BW_{Channel\_CA}$, is defined as

$$BW_{Channel\_CA} = F_{edge,high} - F_{edge,low} \text{ [MHz]}.$$

The lower bandwidth edge $F_{edge,low}$ and the upper bandwidth edge $F_{edge,high}$ of the aggregated channel bandwidth are used as frequency reference points for transmitter and receiver requirements and are defined by

$$F_{edge,low} = F_{C,low} - F_{offset,low}$$

$$F_{edge,high} = F_{C,high} + F_{offset,high}.$$

6 Test Cases

6.1 System Access

6.1.1 Cell Acquisition and Initial Access

6.1.1.1 Test Overview and Purpose

The test is designed to verify that 5G NB is able to transmit signals for UE cell selection and downlink synchronization (i.e., PSS/SSS/ESS, xPBCH) and receive signals from the 5G UE for the uplink synchronization (i.e., xPRACH). On the other hand, it also can be used to verify that the 5G UE is able to search/measure cells, perform downlink synchronization, obtain system information, and carry out random access for uplink synchronization.

Table 6.1.1.1-1: Test Overview for System Access

Overview	Description
Objective	The DUTs shall successfully perform the attachment procedures
Related L1 Function / Channel	PSS/SSS/ESS, xPBCH, xPRACH, ePBCH, xPDSCH, xPUSCH
Test method / procedure	Power on DUT / Check DM message
Required logging item	Random Access Response, RRC Connection Request, RRC Connection Setup, RRC Connection Setup Complete
Pass/Fail Criteria	Downlink synchronization (5G UE), Uplink synchronization (5G NB, 5G UE), RRC Connection Setup completion
Sub test case	According to various xPRACH format and xPBCH payload, e.g., SFN

6.1.2 Minimum Conformance Requirements

- The 5G NB shall transmit synchronization signals including PSS/SSS/ESS and broadcast channel xPBCH periodically with pre-configured periodicity utilizing predefined transmit beam patterns.
- The 5G NB shall be able to transmit BRSs each mapped with a specific Tx beam index.
- The 5G NB shall be able to assign xPRACH regions each associated with different Tx beam index.
- The 5G NB shall perform adjustments for UE timing/ Tx power as needed for proper signal reception based on the uplink signal such as xPRACH
- The 5G UE shall be able to perform time/frequency synchronization and identify cells by detecting PSS/SSS, obtain system information by decoding xPBCH/ePBCH, and select preferred 5G NB Tx and 5G UE Rx beam pair(s) by measuring BRSs.
- The 5G UE shall be able to select an xPRACH resource to transmit a RACH preamble and to adjust uplink transmit timing and Tx power according to the adjustment message from the 5G NB.

6.1.3 Test Description

6.1.3.1 Initial Conditions

1. Connect the 5G NB to the 5G UE antenna connectors. (The over-the-air test configuration can be set if interfaces for conducted test unavailable and/or beamforming effects of 5G NB and 5G UE need to be explicitly applied)
2. The general test parameter settings are set up according to Section 5.4.
3. The system configurations including Cell ID and periodicity of the synchronization signals (PSS/SSS/ESS) are preconfigured at the 5G NB.

Table 6.1.3.1-1: Test Parameter Set 1 for System Access

Parameter	Value	Comment
PRACH Preamble Format	0	A PRACH preamble format for 500m cell radius
PRACH configuration	1	Any frame, subframe 15
Sync signal configuration (PSS/SSS/ESS)	3	Set Cell ID such that mod(CellId,3) =0
BRS configuration	'01'	Period of BRS is 1 subframe (5ms)
UE Location		Place a 5G UE at the rightmost(leftmost) side of 5G NB

Table 6.1.3.1-2: Test Parameter Set 2 for System Access

Parameter	Value	Comment
PRACH Preamble Format	1	A PRACH preamble format for 1000m cell radius
PRACH configuration	1	Any frame, subframe 15
Sync signal configuration (PSS/SSS/ESS)	7	Period of BRS is 2 subframe. Set Cell ID such that mod(CellId,3)=1
BRS configuration	‘10’	Period of BRS is 2 subframe (10ms)
UE Location		Place a 5G UE at the center of 5G NB

Table 6.1.3.1-3: Test Parameter Set 3 for System Access

Parameter	Value	Comment
PRACH Preamble Format	0	A PRACH preamble format for 500m cell radius
PRACH configuration	0	Any frame, subframes 15, 40
Sync signal configuration (PSS/SSS/ESS)	7	Period of BRS is 2 subframes Set Cell ID such that mod(CellId,3)=1
BRS configuration	‘10’	Period of BRS is 2 subframes (10ms)
UE Location		Place a 5G UE at the center of 5G NB

