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:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

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.

z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document specifies requirements for support of Radio Resource Management for the FDD and TDD modes of New Radio(NR). These requirements include requirements on measurements in NR and the UE as well as requirements on node dynamical behaviour and interaction, in terms of delay and response characteristics.

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 TS 38.304: "NR; User Equipment (UE) procedures in idle mode".

[2] 3GPP TS 38.331: "NR; Radio Resource Control (RRC); Protocol specification".

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

[4] 3GPP TS 38.215: "NR; Physical layer measurements".

[5] 3GPP TS 38.533: "NR; User Equipment (UE) conformance specification; Radio Resource Management (RRM)".

[6] 3GPP TS 38.211: "NR; Physical channels and modulation”.

[7] 3GPP TS 38.321: "NR; Medium Access Control (MAC) protocol specification".

[8] 3GPP TS 38. 212 "NR; Multiplexing and channel coding".

[9] 3GPP TS 38.202: "NR; Physical layer services provided by the physical layer".

[10] 3GPP TS 38.300: "NR; Overall description; Stage-2".

[11] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[12] 3GPP TS 38.423: "NG-RAN; Xn Application Protocol (XnAP)".

[13] 3GPP TS 38.104: "NR; Base Station (BS) radio transmission and reception".

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

[15] 3GPP TS 36.133: "Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for support of radio resource management".

[16] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC) protocol specification".

[17] 3GPP TS 37.340: "Evolved Universal Terrestrial Radio Access (E-UTRA) and NR; Multi-connectivity", Stage 2.

[18] 3GPP TS 38.101-1: "NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone".

[19] 3GPP TS 38.101-2: "NR; User Equipment (UE) radio transmission and reception; Part 2: Range 2 Standalone".

[20] 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".

[21] 3GPP TS 38.101-4: "NR; User Equipment (UE) radio transmission and reception; Part 4: Performance requirements".

[22] 3GPP TS 38.305: "NG Radio Access Network (NG-RAN); Stage 2 functional specification of User Equipment (UE) positioning in NG-RAN".

[23] 3GPP TS 36.211: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Channels and Modulation".

[24] 3GPP TS 36.300: "Evolved Universal Terrestrial Radio Access (E-UTRA); Overall description".

[25] 3GPP TS 36.101: "Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [11] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [11].

Active DL BWP: Active DL bandwidth part as defined in TS 38.213 [3].

Blackbox Approach: Testing methodology, in which the UE internal implementation of certain specific UE functionality involved in the test, is unknown.

DL BWP: DL bandwidth part as defined in TS 38.213 [3].

EN-DC: E-UTRA-NR Dual Connectivity as defined in clause 4.1.2 of TS 37.340 [17].

en-gNB: As defined in TS 37.340 [17].

FR1: Frequency range 1 as defined in clause 5.1 of TS 38.104 [13].

FR2: Frequency range 2 as defined in clause 5.1 of TS 38.104 [13].

gNB: as defined in in TS 38.300 [10].

Master Cell Group: As defined in TS 38.331 [2].

Multi-Radio Dual Connectivity: Dual Connectivity between E-UTRA and NR nodes, or between two NR nodes, as defined in TS 37.340 [17].

ng-eNB: As defined in TS 38.300 [10].

NE-DC: NR-E-UTRA Dual Connectivity as defined in clause 4.1.3.2 of TS 37.340 [17].

NGEN-DC: NG-RAN E-UTRA-NR Dual Connectivity as defined in clause 4.1.3.1 of TS 37.340 [17].

NR-DC: NR-NR Dual Connectivity as defined in clause 4.1.3.3 of TS 37.340 [17].

Primary Cell: As defined in TS 38.331 [2].

RLM-RS resource: A resource out of the set of resources configured for RLM by higher layer parameter RLM-RS-List [2] as defined in TS 38.213 [3].

SA operation mode: Operation mode when the UE is configured with at least PCell and not any MR-DC.

Secondary Cell: As defined in TS 38.331 [2].

Secondary Cell Group: As defined in TS 38.331 [2].

Serving Cell: As defined in TS 38.331 [2].

SMTC: An SSB-based measurement timing configuration configured by *SSB-MeasurementTimingConfiguration* as specified in TS 38.331 [2].

SSB: SS/PBCH block as defined in clause 7.8.3 of TS 38.211 [6].

Timing Advance Group: As defined in TS 38.331 [2].

3.2 Symbols

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

[…]	Values included in square bracket must be considered for further studies, because it means that a decision about that value was not taken.
T_c	Basic time unit, defined in clause 4.1 of TS 38.211 [6].
T_s	Reference time unit, defined in clause 4.1 of TS 38.211 [6].

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [11] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [11].

BFD	Beam Failure Detection
BWP	Bandwidth Part
CA	Carrier Aggregation
CBD	Candidate Beam Detection
CC	Component Carrier
CP	Cyclic Prefix
CSI	Channel-State Information
CSI-RS	CSI Reference Signal
DC	Dual Connectivity
DL	Downlink

DMRS	Demodulation Reference Signal
DRX	Discontinuous Reception
E-CID	Enhanced Cell ID
E-UTRA	Evolved UTRA
E-UTRAN	Evolved UTRAN
EN-DC	E-UTRA-NR Dual Connectivity
FDD	Frequency Division Duplex
FR	Frequency Range
HARQ	Hybrid Automatic Repeat Request
HO	Handover
MAC	Medium Access Control
MCG	Master Cell Group
MGL	Measurement Gap Length
MGRP	Measurement Gap Repetition Period
MIB	Master Information Block
MR-DC	Multi-Radio Dual Connectivity
NE-DC	NR-E-UTRA Dual Connectivity
NGEN-DC	NG-RAN E-UTRA-NR Dual Connectivity
NR	New Radio
NR-DC	NR-NR Dual Connectivity
NSA	Non-Standalone operation mode
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
OTDOA	Observed Time Difference Of Arrival
PBCH	Physical Broadcast Channel
PCell	Primary Cell
PLMN	Public Land Mobile Network
PRACH	Physical RACH
PSCell	Primary SCell
PSS	Primary Synchronization Signal
PUCCH	Physical Uplink Control Channel
PUSCH	Physical Uplink Shared Channel
RACH	Random Access Channel
RAT	Radio Access Technology
RLM	Radio Link Monitoring
RLM-RS	Reference Signal for RLM
RRC	Radio Resource Control
RRM	Radio Resource Management
RSSI	Received Signal Strength Indicator
RSTD	Reference Signal Time Difference
SA	Standalone operation mode
SCell	Secondary Cell
SCG	Secondary Cell Group
SCS	Subcarrier Spacing
SCS_{SSB}	SSB subcarrier spacing
SDL	Supplementary Downlink
SFN	System Frame Number
SI	System Information
SIB	System Information Block
SMTC	SSB-based Measurement Timing configuration
SRS	Sounding Reference Signal
SS-RSRP	Synchronization Signal based Reference Signal Received Power
SS-RSRQ	Synchronization Signal based Reference Signal Received Quality
SS-SINR	Synchronization Signal based Signal to Noise and Interference Ratio
SSB	Synchronization Signal Block
SSB_RP	Received (linear) average power of the resource elements that carry NR SSB signals and channels, measured at the UE antenna connector.
SSS	Secondary Synchronization Signal
SUL	Supplementary Uplink
TA	Timing Advance
TAG	Timing Advance Group
TDD	Time Division Duplex

TTI	Transmission Time Interval
UE	User Equipment
UL	Uplink

3.4 Test tolerances

The requirements given in the present document make no allowance for measurement uncertainty. The test specification 38.5xx [x] defines the test tolerances.

Editor's note: intended to capture test tolerances. OTA test tolerance or margin will be captured in this section if needed.

3.5 Frequency bands grouping

3.5.1 Introduction

The intention with the frequency band grouping below is to increase the readability of the specification.

The frequency bands grouping is derived based on UE REFSENS requirements specified in [18, 19, 20] and assuming 0.5 dB step between the neighbour groups. The groups are defined in the order of increasing REFSENS, i.e., the group A has the smallest REFSENS among the groups. For the same SCS and a given bandwidth, the bands within the same group have the same Io conditions in a corresponding requirement in this specification, provided the bands support this SCS. For different SCSs supported by a frequency band and the same bandwidth, different Io conditions may apply for the frequency band in the requirements, while the band group is the same, based on the lowest REFSENS requirement normalized by the number of subcarriers among its supported SCSs for this bandwidth. For the same SCS but different supported bandwidths, the group for a band is determined based on the lowest REFSENS requirement normalized by the number of subcarriers among its supported bandwidths.

3.5.2 NR operating bands in FR1

NR frequency bands grouping for FR1 is specified in Table 3.5.2-1.

Table 3.5.2-1: NR frequency band groups for FR1

Group	NR FDD		NR TDD		NR SDL	
	Band group notation	Operating bands	Band group notation	Operating bands	Band group notation	Operating bands
A	NR_FDD_FR1_A	n1, n70, n74[4]	NR_TDD_FR1_A	n34, n38, n39, n40, n50, n51	NR_SDL_FR1_A	n75, n76
B	NR_FDD_FR1_B	n65, n66, n74[3]	NR_TDD_FR1_B	-	NR_SDL_FR1_B	-
C	NR_FDD_FR1_C	-	NR_TDD_FR1_C	n48, n77[1], n78, n79	NR_SDL_FR1_C	-
D	NR_FDD_FR1_D	n28	NR_TDD_FR1_D	n77[2]	NR_SDL_FR1_D	-
E	NR_FDD_FR1_E	n2, n5, n7	NR_TDD_FR1_E	n41	NR_SDL_FR1_E	-
F	NR_FDD_FR1_F	-	NR_TDD_FR1_F	-	NR_SDL_FR1_F	-
G	NR_FDD_FR1_G	n3, n8, n12, n20, n71	NR_TDD_FR1_G	-	NR_SDL_FR1_G	-
H	NR_FDD_FR1_H	n25	NR_TDD_FR1_H	-	NR_SDL_FR1_H	-
NOTE 1: Except 3.8 GHz to 4.2 GHz. NOTE 2: Only 3.8 GHz to 4.2 GHz. NOTE 3: Except 1475.9 MHz to 1510.9 MHz. NOTE 4: Only when the band is confined in 1475.9 MHz to 1510.9 MHz.						

3.5.3 NR operating bands in FR2

NR frequency bands grouping for FR2 is specified in Table 3.5.3-1.

Table 3.5.3-1: NR frequency band groups for FR2

Group	Band group notation	Operating bands
A	NR_TDD_FR2_A	n257[1], n258[1], n261[1]
B	NR_TDD_FR2_B	n257[4], n258[4], n261[4]
C	NR_TDD_FR2_C	
D	NR_TDD_FR2_D	
E	NR_TDD_FR2_E	
F	NR_TDD_FR2_F	n260[4]
G	NR_TDD_FR2_G	n257[2], n258[2], n260[1], n261[2]
H	NR_TDD_FR2_H	
I	NR_TDD_FR2_I	
J	NR_TDD_FR2_J	
K	NR_TDD_FR2_K	
L	NR_TDD_FR2_L	
M	NR_TDD_FR2_M	
N	NR_TDD_FR2_N	
O	NR_TDD_FR2_O	
P	NR_TDD_FR2_P	
Q	NR_TDD_FR2_Q	
R	NR_TDD_FR2_R	
S	NR_TDD_FR2_S	
T	NR_TDD_FR2_T	n257[3], n258[3], n261[3]
U	NR_TDD_FR2_U	
V	NR_TDD_FR2_V	
W	NR_TDD_FR2_W	
X	NR_TDD_FR2_X	
Y	NR_TDD_FR2_Y	n260[3]
NOTE 1: UE power class 1. NOTE 2: UE power class 2. NOTE 3: UE power class 3. NOTE 4: UE power class 4.		