6.1.3.2 Test Procedure

1. Switch on the 5G NB and pre-configure the 5G NB with the general test parameters and the additional test parameters.
2. Switch on the 5G UE and initiate the initial system access
3. Wait until the UE accomplishes downlink synchronization and detects the Cell-ID as configured by the 5G NB. Check for the Pass/Fail based on the logs at the 5G NB and 5G UE diagnostic monitors. (Note: This test step includes test procedure to check if 5G NB transmits synchronization signals as expect as well.)
4. Upon UE downlink synchronization accomplishment, check the system information obtained from the xPBCH is identical to that transmitted by 5G NB. That is, check if the 5G UE gets system information (MIB).

5. Check the 5G UE measures Beam Reference Signal (BRS) to find preferred 5G NB Tx beam and 5G UE Rx beam pair(s).

6. Check the UE obtains the system information for random access from ePBCH. Check that the obtained information is same as the system information configured at the 5G NB.

7. Wait until the 5G NB detects a RACH preamble among the xPRACH regions. Check if the RACH preamble ID detected at the 5G NB is identical to that transmitted by the UE. Also, check the beam index associated with the xPRACH region, wherein the RACH preamble is detected, is the same as the selected 5G NB Tx beam index at the UE.

8. Check the 5G NB sends a Random Access Response within ra-ResponseWindowSize + 3 subframes to the UE since the end of RACH preamble transmission and the UE receives the Random Access Response. The Random Access Response may include timing /Tx power adjustment. When adjustment is indicated by the 5G NB, it should be checked if the adjustment is applied by the UE as indicated.

9. After accomplishing the uplink synchronization, check the UE sends RRC Connection Request to the 5G NB followed by the RRC Connection Setup transmission from the 5G NB to the UE.

   (NOTE: SRB1 shall be established between UE and 5G NB after the UE receives RRC Connection Setup message.)

10. Upon UE receiving the RRC Connection Setup, check The UE replies RRC Connection Setup Complete message to the 5G NB.

6.1.3.3 Pass/Fail verdict

1. Pass verdict: The 5G NB and the UE successfully complete the system access process as stated in the test procedure for all the test configuration cases.

2. Fail verdict: The 5G NB and the UE do not correctly complete the system access process by failing to accomplish at least one of the steps in the test procedure for at least one of the test configuration cases.

6.2 Data Throughput

6.2.1 Downlink Throughput

6.2.1.1 Test Overview and Purpose

The purpose of this test is to verify that the DL PHY layer can process xPDSCH in a sustainable manner. The test measures the sustainable downlink throughput with a reference transport block success rate considering HARQ, and checks if the received packets corresponding to the maximum number of DL-SCH transport block bits can be decode correctly and delivered to high layers. Table 6.2.1.1.-1 shows an overview of downlink throughput test

Table 6.2.1.1-1: Test Overview for Downlink Throughput

Overview	Description
Objective	Measure the sustainable downlink throughput
Related L1 Function / Channel	xPDSCH
Test method / procedure	Sustainable data rate - Ideal channel condition - Assume that all system access procedure is finished - Check transport block (TB) success rate by UE logging information ○ TB success rate = 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.
Required logging item	Counts for received transport blocks and CRC check result in the UE logging
Pass/Fail Criteria	TB success rate
Sub test case	Carrier aggregation cases and different MCSs

6.2.1.2 Minimum Conformance Requirements

- The 5G NB and UE shall be able to complete RRC setup via system access procedures.
- The 5G NB shall transmit xPDCCH to schedule xPDSCH to a specific UE with a beam(s) acquired at the initial access procedure.
- The UE shall be able to search and decode a relevant DCI in xPDCCH and receive/decode corresponding xPDSCH once finishing synchronization process for time/frequency/TX power from PSS/SSS/ESS and acquiring essential system information from xPBCH/ePBCH.
- The UE shall be able to feedback ACK/NACK information to the 5G NB for received transport blocks.
- The 5G NB shall be able to retransmit the erroneous transport block based on the feedback from the UE.

6.2.1.3 Test Description

The sustained downlink data rate shall be verified in terms of the success rate of delivered PDCP SDU(s) by high layer. The PDCP SDU(s) can be generated by 5G NB internal traffic generator with MAC padding or by external iPerf server in 5G NB side. The test is performed after RRC connection setup is completed, and it is assumed that the test UE has selected a beam for receiving xPDSCH up to rank-2. In order to make rank-2 wireless channels, antenna polarization can be utilized in the wireless setup.

The test case below specifies system setups and the required success rate of delivered TB by PHY layer to meet the sustained data rate requirement. The size of the TB per TTI corresponds to the largest possible DL-SCH transport block using the maximum number of layers for spatial multiplexing. The transmission mode, where rank-2 transmission with an antenna polarization is recommended with radio conditions resembling a scenario where sustained maximum data rates are available. In order to verify the maximum sustainable data rate, carrier aggregation up to 8CCs is considered. Table 6.2.1.3-1 are used for all downlink throughput tests unless otherwise stated.

Table 6.2.1.3-1: Test Parameters for Testing xPDSCH

Parameter Category	Parameter	Unit	Value
System Parameters	Bandwidth	# of PRBs per CC	100
	Symbol indices used for data transmission		l'=1, 3, 4, …., 13 (Note: l'=0 is for downlink control and l'=2 is for DM-RS)
	Cyclic prefix		Normal
	Cell ID		0
	Number of OFDM symbols for xPDCCH (*)	OFDM symbols	1
MIMO Parameters	Rank		2
	DM-RS antenna ports(s)		Any of two AP(s)
	PCRS		One of AP(s)
HARQ Parameters	Maximum number of HARQ transmission		4
	Number of HARQ processes per CC		10
Carrier Aggregation Parameters	Number of CCs		1, 8
	Cross carrier scheduling		Not configured
Channel Parameters	Propagation condition		Static propagation condition No external noise sources are applied

For 5G UE, the requirements are specified in Table 6.2.1.3-2, and the TB success rate is defined as TB success rate = 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 number of bits of a DL-SCH transport block received within a TTI for normal is calculated by the reference measurement channel configurations such as R.5G.D1 and R.5G.D2 in Appendix A. The modulation is fixed to 64QAM, and each of reference measurement channel has a different effective coding rate and subframe configurations. The R.5G.D1 measurement channel is targeting for the highest coding rate, while R.5G.D2 is defined for moderate coding rate. The TB success rate shall be sustained during at least 300 frames.

Table 6.2.1.3-2: Minimum Requirement (64QAM) for xPDSCH

Test	Number of CCs	Number of bits of a DL-SCH transport block received within a subframe	Measurement channel	Reference value
				TB success rate [%]
1	1	132808	R.5G-D1	85
1A		70376	R.5G-D2	85
8	8	132808 x 8	R.5G-D1	85
8A		70376 x 8	R.5G-D2	85

Table 6.2.1.3-3 shows test parameters for each test. Two sets of test cases can be considered depending on the number of CCs up to 8 CCs. The test cases assume that no power boosting of BRS and no unused PRBs, and a fixed codebook is applied to control PMI selection.

Table 6.2.1.3-3: Test Parameters for Sustained Downlink Data Rate (64QAM)

Test	Bandwidth (MHz)	Rank	$\hat{E}_s$ at antenna port (dBm/75kHz)	ACK/NACK feedback mode
1, 1A	100	2	-78 (Note 1)	xPUCCH
8, 8A	8x100*	2	-78	xPUCCH
Note 1: -85dBm in LTE and scaled 5 times due to larger subcarrier spacing				

6.2.1.3 Test Procedure

1. Switch on the 5G NB and pre-configure the 5G NB with the general test parameters and the additional test parameters.
2. Switch on the UE and initiate the initial system access.
3. Wait until UE receiving the RRC Connection Setup and The UE replies RRC Connection Setup Complete message to the 5G NB.
4. Command 5G NB internal traffic generator or iPerf server to provide DL traffic to the test UE.
5. Logging the number of attempt TBs, the retransmitted TBs, and the success TBs, and calculate the TB success rate.

Note: A tester can choose 2 symbols of xPDCCH as another test case and the same procedure can be repeated from 1 to 5

6.2.2 Uplink Throughput

6.2.2.1 Test Overview and Purpose

The purpose of this test is to verify that the UL PHY layer can provide a sustainable data throughput using xPUSCH. Table 6.2.2.1-1 shows an overview of uplink throughput test.