3.6 Applicability of requirements in this specification version

In this specification,

- ‘cell’, ‘PCell’, ‘PSCell’ and ‘SCell’ refer to NR cell, NR PCell, NR PSCell and NR SCell,
- E-UTRA cells are referred to as ‘E-UTRA cell’, ‘E-UTRA PCell’ and ‘E-UTRA SCell’,
- E-UTRA-NR dual connectivity where E-UTRA is the master is referred to as ‘E-UTRA-NR dual connectivity’ or ‘EN-DC’.
- NR-NR dual connectivity which involves two gNB acting as Master gNB and Secondary gNB is referred to as “NR-NR dual connectivity” or “NR-DC”. NR-DC in Rel-15 only includes the scenarios where all serving cells in MCG in FR1 and all serving cells in SCG in FR2.

For UE configured with supplementary UL, the requirements in section 7.1 and 7.3 shall also apply to uplink transmissions on supplementary UL.

3.6.1 RRC connected state requirements in DRX

For the requirements in RRC connected state specified in this version of the specification, the UE shall assume that no DRX is used provided the following conditions are met:

- DRX parameters are not configured or
- DRX parameters are configured and
  - drx-InactivityTimer is running or
  - drx-RetransmissionTimerDL is running or
  - drx-RetransmissionTimerUL is running or

- ra-ContentionResolutionTimer is running or
- a Scheduling Request sent on PUCCH is pending or
  - a PDCCH indicating a new transmission addressed to the C-RNTI of the MAC entity has not been received after successful reception of a Random Access Response for the preamble not selected by the MAC entity

Otherwise the UE shall assume that DRX is used.

3.6.2 Number of serving carriers

3.6.2.1 Number of serving carriers for SA

Requirements for standalone NR with NR PCell are applicable for the UE configured with the following number of serving NR CCs:

- up to 8 NR DL CCs in total, with 1 UL (or 2 UL if SUL is configured) in PCell and up to 1 UL (or 2 UL if SUL is configured) in SCell.
- SUL may be configured together with one of the UL

3.6.2.2 Number of serving carriers for EN-DC

Requirements for EN-DC operation of E-UTRA and NR with E-UTRA PCell and NR PSCell are applicable for the UE configured with the following number of serving NR CCs:

- up to 7 NR DL CCs in total, with 1 UL (or 2 UL if SUL is configured) in PSCell and up to 1 UL (or 2 UL if SUL is configured) in SCell.
- SUL may be configured together with one of the UL

The applicable number of E-UTRA CC for EN-DC in the MCG for both UL and DL is specified in TS 36.133 [15].

3.6.2.3 Number of serving carriers for NE-DC

Requirements for NE-DC operation of NR and E-UTRA with NR PCell and E-UTRA PSCell are applicable for the UE configured with the following number of serving NR CCs:

- up to 7 NR DL CCs in total, with 1 UL (or 2 UL if SUL is configured) in PCell and up to 1 UL (or 2 UL if SUL is configured) in SCell.
- SUL may be configured together with one of the UL

The applicable number of E-UTRA CC for NE-DC in the SCG for both UL and DL is specified in TS 36.133 [15].

3.6.2.4 Number of serving carriers for NR-DC

Requirements for NR-DC are applicable for the UE configured with the following number of serving NR CCs:

- up to TBD NR DL CCs in total in MCG, up to TBD NR DL CCs in total in SCG, with 1 UL (or 2 UL if SUL is configured) in PCell, TBD UL CCs in SCG, and up to 1 UL (or 2 UL if SUL is configured) in each SCell.
- SUL may be configured together with one of the UL.

3.6.3 Applicability for SSB Rx beam in intra-band FR2

For the requirements in RRC connected state specified in this version of the specification, UE shall assume that the SSBs from the serving cells should have the same downlink spatial domain transmission filter in the same band in FR2. If the SSBs don't have same downlink spatial domain transmission filter the UE is not supposed to satisfy any requirements for SCell.

3.6.4 Applicability for FR2 UE power classes

For the requirements of each FR2 power class specified in this version of the specification, certain UE types with specific device architectures are assumed. The UE types can be found in TS 38.101-2 [19].

3.6.5 Applicability of requirements for NGEN-DC operation

All the requirements in this specification applicable for EN-DC are also applicable for NGEN-DC.

4 SA: RRC_IDLE state mobility

Editor's note: intended to capture the RRM requirements for RRC_IDLE state in stand-alone operation.

4.1 Cell Selection

After a UE has switched on and a PLMN has been selected, the Cell selection process takes place, as described in TS 38.304. This process allows the UE to select a suitable cell where to camp on in order to access available services. In this process, the UE can use stored information (*Stored information cell selection*) or not (*Initial cell selection*).

4.2 Cell Re-selection

4.2.1 Introduction

The cell reselection procedure allows the UE to select a more suitable cell and camp on it.

When the UE is in either *Camped Normally* state or *Camped on Any Cell* state on a cell, the UE shall attempt to detect, synchronise, and monitor intra-frequency, inter-frequency and inter-RAT cells indicated by the serving cell. For intra-frequency and inter-frequency cells the serving cell may not provide explicit neighbour list but carrier frequency information and bandwidth information only. UE measurement activity is also controlled by measurement rules defined in TS 38.304, allowing the UE to limit its measurement activity.

In the requirements of Section 4.2, the exceptions for side conditions apply as follows:

- for the UE capable of CA, the applicable exceptions for side conditions are specified in Annex B, Section B.3.2.1, B.3.2.3, or B.3.2.5 for UE supporting CA in FR1, CA in FR2 and CA between FR1 and FR2, respectively;

- for the UE capable of SUL, the applicable exceptions for side conditions are specified in Annex B, Section B.3.4.1 for UE supporting SUL in FR1.

4.2.2 Requirements

4.2.2.1 UE measurement capability

For idle mode cell re-selection purposes, the UE shall be capable of monitoring at least:

- Intra-frequency carrier, and

- Depending on UE capability, 7 NR inter-frequency carriers, and

- Depending on UE capability, 7 FDD E-UTRA inter-RAT carriers, and

- Depending on UE capability, 7 TDD E-UTRA inter-RAT carriers.

In addition to the requirements defined above, a UE supporting E-UTRA measurements in RRC_IDLE state shall be capable of monitoring a total of at least 14 carrier frequency layers, which includes serving layer, comprising of any above defined combination of E-UTRA FDD, E-UTRA TDD and NR layers.

4.2.2.2 Measurement and evaluation of serving cell

The UE shall measure the SS-RSRP and SS-RSRQ level of the serving cell and evaluate the cell selection criterion S defined in [1] for the serving cell at least once every M1*N1 DRX cycle; where:

M1=2 if SMTC periodicity (T_{SMTC}) > 20 ms and DRX cycle ≤ 0.64 second,

otherwise M1=1.

The UE shall filter the SS-RSRP and SS-RSRQ measurements of the serving cell using at least 2 measurements. Within the set of measurements used for the filtering, at least two measurements shall be spaced by, at least DRX cycle/2.

If the UE has evaluated according to Table 4.2.2.2-1 in N_{serv} consecutive DRX cycles that the serving cell does not fulfil the cell selection criterion S, the UE shall initiate the measurements of all neighbour cells indicated by the serving cell, regardless of the measurement rules currently limiting UE measurement activities.

If the UE in RRC_IDLE has not found any new suitable cell based on searches and measurements using the intra-frequency, inter-frequency and inter-RAT information indicated in the system information for 10 s, the UE shall initiate cell selection procedures for the selected PLMN as defined in TS 38.304 [1].

Table 4.2.2.2-1: N_{serv}

DRX cycle length [s]	Scaling Factor (N1)		N_{serv} [number of DRX cycles]
	FR1	FR2[Note1]	
0.32	1	8	M1*N1*4
0.64		5	M1*N1*4
1.28		4	N1*2
2.56		3	N1*2
Note 1: Applies for UE supporting power class 2&3&4. For UE supporting power class 1, N1 = 8 for all DRX cycle length.			

4.2.2.3 Measurements of intra-frequency NR cells

The UE shall be able to identify new intra-frequency cells and perform SS-RSRP and SS-RSRQ measurements of the identified intra-frequency cells without an explicit intra-frequency neighbour list containing physical layer cell identities.

The UE shall be able to evaluate whether a newly detectable intra-frequency cell meets the reselection criteria defined in TS38.304 within T_{detect,NR_Intra} when that Treselection= 0 . An intra frequency cell is considered to be detectable according to the conditions defined in Annex B.1.2 for a corresponding Band.

The UE shall measure SS-RSRP and SS-RSRQ at least every $T_{measure,NR\_Intra}$ (see table 4.2.2.3-1) for intra-frequency cells that are identified and measured according to the measurement rules.

The UE shall filter SS-RSRP and SS-RSRQ measurements of each measured intra-frequency cell using at least 2 measurements. Within the set of measurements used for the filtering, at least two measurements shall be spaced by at least $T_{measure,NR\_Intra}/2$.

The UE shall not consider a NR neighbour cell in cell reselection, if it is indicated as not allowed in the measurement control system information of the serving cell.

For an intra-frequency cell that has been already detected, but that has not been reselected to, the filtering shall be such that the UE shall be capable of evaluating that the intra-frequency cell has met reselection criterion defined [1] within $T_{evaluate,NR\_Intra}$ when $T_{reselection}$ = 0 as specified in table 4.2.2.3-1 provided that:

- when *rangeToBestCell* is not configured, the cell has at least [3]dB in FR1 or [TBD]dB in FR2 better ranked or

- when *rangeToBestCell* is configured, the cell which has the highest number of beams above the threshold *absThreshSS-BlocksConsolidation* among the cells whose cell-ranking criterion R value as specified in TS 38.304 [1, Section 5.2.4.6] is within *rangeToBestCell* of the R value of the best cell where the best cell has at least [TBD] in FR1 or [TBD]dB in FR2 better ranked, and if there are multiple such cells the UE shall perform cell reselection to the highest ranked cell among them.

When evaluating cells for reselection, the SSB side conditions apply to both serving and non-serving intra-frequency cells.

If $T_{reselection}$ timer has a non zero value and the intra-frequency cell is satisfied with the reselection criteria which are defined in TS38.304 [1], the UE shall evaluate this intra-frequency cell for the $T_{reselection}$ time. If this cell remains satisfied with the reselection criteria within this duration, then the UE shall reselect that cell.

Table 4.2.2.3-1: T_{detect,NR_Intra}, $T_{measure,NR\_Intra}$ and $T_{evaluate,NR\_Intra}$

DRX cycle length [s]	Scaling Factor (N1)		T_{detect,NR_Intra} [s] (number of DRX cycles)	$T_{measure,NR\_Intra}$ [s] (number of DRX cycles)	$T_{evaluate,NR\_Intra}$ [s] (number of DRX cycles)
	FR1	FR2[Note1]			
0.32	1	8	11.52 x N1 x M2 (36 x N1 x M2)	1.28 x N1 x M2 (4 x N1 x M2)	5.12 x N1 x M2 (16 x N1 x M2)
0.64		5	17.92 x N1 (28 x N1)	1.28 x N1 (2 x N1)	5.12 x N1 (8 x N1)
1.28		4	32 x N1 (25 x N1)	1.28 x N1 (1 x N1)	6.4 x N1 (5 x N1)
2.56		3	58.88 x N1 (23 x N1)	2.56 x N1 (1 x N1)	7.68 x N1 (3 x N1)
Note 1: Applies for UE supporting power class 2&3&4. For UE supporting power class 1, N1 = 8 for all DRX cycle length. Note 2: M2 = 1.5 if SMTC periodicity of measured intra-frequency cell > 20 ms; otherwise M2=1.					