Table 6.2.2.1-1: Test Overview for Uplink Throughput

Overview	Description
Objective	Measure the sustainable uplink throughput
Related L1 Function / Channel	xPUSCH
Test method / procedure	UL sustainable data rate - Assume that ideal channel condition - Assume that all system access procedure is finished - Check transport block (TB) success rate by 5G NB tracing information
Required logging item	Counts for transport blocks in the 5G NB tracing
Pass/Fail Criteria	TB success rate
Sub test case	Different ranks

6.2.2.2 Minimum Conformance Requirements

- The 5G NB and UE shall be able to complete RRC setup via system access procedures.
- The 5G NB shall transmit xPDCCH to schedule xPUSCH to a specific UE with a beam(s) acquired at the initial access procedure.
- The UE shall be able to search and decode a relevant DCI for uplink transmissions in xPDCCH and transmit xPUSCH in a scheduled subframe indicated in the DCI.
- The 5G NB shall be able to re-schedule retransmissions of the erroneous transport blocks in xPUSCH.

6.2.2.3 Test Description

The PDCP SDU(s) can be generated by external iPerf server attached in UE. The requirement of xPUSCH is determined by the TB success rate which has the same definition with downlink in an ideal channel condition, e.g., high SNR without external noise sources. The TB success rate is measured for the fixed reference channels R.5G.U1 and R.5G.U2 listed in Annex A. The performance requirements assume HARQ retransmissions. Performance requirements apply for a single carrier only. Performance requirements for a 5G NB supporting carrier aggregation are defined in terms of single carrier requirements. Table 6.2.1.3-1 are used for all uplink throughput tests unless otherwise stated.

Table 6.2.2.3-1: Test Parameters for Testing xPUSCH

Parameter Category	Parameter	Unit	Value

System Parameters	Bandwidth	# of PRBs per CC	100
	Symbol indices used for data transmission		l'=3, 4, 5, …, 13 (Note: l'=0 is for downlink control, l'=1 is for gap, and l'=2 is for DM-RS)
MIMO Parameters	Rank		1 (non-SFBC) or 2
	DM-RS AP(s)		One or two depending on ranks
HARQ Parameters	Maximum number of HARQ transmission		4
	Number of HARQ processes		10
Rx Power	$\hat{E}_s$ at antenna port (dBm/75kHz)		-78 (Same as DL)
Carrier Aggregation			Not considered
Channel Parameters	Propagation condition		Static propagation condition No external noise sources are applied

The TB success rate shall be equal to or larger than the reference values stated in the table 6.2.2.3-2 for rank-1 and rank-2 transmissions, and CA is not considered.

Table 6.2.2.3-2: Minimum Requirement (64QAM) for xPUSCH

Test	Rank	Number of bits of a UL-SCH transport block received within a subframe	Measurement channel	Reference value
				TB success rate [%]
1	1	66392	R.5G.U1	85
2	2	132808	R.5G.U2	85

6.2.2.3 Test Procedure

1. Switch on the 5G NB and pre-configure the 5G NB with the general test parameters and the additional test parameters.
2. Switch on the UE and initiate the initial system access.
3. Wait until UE receiving the RRC Connection Setup and The UE replies RRC Connection Setup Complete message to the 5G NB.
4. Command the iPerf server in the UE side to provide UL traffic to the 5G NB.
5. Logging the number of attempt TBs, the retransmitted TBs, and the success TBs, and calculate the TB success rate.

6.3 RRM Measurements

6.3.1 Beam Acquisition

6.3.1.1 Test Overview and Purpose

The main purpose of this test case is to verify that 5G UE can find synchronization signals and detect transmitted BRS sequences. Logical beam index is correctly determined and printed in test logs with measured beam strength and beam ID. Table 6.3.1.1-1 gives an overview of the beam acquisition test case.

Table 6.3.1.1-1: Test Overview for Beam Acquisition

Overview	Description
Objective	The DUT shall successfully detect a beam ID and report the detected ID to 5G NB.
Related L1 Function / Channel	PSS, SSS, ESS, BRS, xPBCH, xPRACH
Test method / procedure	Power on DUT / Check DM message
Required logging item	Beam ID of the strongest beam chosen by UE (UE logs)
Pass/Fail Criteria	Detectability of best beam in ideal channel
Sub test case	For a given AP configuration, various UE directions can be taken into account

6.3.1.2 Minimum Conformance Requirements

- Pre-requisite for this test case is such that 5G NB and UE are correctly calibrated to ensure proper beam patterns in each pre-defined direction. Optionally testers can use 3rd party signal strength scanner to verify it before starting the test
- The 5G NB shall transmit synchronization signals including PSS/SSS/ESS and broadcast channel xPBCH/ePBCH periodically with pre-configured periodicity utilizing predefined transmit beam patterns.
- The 5G NB shall be able to transmit BRSs each mapped with a specific Tx beam index.
- The 5G NB shall be able to assign xPRACH regions each associated with different Tx beam index.
- The 5G NB shall perform adjustments for UE timing/ Tx power as needed for proper signal reception based on the uplink signal such as xPRACH
- The UE shall be able to perform time/frequency synchronization and identify cells by detecting PSS/SSS/ESS, obtain system information by decoding xPBCH and ePBCH, and select preferred 5G NB Tx and UE Rx beam pair(s) by measuring BRSs.

- The UE shall be able to select an xPRACH resource to transmit a RACH preamble and to adjust uplink transmit timing/ Tx power according to the adjustment message from the 5G NB.

6.3.1.3 Test Description

6.3.1.3.1 Initial Conditions

1. Turn on the 5G NB configured with necessary parameters as specified in V5G.211 [1].
2. Turn on the 5G UE configured with necessary parameters as specified in V5G.211 [1].
3. 5G NB transmits beams with static beam IDs assigned to each direction.

Table 6.3.1.3.1-1: Test Parameters for Beam Acquisition

Parameter	Unit	Value	Comment
BRS transmission periodicity configuration		’11’	every 20 ms
UE Location			Place 5G UE at previously calculated, pre-defined position of 5G NB beam pattern in range of the expected strongest beam at given position.

6.3.1.3.2 Test Procedure

1. Place 5G UE at previously defined position, in range of the expected strongest beam at this position.
2. 5G UE successfully accomplishes cell search, timing acquisition procedures and acquires physical Cell ID.
3. Via BRS strength measurements 5G UE detects the best beam and derives system information. 5G UE selects xPRACH resource that is associated to the selected beam determined from the BRSes of the cell.
4. 5G UE starts contention based RA procedure and sends corresponding RACH preamble. Beam ID is derived from the beam sequence and resources allocated in RACH.

6.3.1.3.3 Pass/Fail Criteria

1. Pass: 5G UE chooses the strongest beam ID or the second strongest beam ID and selects the corresponding PRACH configuration. It can be confirmed by comparing expected and reported beam IDs.
2. Fail: 5G UE does not choose the first or second strongest beam IDs, does not choose anything, selects a wrong PRACH configuration, or does not send msg1 at all.

6.3.2 Beam Tracking/Refinement

6.3.2.1 Test Overview and Purpose

The main purpose of this test case is to verify if 5G UE is able to report changing beam quality and report it to 5G NB. 5G NB should be able to perform beam switching based on this report. Table 6.3.2.1-1 gives an overview of the beam tracking/refinement test case.

Table 6.3.2.1-1: Test Overview for Beam Tracking/Refinement

Overview	Description
Objective	The DUT shall successfully detect a set of up to 4 candidate beams, and report BSI to 5G NB as requested by 5G NB. When reporting BSI on xPUCCH, 5G UE reports BSI for a beam with the highest BRSRP in the candidate beam set. When reporting BSI on xPUSCH, 5G UE reports BSIs for N={1, 2, 4} beams with the highest BRSRP in the candidate beam set, where N is provided in the 2-bit BSI trigger from 5G NB. The BSI reports are sorted in decreasing order of BRSRP [3].
Related L1 Function / Channel	PSS, SSS, ESS, BRS, BRRS, xPBCH, xPUSCH, xPUCCH
Test method / procedure	Check DM message
Required logging item	The strongest one and the second strongest (candidate) beam IDs reporting
Pass/Fail Criteria	Beam switching procedure according to the reported beam ID is successful and 5G UE remains in RRC Connected state
Sub test case	For a given AP configuration, various UE directions can be taken into account

6.3.2.2 Minimum Conformance Requirements

- Pre-requisite for this test case is such that 5G NB and UE are correctly calibrated to ensure proper beam patterns in each pre-defined direction. Optionally testers can use 3rd party signal strength scanner to verify it before starting the test.
- The 5G NB shall transmit synchronization signals including PSS/SSS/ESS and broadcast channel xPBCH/ePBCH periodically with pre-configured periodicity utilizing predefined transmit beam patterns.
- The 5G NB shall be able to transmit BRSs each mapped with a specific Tx beam index.
- The 5G NB shall be able to assign xPRACH regions each associated with different Tx beam index.
- The 5G NB shall perform adjustments for UE timing/ Tx power as needed for proper signal reception based on the uplink signal such as xPRACH
- The UE shall be able to perform time/frequency synchronization and identify cells by detecting PSS/SSS/ESS, obtain system information by decoding xPBCH/ePBCH, and select preferred 5G NB Tx and UE Rx beam pair(s) by measuring BRSs.