4.2.2.4 Measurements of inter-frequency NR cells

The UE shall be able to identify new inter-frequency cells and perform SS-RSRP or SS-RSRQ measurements of identified inter-frequency cells if carrier frequency information is provided by the serving cell, even if no explicit neighbour list with physical layer cell identities is provided.

If Srxlev > $S_{nonIntraSearchP}$ and Squal > $S_{nonIntraSearchQ}$ then the UE shall search for inter-frequency layers of higher priority at least every $T_{higher\_priority\_search}$ where $T_{higher\_priority\_search}$ is described in clause 4.2.2.7.

If Srxlev ≤ $S_{nonIntraSearchP}$ or Squal ≤ $S_{nonIntraSearchQ}$ then the UE shall search for and measure inter-frequency layers of higher, equal or lower priority in preparation for possible reselection. In this scenario, the minimum rate at which the UE is required to search for and measure higher priority layers shall be the same as that defined below in this subclause.

The UE shall be able to evaluate whether a newly detectable inter-frequency cell meets the reselection criteria defined in TS38.304 within $K_{carrier}$ * T_{detect,NR_Inter} if at least carrier frequency information is provided for inter-frequency neighbour cells by the serving cells when $T_{reselection}$ = 0 provided that the reselection criteria is met by a margin of at least [5] dB in FR1 or [TBD]dB in FR2 for reselections based on ranking or [6]dB in FR1 or [TBD] dB in FR2 for SS-RSRP reselections based on absolute priorities or [4]dB in FR1 and [TBD] in FR2 for SS-RSRQ reselections based on absolute priorities. The parameter $K_{carrier}$ is the number of NR inter-frequency carriers indicated by the serving cell. An inter-frequency cell is considered to be detectable according to the conditions defined in Annex B.1.3 for a corresponding Band.

When higher priority cells are found by the higher priority search, they shall be measured at least every $T_{measure,NR\_Inter}$. If, after detecting a cell in a higher priority search, it is determined that reselection has not occurred then the UE is not required to continuously measure the detected cell to evaluate the ongoing possibility of reselection. However, the minimum measurement filtering requirements specified later in this section shall still be met by the UE before it makes any determination that it may stop measuring the cell. If the UE detects on a NR carrier a cell whose physical identity is indicated as not allowed for that carrier in the measurement control system information of the serving cell, the UE is not required to perform measurements on that cell.

The UE shall measure SS-RSRP or SS-RSRQ at least every $K_{carrier}$ * $T_{measure,NR\_Inter}$ (see table 4.2.2.4-1) for identified lower or equal priority inter-frequency cells. If the UE detects on a NR carrier a cell whose physical identity is indicated as not allowed for that carrier in the measurement control system information of the serving cell, the UE is not required to perform measurements on that cell.

The UE shall filter SS-RSRP or SS-RSRQ measurements of each measured higher, lower and equal priority inter-frequency cell using at least 2 measurements. Within the set of measurements used for the filtering, at least two measurements shall be spaced by at least $T_{measure,NR\_Inter}$/2.

The UE shall not consider a NR neighbour cell in cell reselection, if it is indicated as not allowed in the measurement control system information of the serving cell.

For an inter-frequency cell that has been already detected, but that has not been reselected to, the filtering shall be such that the UE shall be capable of evaluating that the inter-frequency cell has met reselection criterion defined TS 38.304 within $K_{carrier}$ * $T_{evaluate,NR\_Inter}$ when $T_{reselection}$ = 0 as specified in table 4.2.2.4-1 provided that the reselection criteria is met by

- the condition when performing equal priority reselection and
  - when *rangeToBestCell* is not configured, the cell has at least [5]dB in FR1 or [TBD]dB in FR2 better ranked or
  - when *rangeToBestCell* is configured, the cell which has the highest number of beams above the threshold *absThreshSS-BlocksConsolidation* among the cells whose cell-ranking criterion R value as specified in TS 38.304 [1, Section 5.2.4.6] is within *rangeToBestCell* of the R value of the best cell where the best cell has at least [TBD] in FR1 or [TBD]dB in FR2 better ranked, and if there are multiple such cells the UE shall perform cell reselection to the highest ranked cell among them or
- [6]dB in FR1 or [TBD]dB in FR2 for SS-RSRP reselections based on absolute priorities or
- [4]dB in FR1 or [TBD] in FR2 for SS-RSRQ reselections based on absolute priorities.

When evaluating cells for reselection, the SSB side conditions apply to both serving and inter-frequency cells.

If $T_{reselection}$ timer has a non zero value and the inter-frequency cell is satisfied with the reselection criteria, the UE shall evaluate this inter-frequency cell for the $T_{reselection}$ time. If this cell remains satisfied with the reselection criteria within this duration, then the UE shall reselect that cell.

The UE is not expected to meet the measurement requirements for an inter-frequency carrier under DRX cycle=320 ms defined in Table 4.2.2.4-1 under the following conditions:

- T_{SMTC_intra} = T_{SMTC_inter} = 160 ms; where T_{SMTC_intra} and T_{SMTC_inter} are periodicities of the SMTC occasions configured for the intra-frequency carrier and the inter-frequency carrier respectively,
- SMTC occasions configured for the inter-frequency carrier occur up to TBD ms before the start or up to TBD ms after the end of the SMTC occasions configured for the intra-frequency carrier and
- SMTC occasions configured for the intra-frequency carrier and for the inter-frequency carrier occur up to TBD ms before the start or up to TBD ms after the end of the paging occasion [1].

Table 4.2.2.4-1: T_{detect,NR_Inter}, $T_{measure,NR\_Inter}$ and $T_{evaluate,NR\_Inter}$

DRX cycle length [s]	Scaling Factor (N1)		T_{detect,NR_Inter} [s] (number of DRX cycles)	$T_{measure,NR\_Inter}$ [s] (number of DRX cycles)	$T_{evaluate,NR\_Inter}$ [s] (number of DRX cycles)
	FR1	FR2[Note1]			
0.32	1	8	11.52 x N1 x 1.5 (36 x N1 x 1.5)	1.28 x N1 x 1.5 (4 x N1 x 1.5)	5.12 x N1 x 1.5 (16 x N1 x 1.5)
0.64		5	17.92x N1 (28 x N1)	1.28 x N1 (2 x N1)	5.12 x N1 (8 x N1)
1.28		4	32 x N1 (25 x N1)	1.28 x N1 (1 x N1)	6.4 x N1 (5 x N1)
2.56		3	58.88 x N1 (23 x N1)	2.56 x N1 (1 x N1)	7.68 x N1 (3 x N1)
Note 1: Applies for UE supporting power class 2&3&4. For UE supporting power class 1, N1 = 8 for all DRX cycle length.					

4.2.2.5 Measurements of inter-RAT E-UTRAN cells

If Srxlev > $S_{nonIntraSearchP}$ and Squal > $S_{nonIntraSearchQ}$ then the UE shall search for inter-RAT E-UTRAN layers of higher priority at least every $T_{higher\_priority\_search}$ where $T_{higher\_priority\_search}$ is described in clause 4.2.2

If Srxlev ≤ $S_{nonIntraSearchP}$ or Squal ≤ $S_{nonIntraSearchQ}$ then the UE shall search for and measure inter-RAT E-UTRAN layers of higher, lower priority in preparation for possible reselection. In this scenario, the minimum rate at which the UE is required to search for and measure higher priority inter-RAT E-UTRAN layers shall be the same as that defined below for lower priority RATs.

The requirements in this section apply for inter-RAT E-UTRAN FDD measurements and E-UTRA TDD measurements. When the measurement rules indicate that inter-RAT E-UTRAN cells are to be measured, the UE shall measure RSRP and RSRQ of detected E-UTRA cells in the neighbour frequency list at the minimum measurement rate specified in this section. The parameter $N_{EUTRA\_carrier}$ is the total number of configured E-UTRA carriers in the neighbour frequency list. The UE shall filter RSRP and RSRQ measurements of each measured E-UTRA cell using at least 2 measurements. Within the set of measurements used for the filtering, at least two measurements shall be spaced by at least $T_{measure,EUTRAN}/2$.

An inter-RAT E-UTRA cell is considered to be detectable provided the following conditions are fulfilled:

- the same conditions as for inter-frequency RSRP measurements specified in TS 36.133 [15, Annex B.1.2] are fulfilled for a corresponding Band, and
- the same conditions as for inter-frequency RSRQ measurements specified in TS 36.133 [15, Annex B.1.2] are fulfilled for a corresponding Band.
- SCH conditions specified in TS 36.133 [15, Annex B.1.2] are fulfilled for a corresponding Band

The UE shall be able to evaluate whether a newly detectable inter-RAT E-UTRAN cell meets the reselection criteria defined in TS38.304 within ($N_{EUTRA\_carrier}$) * $T_{detect,EUTRAN}$ when Srxlev ≤ $S_{nonIntraSearchP}$ or Squal ≤ $S_{nonIntraSearchQ}$ when $T_{reselection}$ = 0 provided that the reselection criteria is met by a margin of at least 6dB for RSRP reselections based on absolute priorities or 4dB for RSRQ reselections based on absolute priorities.

Cells which have been detected shall be measured at least every ($N_{EUTRA\_carrier}$) * $T_{measure,EUTRAN}$ when Srxlev ≤ $S_{nonIntraSearchP}$ or Squal ≤ $S_{nonIntraSearchQ}$.

When higher priority cells are found by the higher priority search, they shall be measured at least every $T_{measure,EUTRAN}$. If, after detecting a cell in a higher priority search, it is determined that reselection has not occurred then the UE is not required to continuously measure the detected cell to evaluate the ongoing possibility of reselection. However, the minimum measurement filtering requirements specified later in this section shall still be met by the UE before it makes any determination that it may stop measuring the cell.

If the UE detects on an inter-RAT E-UTRAN carrier a cell whose physical identity is indicated as not allowed for that carrier in the measurement control system information of the serving cell, the UE is not required to perform measurements on that cell.

The UE shall not consider an inter-RAT E-UTRA cell in cell reselection, if it is indicated as not allowed in the measurement control system information of the serving cell.

For a cell that has been already detected, but that has not been reselected to, the filtering shall be such that the UE shall be capable of evaluating that an already identified inter-RAT E-UTRA cell has met reselection criterion defined in TS 38.304 [1] within ($N_{EUTRA\_carrier}$) * $T_{evaluate,EUTRAN}$ when $T_{reselection}$ = 0 as speficied in table 4.2.2.5-1 provided that the reselection criteria is met by a margin of at least 6dB for RSRP reselections based on absolute priorities or 4dB for RSRQ reselections based on absolute priorities.

If $T_{reselection}$ timer has a non zero value and the inter-RAT E-UTRA cell is satisfied with the reselection criteria which are defined in [1], the UE shall evaluate this E-UTRA cell for the $T_{reselection}$ time. If this cell remains satisfied with the reselection criteria within this duration, then the UE shall reselect that cell.