- The UE shall be able to select an xPRACH resource to transmit a RACH preamble and to adjust uplink transmit timing/ Tx power according to the adjustment message from the 5G NB.
- The UE shall be able to adjust its Rx beams using BRS or BRRS signals
- The UE shall be able to report BSI and BRI via xPUCCH or xPUSCH.

6.3.2.3 Test Description

6.3.2.3.1 Initial Conditions

1. 5G NB is in operational state.
2. 5G UE is placed in range of one of the outermost beams.
3. 5G UE is in operational, RRC connected state.
4. Bidirectional communication is ongoing – either using iPerf in DL and UL or ICMP (ping).

Table 6.3.2.3.1-1: Test Parameters for Beam Tracking/Refinement

Parameter	Unit	Value	Comment
BRS transmission periodicity configuration		'11'	every 20 ms
BRRS symbols per assignment	symbols	1 or 2	The 5G NB can transmit a BRRS symbol(s) with DCI indications
UE Location			Place 5G UE at previously calculated, pre-defined position of 5G NB beam pattern in range of the expected strongest beam at given position. During the test 5G UE will be moved along pre-defined path or rotated at the given position

6.3.2.3.2 Test Procedure

1. 5G UE reports current set of beams including the strongest candidate beam based on the measurements in BRS or BRRS.
2. Tester moves the 5G UE towards neighbour beam (assumption is that beam pattern is such that there is one strongest neighbour beam on the path of the move) and keep moving along pre-defined path to simulate changing Tx beam environment or tester rotates the 5G UE at the original position to simulate different Rx beam environments
3. 5G UE is reporting BSI or BRI of the best beam and beam candidates to 5G NB via xPUCCH or xPUSCH.
4. 5G NB is making decision on beam switching according to the reports provided by 5G UE.
5. 5G NB changes current operating beam for the 5G UE to the one reported as the best one.

6. 5G UE follows the change different beam ID as active, and continue to refine its Rx beams when BRS or BRRS are available with the changed Tx beam condition.

6.3.2.3.3 Pass/Fail criteria

1. Pass: the expected strongest beam or the second strongest beam at different locations or different rotations is used (verified in 5G UE logs), transmission still ongoing.
2. Fail: the expected strongest beam or the second strongest beam at different locations or different rotations is not always selected. Communication might be still ongoing on the same beam ID and the same Rx beam or be stopped.

6.4 Link Adaptations

6.4.1 CQI Reporting

6.4.1.1 Test Overview and Purpose

The purpose of this test is to verify that the reported CQI value should be decoded correctly in 5G NB side and throughput should be changed according to CQI value. Table 6.4.1.1-1 shows an overview of CQI reporting test.

Table 6.4.1.1-1: Test Overview for CQI reporting

Overview	Description
Objective	Verify CQI in xPUCCH or xPUSCH
Related L1 Function / Channel	xPUCCH, xPUSCH
Test method / procedure	Transmit DL data / check DM message / Measure BLER
Required logging item	CQI, SNR
Pass/Fail Criteria	Reported CQI value, BLER(Throughput)
Sub test case	Various reporting formats, xPUCCH, xPUSCH

6.4.1.2 Minimum Conformance Requirements

The reported CQI value should be decoded correctly in 5G NB side. It will be verified in various SNR conditions, and CQI and throughput shall be changed by SNR conditions.

6.4.1.3 Initial Condition

- Connect the 5G NB to the 5G UE as shown in Figure 5.1-1.
- The parameter settings for the cell and downlink signals are initially set up according to Tables 6.4.1.3-1 and 6.4.1.3-2.

Table 6.4.1.3-1: Test Parameter Set 1 for CQI Reporting

Parameter	Unit	Value
Bandwidth	MHz	100
Cyclic prefix		Normal
Cell ID		0
Number of OFDM symbols for xPDCCH	symbols	1
PDSCH transmission mode		Fixed TM through the test
Propagation condition and antenna configuration		Static propagation condition
SNR	dB	5, 10, 15
Max number of HARQ transmissions		1
Physical channel for CQI reporting		xPUCCH

Table 6.4.1.3-2: Test Parameter Set 2 for CQI Reporting

Parameter	Unit	Value
Bandwidth	MHz	100
Cyclic prefix		Normal
Cell ID		0
Number of OFDM symbols for xPDCCH	symbols	1
PDSCH transmission mode		Fixed TM through the test
Propagation condition and antenna configuration		Static propagation condition
SNR	dB	5, 10, 15
Max number of HARQ transmissions		1
Physical channel for CQI reporting		xPUSCH

6.4.1.4 Test Procedure

1. Set the parameters and generate downlink traffic using 5G NB internal traffic generator with MAC padding or by external iPerf server in 5G NB side after system access procedure.

2. Set 5dB SNR level in UE by changing position or combining AWGN generator. Reported CQI value, SNR, and L1 Throughput should be monitored using DM. Check the reported CQI values are stable in both 5G NB and UE side. After stabilizing, record all monitored parameters (CQI, SNR, and Throughput) and compare CQI value between 5G NB and UE. If compared value is different, then fail the UE for this test.

3. Set 10dB SNR level in UE by changing position or combining AWGN generator. Check the reported CQI values are stable in both 5G NB and UE side. After stabilizing, record all monitored

parameters (CQI, SNR, and Throughput), and compare CQI value between 5G NB and UE. CQI, and L1 throughput value shall be greater than the results from step 2, otherwise fail this case

4. Set 15dB SNR level in UE by changing position or combining AWGN generator. Check the reported CQI values are stable in both 5G NB and UE side. After stabilizing, record all monitored parameters (CQI, SNR, Throughput), and compare CQI value between 5G NB and UE. CQI, and L1 value shall be greater than the results from step 3, otherwise fail this case
5. If both PUCCH and PUSCH reporting tests have not been done, then repeat the same procedure (steps 1 to 4) with test conditions according to the table 6.4.1.3-1 and table 6.4.1.3-2. Otherwise the UE passes the test.

6.4.1.5 Pass/Fail Criteria

The pass fail decision is as specified in the test procedure in clause 6.4.1.4

6.4.2 RI Reporting

6.4.2.1 Test Overview and Purpose

The purpose of this test is to verify that the reported rank indicator accurately represents the channel rank.

Table 6.4.2.1-1: Test Overview for RI Reporting

Overview	Description
Objective	Verify RI in xPUCCH or xPUSCH
Related L1 Function / Channel	xPUCCH, xPUSCH
Test method / procedure	Transmit DL data / check DM message / Measure throughput
Required logging item	RI
Pass/Fail Criteria	Reported RI value, Throughput(BLER)
Sub test case	Various reporting formats / Rank

6.4.2.2 Minimum Conformance Requirements

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. Transmission mode 3 is used, and either 5G NB or 5G UE should support the function of fixing rank for test purpose.

6.4.2.3 Initial Condition

1. Connect the 5G NB to the UE as shown in Figure 5.1-1.
2. The parameter settings for the cell and downlink signals are initially set up according to Table 6.4.2.3-1.

Table 6.4.2.3-1: Test Parameters for RI Reporting

Parameter	Unit	Value
Bandwidth	MHz	100
Cyclic prefix		Normal
Cell ID		0
Number of OFDM symbols for xPDCCH	Symbols	1
PDSCH transmission mode		3
Propagation condition and antenna configuration		Static propagation condition
Physical channel for CQI/PMI reporting		PUCCH
Physical channel for RI reporting		PUCCH

6.4.2.4 Test Procedure

1. Set the parameters and generate downlink traffic using 5G NB internal traffic generator with MAC padding or by external iPerf server in 5G NB side after system access procedure.
2. Check reported RI value and find appropriate position to get rank 2. Check the reported RI values are stable in both 5G NB and UE side and compare RI value between 5G NB and UE. If compared value is different, then fail the UE for this test.
3. Measure L1 downlink throughput during 3 min, and record average throughput ($T_{Reported}$).
4. The 5G NB transmit downlink data with fixed rank
5. Measure L1 downlink throughput during 3 min, and record average throughput (T_{Fixed}).
6. Repeat steps 4 to 5 with fixed RI=1,2 and record maximum throughput among them ($T_{Fixed-max}$).
7. If the ratio ($T_{Reported}$ / $T_{Fixed-max}$) satisfies the requirement in clause 6.4.2.5, then pass the UE for this test and go to step 8. Otherwise, fail the UE.
8. If all tests have not been done, then repeat the same procedure (steps 1 to 7) with various rank condition (RI=1, 2). Otherwise pass the UE.

6.4.2.5 Pass/Fail Criteria

The pass fail decision is as specified in the test procedure in clause 6.4.2.4

- The ratio of the throughput obtained when transmitting based on UE reported RI and that obtained when transmitting with fixed rank 1 shall be ≥ 1;

- The ratio of the throughput obtained when transmitting based on UE reported RI and that obtained when transmitting with fixed rank 2 shall be ≥ 1;

6.4.3 PMI Reporting

6.4.3.1 Test Overview and Purpose

This test is designed to verify the Precoding Matrix Indicator (PMI) reporting functionality.