Table 4.2.2.5-1: $T_{detect,EUTRAN}$, $T_{measure,EUTRAN}$, and $T_{evaluate,EUTRAN}$

DRX cycle length [s]	$T_{detect,EUTRAN}$ [s] (number of DRX cycles)	$T_{measure,EUTRAN}$ [s] (number of DRX cycles)	$T_{evaluate,EUTRAN}$ [s] (number of DRX cycles)
0.32	11.52 (36)	1.28 (4)	5.12 (16)
0.64	17.92 (28)	1.28 (2)	5.12 (8)
1.28	32(25)	1.28 (1)	6.4 (5)
2.56	58.88 (23)	2.56 (1)	7.68 (3)

4.2.2.6 Maximum interruption in paging reception

UE shall perform the cell re-selection with minimum interruption in monitoring downlink channels for paging reception.

At intra-frequency and inter-frequency cell re-selection, the UE shall monitor the downlink of serving cell for paging reception until the UE is capable to start monitoring downlink channels of the target intra-frequency and inter-frequency cell for paging reception. The interruption time shall not exceed T_{SI-NR} + $2*T_{target\_cell\_SMTC\_period}$ ms.

At inter-RAT cell re-selection, the UE shall monitor the downlink of serving cell for paging reception until the UE is capable to start monitoring downlink channels for paging reception of the target inter-RAT cell. For NR to E-UTRAN cell re-selection the interruption time must not exceed $T_{SI-EUTRA}$ + 55 ms.

T_{SI-NR} is the time required for receiving all the relevant system information data according to the reception procedure and the RRC procedure delay of system information blocks defined in TS 38.331 [2] for an NR cell.

$T_{SI-EUTRA}$ is the time required for receiving all the relevant system information data according to the reception procedure and the RRC procedure delay of system information blocks defined in TS 36.331 [16] for an E-UTRAN cell.

These requirements assume sufficient radio conditions, so that decoding of system information can be made without errors and does not take into account cell re-selection failure.

4.2.2.7 General requirements

The UE shall search every layer of higher priority at least every $T_{higher\_priority\_search}$ = ([60] * N_{layers}) seconds, where N_{layers} is the total number of higher priority NR and E-UTRA carrier frequencies broadcasted in system information.

5 SA: RRC_INACTIVE state mobility

5.1 Cell Re-selection

5.1.1 Introduction

The cell reselection procedure allows the UE to select a more suitable cell and camp on it.

When the UE is in *Camped Normally* state on a cell, the UE shall attempt to detect, synchronise, and monitor intra-frequency, inter-frequency and inter-RAT cells indicated by the serving cell. For intra-frequency and inter-frequency cells the serving cell may not provide explicit neighbour list but carrier frequency information and bandwidth information only. UE measurement activity is also controlled by measurement rules defined in TS38.304, allowing the UE to limit its measurement activity.

5.1.2 Requirements

5.1.2.1 UE measurement capability

The requirements in sub-clause 4.2.2.1 shall apply.

5.1.2.2 Measurement and evaluation of serving cell

The requirements in sub-clause 4.2.2.2 shall apply.

5.1.2.3 Measurements of intra-frequency NR cells

The requirements in sub-clause 4.2.2.3 shall apply.

5.1.2.4 Measurements of inter-frequency NR cells

The requirements in sub-clause 4.2.2.4 shall apply.

5.1.2.5 Measurements of inter-RAT E-UTRAN cells

The requirements in sub-clause 4.2.2.5 shall apply.

5.1.2.6 Maximum interruption in paging reception

The requirements in sub-clause 4.2.2.6 shall apply.

5.1.2.7 General requirements

The requirements in sub-clause 4.2.2.7 shall apply.

5.2 RRC_INACTIVE Mobility Control

Editor's note: intended to capture requirements which applies for the transition between INACTIVE and IDLE state. This section might be removed if unnecessary.

6 RRC_CONNECTED state mobility

6.1 Handover

6.1.1 NR Handover

6.1.1.1 Introduction

The purpose of NR handover is to change the NR PCell to another NR cell. The requirements in this clause are applicable to SA NR, NE-DC and NR-DC.

6.1.1.2 NR FR1 - NR FR1 Handover

The requirements in this clause are applicable to both intra-frequency and inter-frequency handovers from NR FR1 cell to NR FR1 cell.

6.1.1.2.1 Handover delay

Procedure delays for all procedures that can command a handover are specified in TS 38.331 [2].

When the UE receives a RRC message implying handover the UE shall be ready to start the transmission of the new uplink PRACH channel within $D_{handover}$ seconds from the end of the last TTI containing the RRC command.

Where:

$D_{handover}$ equals the maximum RRC procedure delay to be defined in clause12 in TS 38.331 [2] plus the interruption time stated in clause 6.1.1.2.2.

6.1.1.2.2 Interruption time

The interruption time is the time between end of the last TTI containing the RRC command on the old PDSCH and the time the UE starts transmission of the new PRACH, excluding the RRC procedure delay.

When intra-frequency or inter-frequency handover is commanded, the interruption time shall be less than $T_{interrupt}$

$$T_{interrupt} = T_{search} + T_{IU} + 20 + T_{\Delta} \text{ ms}$$

Where:

T_{search} is the time required to search the target cell when the target cell is not already known when the handover command is received by the UE. If the target cell is known, then T_{search} = 0 ms. If the target cell is an unknown intra-frequency cell and the target cell Es/Iot ⩾ -TBD dB, then $T_{search} = T_{rs}$ + 2 ms. If the target cell is an unknown inter-frequency cell and the target cell Es/Iot ⩾ -TBD dB, then T_{search} = [3* T_{rs} + 2] ms. Regardless of whether DRX is in use by the UE, T_{search} shall still be based on non-DRX target cell search times.

T_{Δ} is time for fine time tracking and acquiring full timing information of the target cell. $T_{\Delta} = T_{rs}$.

T_{IU} is the interruption uncertainty in acquiring the first available PRACH occasion in the new cell. T_{IU} can be up to x*10 +10 ms. x is defined in the table 6.3.3.2-2 of TS 38.211 [6].

T_{rs} is the SMTC periodicity of the target NR cell if the UE has been provided with an SMTC configuration for the target cellin the handover command, otherwise Trs is the SMTC configured in the measObjectNR having the same SSB frequency and subcarrier spacing. If the UE is not provided SMTC configuration or measurement object on this frequency, the requirement in this section is applied with Trs = [5] ms assuming the SSB transmission periodicity is 5 ms. There is no requirements if the SSB transmission periodicity is not 5 ms.

NOTE 1: The actual value of T_{IU} shall depend upon the PRACH configuration used in the target cell.

In the interruption requirement a cell is known if it has been meeting the relevant cell identification requirement during the last 5 seconds otherwise it is unknown. Relevant cell identification requirements are described in Clause 9.2.5 for intra-frequency handover and Clause 9.3.1 for inter-frequency handover.

6.1.1.3 NR FR2- NR FR1 Handover

The requirements in this clause are applicable to inter-frequency handovers from NR FR2 cell to NR FR1 cell.

6.1.1.3.1 Handover delay

Procedure delays for all procedures that can command a handover are specified in TS 38.331 [2].

When the UE receives a RRC message implying handover the UE shall be ready to start the transmission of the new uplink PRACH channel within $D_{handover}$ seconds from the end of the last TTI containing the RRC command.

Where:

$D_{handover}$ equals the maximum RRC procedure delay to be defined in clause 12 in TS 38.331 [2] plus the interruption time stated in clause 6.1.1.3.2.

6.1.1.3.2 Interruption time

The interruption time is the time between end of the last TTI containing the RRC command on the old PDSCH and the time the UE starts transmission of the new PRACH, excluding the RRC procedure delay.

When intra-frequency or inter-frequency handover is commanded, the interruption time shall be less than $T_{interrupt}$

$$T_{interrupt} = T_{search} + T_{IU} + 40 + T_{\Delta} \text{ ms}$$

Where:

T_{search} is the time required to search the target cell when the target cell is not already known when the handover command is received by the UE. If the target cell is known, then T_{search} = 0 ms. If the target cell is an unknown inter-frequency cell and the target cell Es/Iot ⩾ -TBD dB, then T_{search} = [3* T_{rs} + 2] ms. Regardless of whether DRX is in use by the UE, T_{search} shall still be based on non-DRX target cell search times.

T_{Δ} is time for fine time tracking and acquiring full timing information of the target cell. $T_{\Delta} = T_{rs}$.

T_{IU} is the interruption uncertainty in acquiring the first available PRACH occasion in the new cell. T_{IU} can be up to x*10 +10 ms. x is defined in the table 6.3.3.2-2 of [6].

T_{rs} is the SMTC periodicity of the target NR cell if the UE has been provided with an SMTC configuration for the target cell in the handover command, otherwise Trs is the SMTC configured in the measObjectNR having the same SSB frequency and subcarrier spacing. If the UE is not provided SMTC configuration or measurement object on this frequency, the requirement in this section is applied with Trs = [5] ms assuming the SSB transmission periodicity is 5 ms. There is no requirement if the SSB transmission periodicity is not 5ms. If the UE has been provided with higher layer in TS 38.331 [2] signaling of *smtc2* prior to the handover command, T_{rs} follows *smtc1* or *smtc2* according to the physical cell ID of the target cell.

NOTE 1: The actual value of T_{IU} shall depend upon the PRACH configuration used in the target cell.

In the interruption requirement a cell is known if it has been meeting the relevant cell identification requirement during the last 5 seconds otherwise it is unknown. Relevant cell identification requirements are described in Clause 9.2.5 for intra-frequency handover and Clause 9.3.1 for inter-frequency handover.

6.1.1.4 NR FR2- NR FR2 Handover

The requirements in this clause are applicable to both intra-frequency and inter-frequency handovers from NR FR2 cell to NR FR2 cell.

6.1.1.4.1 Handover delay

Procedure delays for all procedures that can command a handover are specified in TS 38.331 [2].

When the UE receives a RRC message implying handover the UE shall be ready to start the transmission of the new uplink PRACH channel within $D_{handover}$ seconds from the end of the last TTI containing the RRC command.

Where:

$D_{handover}$ equals the maximum RRC procedure delay to be defined in clause 12 in TS 38.331 [2] plus the interruption time stated in clause 6.1.1.4.2.

6.1.1.4.2 Interruption time

The interruption time is the time between end of the last TTI containing the RRC command on the old PDSCH and the time the UE starts transmission of the new PRACH, excluding the RRC procedure delay.

When intra-frequency or inter-frequency handover is commanded, the interruption time shall be less than $T_{interrupt}$

$$T_{interrupt} = T_{search} + T_{IU} + T_{processing} + T_{\Delta} \text{ ms}$$

Where:

T_{search} is the time required to search the target cell when the handover command is received by the UE. If the target cell is an intra-frequency cell and the target cell Es/Iot ⩾ -TBD dB, then T_{search} = [8* T_{rs} + 2] ms. If the target cell is an inter-frequency cell and the target cell Es/Iot ⩾ -TBD dB, then T_{search} = [8*3* T_{rs} + 2] ms. Regardless of whether DRX is in use by the UE, T_{search} shall still be based on non-DRX target cell search times.

$T_{processing}$ is time for UE processing. $T_{processing}$ can be up to 20ms.

T_{Δ} is time for fine time tracking and acquiring full timing information of the target cell. T_{Δ} = [1]* T_{rs}.

T_{IU} is the interruption uncertainty in acquiring the first available PRACH occasion in the new cell. T_{IU} can be up to x*10 +10 ms. x is defined in the table 6.3.3.2-2 of [6].