Table 6.4.3.1-1: Test Overview for PMI Reporting

Overview	Description
Objective	Verify PMI reporting in xPUCCH or xPUSCH
Related L1 Function / Channel	xPUCCH, xPUSCH
Test method / procedure	Transmit DL data / check DM message / measure throughput
Required logging item	PMI
Pass/Fail Criteria	Reported PMI value, Throughput(BLER)
Sub test case	Various reporting formats / PMI / RI

Table 6.4.3.1-2: Sub Test Case Definitions for PMI Reporting

Cases	Configurations
Test case 1	Reporting Format #1, Rank=2, PMI #1
Test case 2	Reporting Format #1, Rank=2, PMI #2
Test case 3	Reporting Format #2, Rank=2, PMI #1
Test case 4	Reporting Format #2, Rank=2, PMI #2

6.4.3.2 Minimum Conformance Requirements

Check the reported PMI values are stable in both 5G NB and UE side and compare PMI value between 5G NB and UE.

6.4.3.3 Initial Condition

1. Connect the 5G NB to the UE as shown in Figure 5.1-1.
2. The parameter settings for the cell and downlink signals are initially set up according to Table 6.4.3.3-1.

Table 6.4.3.3-1: Test Parameter Sets 1 and 2 for PMI Reporting

Parameter	Unit	Value
Bandwidth	MHz	100

Cyclic prefix		Normal
Cell ID		0
Number of OFDM symbols for xPDCCH	symbols	1
PDSCH transmission mode		3
Propagation condition and antenna configuration		Static propagation condition
Reporting channel		xPUCCH

Table 6.4.3.3-2: Test Parameter Sets 3 and 4 for PMI Reporting

Parameter	Unit	Value
Bandwidth	MHz	100
Cyclic prefix		Normal
Cell ID		0
Number of OFDM symbols for xPDCCH	symbols	1
PDSCH transmission mode		3
Propagation condition and antenna configuration		Static propagation condition
Reporting channel		xPUSCH

6.4.3.4 Test Procedure

1. Set the parameters and generate downlink traffic using 5G NB internal traffic generator with MAC padding or by external iPerf server in 5G NB side after system access procedure.
2. Check reported PMI value and find appropriate position to get rank 2. Check the reported PMI values are stable in both 5G NB and UE side and compare PMI value between 5G NB and UE. If compared value is different, then fail the UE for this test.
3. If all tests have not been done, then repeat the same procedure (steps 1 to 2) with sub test cases defined in table 6.4.3.1-2. Otherwise pass the UE.

6.4.3.5 Pass/Fail Criteria

The pass fail decision is as specified in the test procedure in clause 6.4.3.4

Annex A: Fixed Reference Channel

The parameters for the reference measurement channels are specified in Table A-1 and Table A-2 for sustained data-rate test for downlink and uplink, respectively.

Table A -1: Fixed Reference Channel for DL Sustained Data-Rate Test (64QAM)

Per CC Parameter	Unit	Value	
Reference channel		R.5G.D1	R.5G.D2
Channel bandwidth	MHz	100	100
Allocated resource blocks	PRBs	100	100
Symbol indices used for data transmission		l'=1, 3, 4, …., 13	l'=1, 3, 4, …., 13
# of DL PCRS subcarriers per 4PRBs		1	1
# of PDCCH symbols		1	1
Modulation		64QAM	16QAM
Target Coding Rate		0.785	0.624
Information Bit Payload Per Sub-Frame	Bits	132808	70376
Binary Channel Bits Per Sub-Frame	Bits	169200	112800
Number of layers		2	2

Table A -2: Fixed Reference Channel for UL Sustained Data-Rate Test (64QAM)

Per CC Parameter	Unit	Value	
Reference channel		R.5G.U1	R.5G.U2
Channel bandwidth	MHz	100	100
Allocated resource blocks		100	100
Symbol indices used for data transmission		l'=3, 4, …., 13	l'=3, 4, …., 13
# of UL PCRS subcarriers per 4PRBs		1	1
# of PDCCH symbols		1	1

Modulation		64QAM	64QAM
Target Coding Rate		0.428	0.856
Information Bit Payload	Bits	66392	132808
Binary Channel Bits Per Sub-Frame	Bits	155100	155100
Number of layers		1	2