T_{rs} is the SMTC periodicity of the target NR cell if the UE has been provided with an SMTC configuration for the target cell in the handover command, otherwise Trs is the SMTC configured in the measObjectNR having the same SSB frequency and subcarrier spacing. If the UE is not provided SMTC configuration or measurement object on this frequency, the requirement in this section is applied with Trs = [5] ms assuming the SSB transmission periodicity is 5 ms. There is no requirements if the SSB transmission periodicity is not 5 ms. If the UE has been provided with higher layer in TS 38.331 [2] signaling of *smtc2* prior to the handover command, T_{rs} follows *smtc1* or *smtc2* according to the physical cell ID of the target cell.

NOTE 1: The actual value of T_{IU} shall depend upon the PRACH configuration used in the target cell.

NOTE 2: Void

6.1.1.5 NR FR1- NR FR2 Handover

The requirements in this clause are applicable to inter-frequency handovers from NR FR1 cell to NR FR2 cell.

6.1.1.5.1 Handover delay

Procedure delays for all procedures that can command a handover are specified in TS 38.331 [2].

When the UE receives a RRC message implying handover the UE shall be ready to start the transmission of the new uplink PRACH channel within $D_{handover}$ seconds from the end of the last TTI containing the RRC command.

Where:

$D_{handover}$ equals the maximum RRC procedure delay to be defined in clause 12 in TS 38.331 [2] plus the interruption time stated in clause 6.1.1.5.2.

6.1.1.5.2 Interruption time

The interruption time is the time between end of the last TTI containing the RRC command on the old PDSCH and the time the UE starts transmission of the new PRACH, excluding the RRC procedure delay.

When intra-frequency or inter-frequency handover is commanded, the interruption time shall be less than $T_{interrupt}$

$$T_{interrupt} = T_{search} + T_{IU} + T_{processing} + T_{\Delta} \text{ ms}$$

Where:

T_{search} is the time required to search the target cell when the handover command is received by the UE. If the target cell is an intra-frequency cell and the target cell Es/Iot ⩾ -TBD dB, then T_{search} = [8* T_{rs} + 2] ms. If the target cell is an inter-frequency cell and the target cell Es/Iot ⩾ -TBD dB,, then T_{search} = [8*3* T_{rs} + 2] ms. Regardless of whether DRX is in use by the UE, T_{search} shall still be based on non-DRX target cell search times.

$T_{processing}$ is time for UE processing. $T_{processing}$ can be up 40ms.

T_{Δ} is time for fine time tracking and acquiring full timing information of the target cell. T_{Δ} = [1]* T_{rs}.

T_{IU} is the interruption uncertainty in acquiring the first available PRACH occasion in the new cell. T_{IU} can be up to x*10 +10 ms. x is defined in the table 6.3.3.2-2 of [6].

T_{rs} is the SMTC periodicity of the target NR cell if the UE has been provided with an SMTC configuration for the target cell in the handover command, otherwise Trs is the SMTC configured in the measObjectNR having the same SSB frequency and subcarrier spacing. If the UE is not provided SMTC configuration or measurement object on this frequency, the requirement in this section is applied with Trs=[5] ms assuming the SSB transmission periodicity is 5 ms. There is no requirements if the SSB transmission periodicity is not 5 ms. If the UE has been provided with higher layer in TS 38.331 [2] signaling of *smtc2* prior to the handover command, T_{rs} follows *smtc1* or *smtc2* according to the physical cell ID of the target cell.

NOTE 1: The actual value of T_{IU} shall depend upon the PRACH configuration used in the target cell.

NOTE 2: Void

6.1.2 NR Handover to other RATs

6.1.2.1 NR – E-UTRAN Handover

6.1.2.1.1 Introduction

The purpose of inter-RAT handover from NR to E-UTRAN is to change the radio access mode of PCell from NR to E-UTRAN. The handover procedure is initiated from NR with a RRC message that implies a handover as described in TS 38.331 [2]. The requirements in this clause are applicable to SA NR, NE-DC and NR-DC.

6.1.2.1.2 Handover delay

When the UE receives a RRC message implying handover to E-UTRAN the UE shall be ready to start the transmission of the uplink PRACH channel in E-UTRA within $D_{handover}$ seconds from the end of the last TTI containing the RRC command. $D_{handover}$ is defined as

$$D_{handover} = T_{RRC\_procedure\_delay} + T_{interrupt}$$

Where:

$T_{RRC\_procedure\_delay}$: it is the RRC procedure delay, which is 50ms

$T_{interrupt}$: it is the time between end of the last TTI containing the RRC command on the NR PDSCH and the time the UE starts transmission of the PRACH in E-UTRAN, excluding $T_{RRC\_procedure\_delay}$. $T_{interrupt}$ is defined in clause 6.1.2.1.3.

6.1.2.1.3 Interruption time

When the inter-RAT handover to E-UTRAN is commanded, the interruption time shall be less than $T_{interrupt}$

$$T_{interrupt} = T_{search} + T_{IU} + 20 \text{ ms}$$

Where:

T_{search} is the time required to search the target cell when the target cell is not already known when the handover command is received by the UE. If the target cell is known, then T_{search} = 0 ms. If the target cell is unknown and signal quality is sufficient for successful cell detection on the first attempt, then T_{search} = 80 ms. Regardless of whether DRX is in use by the UE, T_{search} shall still be based on non-DRX target cell search times.

T_{IU} is the interruption uncertainty in acquiring the first available PRACH occasion in the new cell. T_{IU} can be up to 30 ms.

NOTE: The actual value of T_{IU} shall depend upon the PRACH configuration used in the target cell.

In the interruption requirement a cell is known if it has been meeting the relevant cell identification requirement during the last 5 seconds otherwise it is unknown. Relevant E-UTRAN cell identification requirements are described in clause [9.4.1].

6.2 RRC Connection Mobility Control

6.2.1 SA: RRC Re-establishment

6.2.1.1 Introduction

This clause contains requirements on the UE regarding RRC connection re-establishment procedure. RRC connection re-establishment is initiated when a UE in RRC_CONNECTED state loses RRC connection due to any of failure cases, including radio link failure, handover failure, and RRC connection reconfiguration failure. The RRC connection re-establishment procedure is specified in clause 5.3.7 of TS 38.331 [2].

The requirements in this clause are applicable for RRC connection re-establishment to NR cell.

6.2.1.2 Requirements

In RRC connected mode the UE shall be capable of sending *RRCReestablishmentRequest* message within $T_{re\text{-}establish\_delay}$ seconds from the moment it detects a loss in RRC connection. The total RRC connection delay ($T_{re\text{-}establish\_delay}$) shall be less than:

$$T_{re-establish\_delay} = T_{UE\_re-establish\_delay} + T_{UL\_grant}$$

T_{UL_grant}: It is the time required to acquire and process uplink grant from the target PCell. The uplink grant is required to transmit *RRCReestablishmentRequest* message.

The UE re-establishment delay ($T_{UE\_re\text{-}establish\_delay}$) is specified in clause 6.2.1.2.1.

6.2.1.2.1 UE Re-establishment delay requirement

The UE re-establishment delay ($T_{UE\_re\text{-}establish\_delay}$) is the time between the moments when any of the conditions requiring RRC re-establishment as defined in clause 5.3.7 in TS 38.331 [2] is detected by the UE and when the UE sends PRACH to the target PCell. The UE re-establishment delay ($T_{UE\_re\text{-}establish\_delay}$) requirement shall be less than:

$$T_{UE\_re-establish\_delay} = 50 + T_{identify\_intra\_NR} + \sum_{i=1}^{Nfreq-1} T_{identify\_inter\_NR,i} + T_{SI-NR} + T_{PRACH}$$

The intra-frequency target NR cell shall be considered detectable when for each relevant SSB:

- SS-RSRP related side conditions given in Section 10.1.2 and 10.1.3 are fulfilled for a corresponding NR Band for FR1 and FR2, respectively,
- SSB_RP and SSB Ês/Iot according to Annex B.2.2 for a corresponding NR Band.

The inter-frequency target NR cell shall be considered detectable when for each relevant SSB:

- SS-RSRP related side conditions given in Section 10.1.4 and 10.1.5 are fulfilled for a corresponding NR Band for FR1 and FR2, respectively,
- SSB_RP and SSB Ês/Iot according to Annex B.2.2 for a corresponding NR Band.

$T_{identify\_intra\_NR}$: It is the time to identify the target intra-frequency NR cell and it depends on whether the target NR cell is known cell or unknown cell and on the frequency range (FR) of the target NR cell. If the UE is not configured with intra-frequency NR carrier for RRC re-establishment then $T_{identify\_intra\_NR}$=0; otherwise $T_{identify\_intra\_NR}$ shall not exceed the values defined in table 6.2.1.2.1-1.

$T_{identify\_inter\_NR,i}$: It is the time to identify the target inter-frequency NR cell on inter-frequency carrier *i* configured for RRC re-establishment and it depends on whether the target NR cell is known cell or unknown cell and on the frequency range (FR) of the target NR cell. $T_{identify\_inter\_NR,i}$ shall not exceed the values defined in table 6.2.1.2.1-2.

T_{SMTC}: It is the periodicity of the SMTC occasion configured for the intra-frequency carrier. If the UE has been provided with higher layer in TS 38.331 [2] signaling of *smtc2*, T_{smtc} follows *smtc1* or *smtc2* according to the physical cell ID of the target cell.

$T_{SMTC,i}$: It is the periodicity of the SMTC occasion configured for the inter-frequency carrier *i*.

$T_{SI\text{-}NR}$ = It is the time required for receiving all the relevant system information according to the reception procedure and the RRC procedure delay of system information blocks defined in TS 38.331 [2] for the target NR cell.

T_{PRACH} = It is the delay caused due to the random access procedure when sending random access to the target NR cell. The delay depends on the PRACH configuration defined in Table 6.3.3.2-2 [6] or Table 6.3.3.2-3 [6] for FR1 and in Table 6.3.3.2-4 [6] for FR2.

N_{freq}: It is the total number of NR frequencies to be monitored for RRC re-establishment; N_{freq} = 1 if the target intra-frequency NR cell is known, else N_{freq} = 2 and $T_{identify\_intra\_NR}$ = 0 if the target inter-frequency NR cell is known.

There is no requirement if the target cell does not contain the UE context.

In the requirement defined in the below tables, the target FR1 cell is known if it has been meeting the relevant cell identification requirement during the last [5] seconds otherwise it is unknown.

Table 6.2.1.2.1-1: Time to identify target NR cell for RRC connection re-establishment to NR intra-frequency cell

Serving cell SSB Ês/Iot (dB)	Frequency range (FR) of target NR cell	$T_{identify\_intra\_NR}$ [ms]	
		Known NR cell	Unknown NR cell
⩾ [-8]	FR1	MAX (200 ms, [5] x T_{SMTC})	MAX (800 ms, [10] x T_{SMTC})
⩾ [-8]	FR2	N/A	MAX (1000 ms, [80] x T_{SMTC}))
< [-8]	FR1	N/A	800 Note1
< [-8]	FR2	N/A	3520 Note1
Note 1: The UE is not required to successfully identify a cell on any NR frequency layer when T_{SMTC} > 20 ms and serving cell SSB Ês/Iot < [-8] dB.			

Table 6.2.1.2.1-2: Time to identify target NR cell for RRC connection re-establishment to NR inter-frequency cell

Serving cell SSB Ês/Iot (dB)	Frequency range (FR) of target NR cell	$T_{identify\_inter\_NR,\ i}$ [ms]	
		Known NR cell	Unknown NR cell
⩾ [-8]	FR1	MAX (200 ms, [6] x $T_{SMTC,\ i}$)	MAX (800 ms, [13] x $T_{SMTC,\ i}$)
⩾ [-8]	FR2	N/A	MAX (1000 ms, [104] x $T_{SMTC,\ i}$))
< [-8]	FR1	N/A	800 Note1
< [-8]	FR2	N/A	4000 Note1
Note 1: The UE is not required to successfully identify a cell on any NR frequency layer when $T_{SMTC,i}$ > 20 ms and serving cell SSB Ês/Iot < [-8] dB.			

6.2.2 Random access

6.2.2.1 Introduction

This clause contains requirements on the UE regarding random access procedure. The random access procedure is initiated to establish uplink time synchronization for a UE which either has not acquired or has lost its uplink synchronization, or to convey UE's request Other SI, or for beam failure recovery. The random access is specified in clause 8 of TS 38.213 [3] and the control of the RACH transmission is specified in clause 5.1 of TS 38.321 [7].

6.2.2.2 Requirements

The UE shall have capability to calculate PRACH transmission power according to the PRACH power formula defined in TS 38.213 [3] and apply this power level at the first preamble or additional preambles. The absolute power applied to the first preamble shall have an accuracy as specified in Table 6.3.4.2-1 of TS 38.101-1 [18] for frequency range 1 and in Table 6.3.4.2-1 of TS 38.101-2 [19] for frequency range 2. The relative power applied to additional preambles shall have an accuracy as specified in Table 6.3.4.3-1 of TS 38.101-1 [18] for frequency range 1 and clause 6.3.4.3 of TS38.101-2 [19] for frequency range 2.

The UE shall indicate a Random Access problem to upper layers if the maximum number of preamble transmission counter has been reached for the random access procedure on PCell or PSCell as specified in clause 5.1.4 in TS 38.321 [7].

The requirements in this section apply for UE in SA operation mode or any MR-DC operation mode.

6.2.2.2.1 Contention based random access

6.2.2.2.1.1 Correct behaviour when transmitting Random Access Preamble

With the UE selected SSB with SS-RSRP above *rsrp-ThresholdSSB*, UE shall have the capability to select a Random Access Preamble randomly with equal probability from the Random Access Preambles associated with the selected SSB if the association between Random Access Preambles and SS blocks is configured, as specified in clause 5.1.2 in TS 38.321 [7].

With the UE selected SSB with SS-RSRP above *rsrp-ThresholdSSB*, UE shall have the capability to transmit Random Access Preamble on the next available PRACH occasion from the PRACH occasions corresponding to the selected SSB permitted by the restrictions given by the *ra-ssb-OccasionMaskIndex* if configured, if the association between PRACH occasions and SSBs is configured, and PRACH occasion shall be randomly selected with equal probability amongst the selected SSB associated PRACH occasions occurring simultaneously but on different subcarriers, as specified in clause 5.1.2 in TS 38.321 [7].

6.2.2.2.1.2 Correct behaviour when receiving Random Access Response

The UE may stop monitoring for Random Access Response(s) and shall transmit the msg3 if the Random Access Response contains a Random Access Preamble identifier corresponding to the transmitted Random Access Preamble.

The UE shall again perform the Random Access Resource selection procedure defined in clause 5.1.2 in TS 38.321 [7], and transmit with the calculated PRACH transmission power when the backoff time expires if all received Random Access Responses contain Random Access Preamble identifiers that do not match the transmitted Random Access Preamble.

6.2.2.2.1.3 Correct behaviour when not receiving Random Access Response

The UE shall again perform the Random Access Resource selection procedure defined in clause 5.1.2 in TS 38.321 [7], and transmit with the calculated PRACH transmission power when the backoff time expires if no Random Access Response is received within the RA Response window defined in clause 5.1.4 in TS 38.321 [7].

6.2.2.2.1.4 Correct behaviour when receiving a NACK on msg3

The UE shall re-transmit the msg3 upon the reception of a NACK on msg3.

6.2.2.2.1.5 Correct behaviour when receiving a message over Temporary C-RNTI

The UE shall send ACK if the Contention Resolution is successful.

The UE shall again perform the Random Access Resource selection procedure defined in clause 5.1.2 in TS 38.321 [7], and transmit with the calculated PRACH transmission power when the backoff time expires unless the received message includes a UE Contention Resolution Identity MAC control element and the UE Contention Resolution Identity included in the MAC control element matches the CCCH SDU transmitted in the uplink message.

6.2.2.2.1.6 Correct behaviour when contention Resolution timer expires

The UE shall re-select a preamble and transmit with the calculated PRACH transmission power when the backoff time expires if the Contention Resolution Timer expires.

6.2.2.2.2 Non-Contention based random access

6.2.2.2.2.1 Correct behaviour when transmitting Random Access Preamble

If the contention-free Random Access Resources and the contention-free PRACH occasions associated with SSBs is configured, with the UE selected SSB with SS-RSRP above *rsrp-ThresholdSSB* amongst the associated SSBs, UE shall have the capability to select the Random Access Preamble corresponding to the selected SSB, and to transmit Random Access Preamble on the next available PRACH occasion from the PRACH occasions corresponding to the selected SSB permitted by the restrictions given by the *ra-ssb-OccasionMaskIndex* if configured, and PRACH occasion shall be randomly selected with equal probability amongst the selected SSB associated PRACH occasions occurring simultaneously but on different subcarriers, as specified in clause 5.1.2 in TS 38.321 [7].

If the contention-free Random Access Resources and the contention-free PRACH occasions associated with CSI-RSs is configured, with the UE selected CSI-RS with CSI-RSRP above *cfra-csirs-DedicatedRACH-Threshold* amongst the associated CSI-RSs, UE shall have the capability to select the Random Access Preamble corresponding to the selected CSI-RS, and to transmit Random Access Preamble on the next available PRACH occasion from the PRACH occasions in *ra-OccasionList* corresponding to the selected CSI-RS, and PRACH occasion shall be randomly selected with equal probability amongst the selected CSI-RS associated PRACH occasions occurring simultaneously but on different subcarriers, as specified in clause 5.1.2 in TS 38.321 [7].

If the random access procedure is initialized for beam failure recovery and if the contention-free Random Access Resources and the contention-free PRACH occasions for beam failure recovery request associated with any of the SSBs and/or CSI-RSs is configured, UE shall have the capability to select the Random Access Preamble corresponding to the selected SSB with SS-RSRP above *rsrp-ThresholdSSB* amongst the associated SSBs or the selected CSI-RS with CSI-RSRP above *cfra-csirs-DedicatedRACH-Threshold* amongst the associated CSI-RSs, and to transmit Random Access Preamble on the next available PRACH occasion from the PRACH occasions corresponding to the selected SSB permitted by the restrictions given by the *ra-ssb-OccasionMaskIndex* if configured, or from the PRACH occasions in *ra-OccasionList* corresponding to the selected CSI-RS, and PRACH occasion shall be randomly selected with equal probability amongst the selected SSB assocated PRACH occasions or the selected CSI-RS associated PRACH occasions occurring simultaneously but on different subcarriers, as specified in clause 5.1.2 in TS 38.321 [7].

6.2.2.2.2.2 Correct behaviour when receiving Random Access Response

The UE may stop monitoring for Random Access Response(s), if the Random Access Response contains a Random Access Preamble identifier corresponding to the transmitted Random Access Preamble, unless the random access procedure is initialized for Other SI request from UE.

The UE may stop monitoring for Random Access Response(s) and shall monitor the Other SI transmission if the Random Access Response only contains a Random Access Preamble identifier which is corresponding to the transmitted Random Access Preamble and the random access procedure is initialized for SI request from UE, as specified in clause 5.1.4 in TS 38.321 [7].

The UE may stop monitoring for Random Access Response(s), if the contention-free Random Access Preamble for beam failure recovery request was transmitted and if the PDCCH addressed to UE's C-RNTI is received, as specified in clause 5.1.4 in TS 38.321 [7].

The UE shall again perform the Random Access Resource selection procedure defined in clause 5.1.2 in TS 38.321 [7] for the next available PRACH occasion, and transmit the preamble with the calculated PRACH transmission power if all received Random Access Responses contain Random Access Preamble identifiers that do not match the transmitted Random Access Preamble.

6.2.2.2.2.3 Correct behaviour when not receiving Random Access Response

The UE shall again perform the Random Access Resource selection procedure defined in clause 5.1.2 in TS 38.321 [7] for the next available PRACH occasion, and transmit the preamble with the calculated PRACH transmission power, if no Random Access Response is received within the RA Response window configured in *RACH-ConfigCommon* or if no PDCCH addressed to UE's C-RNTI is received within the RA Response window configured in *BeamFailureRecoveryConfig*, as defined in clause 5.1.4 in TS 38.321 [7].

6.2.2.2.3 UE behaviour when configured with supplementary UL

In addition to the requirements defined in clause 6.2.2.2.1 and 6.2.2.2.2, a UE configured with supplementary UL carrier shall use RACH configuration for the supplementary UL carrier contained in RMSI and RRC dedicated signalling. If the cell for the random access procedure is configured with supplementary UL, the UE shall transmit or re-transmit PRACH preamble on the supplementary UL carrier if the SS-RSRP measured by the UE on the DL carrier is lower than the *rsrp-ThresholdSSB-SUL* as defined in TS 38.331 [2].

6.2.3 SA: RRC Connection Release with Redirection

6.2.3.1 Introduction

This clause contains requirements on the UE regarding RRC connection release with redirection procedure. RRC connection release with redirection is initiated by the *RRCConnectionRelease* message with redirection to E-UTRAN or NR from NR specified in TS 38.331 [2]. The RRC connection release with redirection procedure is specified in clause 5.3.8 of TS 38.331 [2].

6.2.3.2 Requirements

6.2.3.2.1 RRC connection release with redirection to NR

The UE shall be capable of performing the RRC connection release with redirection to the target NR cell within $T_{connection\_release\_redirect\_NR}$.

The time delay ($T_{connection\_release\_redirect\_NR}$) is the time between the end of the last slot containing the RRC command, "*RRCRelease*" (TS 38.331 [2]) on the NR PDSCH and the time the UE starts to send random access to the target NR cell. The time delay ($T_{connection\_release\_redirect\_NR}$) shall be less than:

$$T_{connection\_release\_redirect\_NR} = T_{RRC\_procedure\_delay} + T_{identify\text{-}NR} + T_{SI\text{-}NR} + T_{RACH}$$

The target NR cell shall be considered detetable when for each relevant SSB, the side conditions should be met that,

- SSB_RP and SSB Ês/Iot according to Annex B.2.5 for a corresponding NR Band.

$T_{RRC\_procedure\_delay}$: It is the RRC procedure delay for processing the received message "*RRCRelease*" as defined in clause 6.2.2 of TS 38.331 [2].

$T_{identify\text{-}NR}$: It is the time to identify the target NR cell and depend on the frequency range (FR) of the target NR cell. It is defined in table 6.2.3.2.1-1. Note that $T_{identify\text{-}NR} = T_{PSS/SSS\text{-}sync} + T_{meas}$, in which $T_{PSS/SSS\text{-}sync}$ is the cell search time and T_{meas} is the measurement time due to cell selection criteria evaluation.

$T_{SI\text{-}NR}$: It is the time required for acquiring all the relevant system information of the target NR cell. This time depends upon whether the UE is provided with the relevant system information of the target NR cell or not by the old NR cell before the RRC connection is released. $T_{SI\text{-}NR} = 0$ provided the UE is provided with the SI (including MIB and all relevant SIBs) of the target NR cell before the RRC connection is released by the old NR cell.

T_{RACH}: It is the delay caused due to the random access procedure when sending random access to the target NR cell. This delay depends on the PRACH configuration defined in Table 6.3.3.2-2 [6] or Table 6.3.3.2-3 [6] for FR1 and in Table 6.3.3.2-4 [6] for FR2.

T_{rs} is the SMTC periodicity of the target NR cell if the UE has been provided with an SMTC configuration for the target cell in the redirection command, otherwise T_{rs} is the SMTC configured in the measObjectNR having the same SSB frequency and subcarrier spacing configured for the RRC connection release with redirection. If the UE is not provided with SMTC configuration or measurement object for the frequency which is also configured for the RRC connection release with redirection then:

- the requirement in this section is applied with T_{rs} = 20 ms assuming the SSB transmission periodicity is not larger than 20 ms,
- there is no requirement if the SSB transmission periodicity is larger than 20ms.

Table 6.2.3.2.1-1: Time to identify target NR cell for RRC connection release with redirection to NR

Frequency range (FR) of target NR cell	$T_{identify-NR}$
FR1	MAX (680 ms, [11] x T_{rs})
FR2	MAX (880 ms, 8x[11] x T_{rs})
Note : If the UE has been provided with higher layer in TS 38.331 [2] signaling of *smtc2* prior to the redirection command, SMTC follows *smtc1* or *smtc2* according to the physical cell ID of the target cell.	

6.2.3.2.2 RRC connection release with redirection to E-UTRAN

The UE shall be capable of performing the RRC connection release with redirection to the target E-UTRAN cell within $T_{connection\_release\_redirect\_E-UTRA}$.

The time delay ($T_{connection\_release\_redirect\_E-UTRA}$) is the time between the end of the last slot containing the RRC command, "*RRCRelease*" (TS 38.331 [2]) on the PDSCH and the time the UE starts to send random access to the target E-UTRA cell. The time delay ($T_{connection\_release\_redirect\_E-UTRA}$) shall be less than:

$$T_{connection\_release\_redirect\_E-UTRA} = T_{RRC\_procedure\_delay} + T_{identify-E-UTRA} + T_{SI-E-UTRA} + T_{RACH}$$

The target E-UTRA FDD or TDD cell shall be considered detectable when for each relevant SSB:

- RSRP related conditions in the accuracy requirements in Section 10.2.2 are fulfilled for a corresponding Band, together with the corresponding side conditions in Annex B.2 and Annex B.3 of TS 36.133 [15],
- RSRQ related conditions in the accuracy requirements in Section 10.2.3 are fulfilled for a corresponding Band, together with the corresponding side conditions in Annex B.2 and Annex B.3 of TS 36.133 [15],
- RS-SINR related conditions in the accuracy requirements in Section 10.2.5 are fulfilled for a corresponding Band, together with the corresponding side conditions in Annex B.2 and Annex B.3 of TS 36.133 [15].

$T_{RRC\_procedure\_delay}$: It is the RRC procedure delay for processing the received message "*RRCRelease*" as defined in clause 6.2.2 of TS 38.331 [2].

$T_{identify-E-UTRA}$: It is the time to identify the target E-UTRA cell. It shall be less than 320 ms.

$T_{SI-E-UTRA}$: It is the time required for acquiring all the relevant system information of the target E-UTRA cell. This time depends upon whether the UE is provided with the relevant system information (SI) of the target E-UTRA cell or not by the old NR cell before the RRC connection is released. $T_{SI-E-UTRA}$ = 0 provided the UE is provided with the SI (including MIB and all relevant SIBs) of the target E-UTRA cell before the RRC connection is released by the old NR cell.

T_{RACH}: It is the delay caused due to the random access procedure when sending random access to the target E-UTRA cell.

7 Timing

7.1 UE transmit timing

7.1.1 Introduction

The UE shall have capability to follow the frame timing change of the reference cell in connected state. The uplink frame transmission takes place $(N_{\mathrm{TA}} + N_{\mathrm{TA\,offset}}) \times T_{\mathrm{c}}$ before the reception of the first detected path (in time) of the corresponding downlink frame from the reference cell. If the UE is configured with a pTAG containing the PCell, UE shall use the PCell as the reference cell for deriving the UE transmit timing for cells in the pTAG. If the UE is configured with a psTAG containing the PSCell, UE shall use the PSCell as the reference cell for deriving the UE transmit timing for cells in the psTAG. UE initial transmit timing accuracy, maximum amount of timing change in one adjustment, minimum and maximum adjustment rate are defined in the following requirements.

7.1.2 Requirements

The UE initial transmission timing error shall be less than or equal to $\pm T_e$ where the timing error limit value T_e is specified in Table 7.1.2-1. This requirement applies:

- when it is the first transmission in a DRX cycle for PUCCH, PUSCH and SRS or it is the PRACH transmission.

The UE shall meet the Te requirement for an initial transmission provided that at least one SSB is available at the UE during the last 160 ms. The reference point for the UE initial transmit timing control requirement shall be the downlink timing of the reference cell minus $(N_{\mathrm{TA}} + N_{\mathrm{TA\,offset}}) \times T_{\mathrm{c}}$. The downlink timing is defined as the time when the first detected path (in time) of the corresponding downlink frame is received from the reference cell. N_{TA} for PRACH is defined as 0.

$(N_{\mathrm{TA}} + N_{\mathrm{TA\,offset}}) \times T_{\mathrm{c}}$ (in T_c units) for other channels is the difference between UE transmission timing and the downlink timing immediately after when the last timing advance in clause 7.3 was applied. N_{TA} for other channels is not changed until next timing advance is received. The value of $N_{\mathrm{TA\,offset}}$ depends on the duplex mode of the cell in which the uplink transmission takes place and the frequency range (FR). $N_{\mathrm{TA\,offset}}$ is defined in Table 7.1.2-2.

Table 7.1.2-1: T_e Timing Error Limit

Frequency Range	SCS of SSB signals (KHz)	SCS of uplink signals s(KHz)	T_e
1	15	15	12*64*T_c
		30	10*64*T_c
		60	10*64*T_c
	30	15	8*64*T_c
		30	8*64*T_c
		60	7*64*T_c
2	120	60	3.5*64*T_c
		120	3.5*64*T_c
	240	60	3*64*T_c
		120	3*64*T_c
Note 1: T_c is the basic timing unit defined in TS 38.211 [6]			

Table 7.1.2-2: The Value of $N_{\mathrm{TA\,offset}}$

Frequency range and band of cell used for uplink transmission	$N_{\mathrm{TA\,offset}}$ (Unit: T_C)
FR1 FDD band without LTE-NR coexistence case or FR1 TDD band without LTE-NR coexistence case	25600 (Note 1)
FR1 FDD band with LTE-NR coexistence case	0 (Note 1)
FR1 TDD band with LTE-NR coexistence case	39936 (Note 1)
FR2	13792
Note 1: The UE identifies $N_{\mathrm{TA\,offset}}$ based on the information n-TimingAdvanceOffset according to [2]. If UE is not provided with the information n-TimingAdvanceOffset, the default value of $N_{\mathrm{TA\,offset}}$ is set as 25600 for FR1 band. In case of multiple UL carriers in the same TAG, UE expects that the same value of n-TimingAdvanceOffset is provided for all the UL carriers according to section 4.2 in [3] and the value 39936 of $N_{\mathrm{TA\,offset}}$ can also be provided for a FDD serving cell.Note 2: Void	

When it is not the first transmission in a DRX cycle or there is no DRX cycle, and when it is the transmission for PUCCH, PUSCH and SRS transmission, the UE shall be capable of changing the transmission timing according to the received downlink frame of the reference cell except when the timing advance in clause 7.3 is applied.

When the transmission timing error between the UE and the reference timing exceeds $\pm T_e$, the UE is required to adjust its timing to within $\pm T_e$. The reference timing shall be $(N_{\mathrm{TA}} + N_{\mathrm{TA\,offset}}) \times T_c$ before the downlink timing of the reference cell. All adjustments made to the UE uplink timing shall follow these rules:

1) The maximum amount of the magnitude of the timing change in one adjustment shall be T_q.

2) The minimum aggregate adjustment rate shall be T_p per second.

3) The maximum aggregate adjustment rate shall be T_q per 200ms.

where the maximum autonomous time adjustment step T_q and the aggregate adjustment rate T_p are specified in Table 7.1.2-3.

Table 7.1.2-3: T_q Maximum Autonomous Time Adjustment Step and T_p Minimum Aggregate Adjustment rate

Frequency Range	SCS of uplink signals (KHz)	T_q	T_p
1	15	$5.5*64*T_c$	$5.5*64*T_c$
	30	$5.5*64*T_c$	$5.5*64*T_c$
	60	$5.5*64*T_c$	$5.5*64*T_c$
2	60	$2.5*64*T_c$	$2.5*64*T_c$
	120	$2.5*64*T_c$	$2.5*64*T_c$
NOTE 1: T_c is the basic timing unit defined in TS 38.211 [6]			

7.2 UE timer accuracy

7.2.1 Introduction

UE timers are used in different protocol entities to control the UE behaviour.

7.2.2 Requirements

For UE timers specified in TS 38.331 [2], the UE shall comply with the timer accuracies according to Table 7.2.2-1.

The requirements are only related to the actual timing measurements internally in the UE. They do not include the following:

- Inaccuracy in the start and stop conditions of a timer (e.g. UE reaction time to detect that start and stop conditions of a timer is fulfilled), or

- Inaccuracies due to restrictions in observability of start and stop conditions of a UE timer (e.g. slot alignment when UE sends messages at timer expiry).

Table 7.2.2-1

Timer value [s]	Accuracy
timer value < 4	± 0.1s
timer value ≥ 4	± 2.5%

7.3 Timing advance

7.3.1 Introduction

The timing advance is initiated from PSCell in EN-DC and NR-DC operation modes, and from PCell in SA, NE-DC, or NR-DC operation modes, with MAC message that implies and adjustment of the timing advance, as defined in clause 5.2 of TS 38.321 [7].

7.3.2 Requirements

7.3.2.1 Timing Advance adjustment delay

UE shall adjust the timing of its uplink transmission timing at time slot $n+k$ for a timing advance command received in time slot n, and the value of k is defined in section 4.2 in TS 38.213 [3]. The same requirement applies also when the UE is not able to transmit a configured uplink transmission due to the channel assessment procedure.

7.3.2.2 Timing Advance adjustment accuracy

The UE shall adjust the timing of its transmissions with a relative accuracy better than or equal to the UE Timing Advance adjustment accuracy requirement in Table 7.3.2.2-1, to the signalled timing advance value compared to the timing of preceding uplink transmission. The timing advance command step is defined in TS 38.213 [3].

Table 7.3.2.2-1: UE Timing Advance adjustment accuracy

Sub Carrier Spacing, SCS kHz	15	30	60	120
UE Timing Advance adjustment accuracy	±256 T_c	±256 T_c	±128 T_c	±32 T_c

7.4 Cell phase synchronization accuracy

7.4.1 Definition

Cell phase synchronization accuracy for TDD is defined as the maximum absolute deviation in frame start timing between any pair of cells on the same frequency that have overlapping coverage areas.

7.4.2 Minimum requirements

The cell phase synchronization accuracy measured at BS antenna connectors shall be better than 3 μs.

7.5 Maximum Transmission Timing Difference

7.5.1 Introduction

A UE shall be capable of handling a relative transmission timing difference between subframe timing boundary of E-UTRA PCell and slot timing boundary of PSCell to be aggregated for EN-DC operation.

A UE shall be capable of handling a relative transmission timing difference among slot timing boundaries of different carriers to be aggregated in NR carrier aggregation.

7.5.2 Minimum Requirements for inter-band EN-DC

The UE shall be capable of handling a maximum uplink transmission timing difference between E-UTRA PCell and PSCell as shown in Table 7.5.2-1.

Table 7.5.2-1 Maximum uplink transmission timing difference requirement for asynchronous EN-DC

Sub-carrier spacing in E-UTRA PCell (kHz)	UL Sub-carrier spacing for data in PSCell (kHz)	Maximum uplink transmission timing difference (µs)
15	15	500
15	30	250
15	60	125
15	120[Note1]	62.5
NOTE 1: For E-UTRA FDD-NR FDD and E-UTRA TDD-NR TDD intra-band EN-DC, for which the requirement is defined in Section 7.5.3 and this Table 7.5.2-1 is also applicable, the scenario with 120kHz PSCell does not exist.		

The UE shall be capable of handling a maximum uplink transmission timing difference between E-UTRA PCell and PSCell as shown in Table 7.5.2-2. The requirements for synchronous EN-DC are applicable for E-UTRA TDD-NR TDD, E-UTRA FDD-NR FDD, E-UTRA TDD-NR FDD and E-UTRA FDD-NR TDD inter-band EN-DC.

Table 7.5.2-2 Maximum uplink transmission timing difference requirement for inter-band synchronous EN-DC

Sub-carrier spacing in E-UTRA PCell (kHz)	UL Sub-carrier spacing for data in PSCell (kHz)	Maximum uplink transmission timing difference (µs)
15	15	35.21
15	30	35.21
15	60	35.21
15	120	35.21
NOTE 1: Void		

Editor Note: It is FFS the necessity of inter-band EN-DC synchronous requirement for MTTD.

7.5.3 Minimum Requirements for intra-band EN-DC

For intra-band EN-DC, only collocated deployment is applied.

The UE shall be capable of handling a maximum uplink transmission timing difference between E-UTRA PCell and PSCell as shown in Table 7.5.2-1 for E-UTRA FDD-NR FDD intra-band EN-DC provided the UE indicates that it is capable of asynchronous EN-DC operation [16]. No requirement on maximum uplink transmission timing difference is applicable for synchronous E-UTRA FDD-NR FDD and E-UTRA TDD-NR TDD intra-band EN-DC.

7.5.4 Minimum Requirements for NR Carrier Aggregation

The UE shall be capable of handling at least a relative transmission timing difference between slot timing of different TAGsas shown in Table 7.5.4-1, provided that the UE is:

- configured with the pTAG and the sTAG for inter-band NR carrier aggregation in SA mode. or
- configured with more than one sTAG for inter-band NR carrier aggregation in NSA mode.

Table 7.5.4-1: Maximum transmission timing difference requirement for inter-band NR carrier aggregation

Frequency Range	Maximum transmission timing difference (μs)
FR1	34.6
FR2	8.5
Between FR1 and FR2	26.1

7.5.5 Minimum Requirements for inter-band NE-DC

The UE shall be capable of handling a maximum uplink transmission timing difference between NR PCell and PSCell as shown in Table 7.5.5-1.

Table 7.5.5-1: Maximum uplink transmission timing difference requirement for asynchronous NE-DC

Sub-carrier spacing in NR PCell (kHz)	UL Sub-carrier spacing for data in PSCell (kHz)	Maximum uplink transmission timing difference (μs)
15	15	500
30	15	250
60	15	125
120[Note1]	15	62.5
NOTE 1: For NR FDD- E-UTRA FDD and NR TDD- E-UTRA TDD intra-band NE-DC, for which the requirement is defined in Section [7.5.X] and this Table 7.5.5-1 is also applicable, the scenario with 120kHz PCell does not exist.		

The UE shall be capable of handling a maximum uplink transmission timing difference between NR PCell and PSCell as shown in Table 7.5.5-2. The requirements for synchronous NE-DC are applicable for NR TDD- E-UTRA TDD, NR FDD- E-UTRA FDD, NR TDD- E-UTRA FDD and NR FDD- E-UTRA TDD inter-band NE-DC.

Table 7.5.5-2: Maximum uplink transmission timing difference requirement for inter-band synchronous NE-DC

Sub-carrier spacing in NR PCell (kHz)	UL Sub-carrier spacing for data in PSCell (kHz)	Maximum uplink transmission timing difference (μs)
15	15	35.21
30	15	35.21
60	15	35.21
120	15	35.21
NOTE 1: Void		

Editor Note: It is FFS the necessity of inter-band NE-DC synchronous requirement for MTTD.

7.5.6 Minimum Requirements for inter-band NR-NR DC

The UE shall be capable of handling a maximum uplink transmission timing difference between PCell and PSCell as shown in Table 7.5.6-1 provided that the UE indicates that it is capable of synchronous NR-NR DC [16].

Table 7.5.6-1: Maximum transmission timing difference requirement for inter-band NR-NR synchronous dual connectivity

Frequency Range		Maximum transmission timing difference (μs)
PCell	PSCell	
FR1	FR2	34.1

7.6 Maximum Receive Timing Difference

7.6.1 Introduction

A UE shall be capable of handling a relative receive timing difference between subframe timing boundary of E-UTRA PCell and slot timing boundary of PSCell to be aggregated for EN-DC operation.

A UE shall be capable of handling a relative receive timing difference among slot timing boundaries of different carriers to be aggregated in NR carrier aggregation.

7.6.2 Minimum Requirements for inter-band EN-DC

The UE shall be capable of handling at least a relative receive timing difference between subframe timing of signal from E-UTRA PCell and slot timing of signal from PSCell at the UE receiver as shown in Table 7.6.2-1.

Table 7.6.2-1: Maximum receive timing difference requirement for asynchronous EN-DC

Sub-carrier spacing in E-UTRA PCell (kHz)	DL Sub-carrier spacing in PSCell (kHz) (Note 1)	Maximum receive timing difference (μs)
15	15	500
15	30	250
15	60	125
15	120 Note2	62.5
NOTE 1: DL Sub-carrier spacing is min{SCS_{SS}, SCS_{DATA}}. NOTE 2: For E-UTRA FDD-NR FDD and E-UTRA TDD-NR TDD intra-band EN-DC, for which the requirement is defined in Section 7.6.3 and this Table 7.6.2-1 is also applicable, the scenario with 120kHz does not exit.		

The UE shall be capable of handling at least a relative receive timing difference between subframe timing of signal from E-UTRA PCell and slot timing of signal from PSCell at the UE receiver as shown in Table 7.6.2-2. The requirements for synchronous EN-DC are applicable for E-UTRA TDD-NR TDD, E-UTRA FDD-NR FDD, E-UTRA TDD-NR FDD and E-UTRA FDD-NR TDD inter-band EN-DC.

Table 7.6.2-2: Maximum receive timing difference requirement for inter-band synchronous EN-DC

Sub-carrier spacing in E-UTRA PCell (kHz)	DL Sub-carrier spacing in PSCell (kHz) (Note1)	Maximum receive timing difference (μs)
15	15	33
15	30	
15	60	
15	120	
NOTE 1: DL Sub-carrier spacing is min{SCS_{SS}, SCS_{DATA}}. NOTE 2: Void		

Editor Note: It is FFS the necessity of inter-band EN-DC synchronous requirement for MRTD.

Table 7.6.2-3 Void

7.6.3 Minimum Requirements for intra-band EN-DC

For intra-band EN-DC, only collocated deployment is applied.

The UE shall be capable of handling at least a relative receive timing difference between subframe timing of signal from E-UTRA PCell and slot timing of signal from PSCell as shown in Table 7.6.2-1 for E-UTRA FDD-NR FDD intra-band EN-DC provided the UE indicates that it is capable of asynchronous EN-DC operation[16].

The UE shall be capable of handling at least a relative receive timing difference between subframe timing of signal from E-UTRA PCell and slot timing of signal from PSCell as shown in Table 7.6.3-1. The requirements for synchronous EN-DC are applicable for E-UTRA TDD-NR TDD and E-UTRA FDD-NR FDD intra-band EN-DC.

Table 7.6.3-1 Maximum receive timing difference requirement for intra-band synchronous EN-DC

Sub-carrier spacing in E-UTRA PCell (kHz)	DL Sub-carrier spacing in PSCell (kHz) Note1	Maximum receive timing difference (μs)
15	15	3
15	30	3
15	60	3
NOTE 1: DL Sub-carrier spacing is min{SCS_{SS}, SCS_{DATA}}.		

Table 7.6.3-2 Void

7.6.4 Minimum Requirements for NR Carrier Aggregation

For intra-band CA, only collocated deployment is applied. For intra-band non-contiguous NR carrier aggregation, the UE shall be capable of handling at least a relative receive timing difference between slot timing of different carriers to be aggregated at the UE receiver as shown in Table 7.6.4-1 below.

Table 7.6.4-1: Maximum receive timing difference requirement for intra-band non-contiguous NR carrier aggregation

Frequency Range	Maximum receive timing difference (μs)
FR1	3
FR2	3

For inter-band NR carrier aggregation, the UE shall be capable of handling at least a relative receive timing difference between slot timing of different carriers to be aggregated at the UE receiver as shown in Table 7.6.4-2 below.

Table 7.6.4-2: Maximum receive timing difference requirement for inter-band NR carrier aggregation

Frequency Range	Maximum receive timing difference (μs)
FR1	33
FR2	8
Between FR1 and FR2	25

7.6.5 Minimum Requirements for inter-band NE-DC

The UE shall be capable of handling at least a relative receive timing difference between subframe timing of signal from NR PCell and slot timing of signal from PSCell at the UE receiver as shown in Table 7.6.5-1.

Table 7.6.5-1: Maximum receive timing difference requirement for asynchronous NE-DC

Sub-carrier spacing in NR PCell (kHz)	DL Sub-carrier spacing in PSCell (kHz) (Note 1)	Maximum receive timing difference (µs)
15	15	500
30	15	250
60	15	125
120[Note2]	15	62.5
NOTE 1: DL Sub-carrier spacing is min{SCS_{SS}, SCS_{DATA}}. NOTE 2: For NR FDD- E-UTRA FDD and NR TDD- E-UTRA TDD intra-band NE-DC, for which the requirement is defined in Section [7.6.X] and this Table 7.6.5-1 is also applicable, the scenario with 120kHz does not exit.		

The UE shall be capable of handling at least a relative receive timing difference between subframe timing of signal from NR PCell and slot timing of signal from PSCell at the UE receiver as shown in Table 7.6.5-2. The requirements for synchronous NE-DC are applicable for NR TDD- E-UTRA TDD, NR FDD- E-UTRA FDD, NR TDD- E-UTRA FDD and NR FDD- E-UTRA TDD inter-band NE-DC.

Table 7.6.5-2: Maximum receive timing difference requirement for inter-band synchronous NE-DC

Sub-carrier spacing in NR PCell (kHz)	DL Sub-carrier spacing in PSCell (kHz) (Note1)	Maximum receive timing difference (µs)
15	15	33
30	15	
60	15	
120	15	
NOTE 1: DL Sub-carrier spacing is min{SCS_{SS}, SCS_{DATA}}. NOTE 2: Void		

Editor Note: It is FFS the necessity of inter-band NE-DC synchronous requirement for MRTD.

7.6.6 Minimum Requirements for inter-band NR-NR DC

The UE shall be capable of handling at least a relative receive timing difference between subframe timing of signal from PCell and slot timing of signal from PSCell at the UE receiver as shown in Table 7.6.6-1 provided that the UE indicates that it is capable of synchronous NR-NR DC [16].

Table 7.6.6-1: Maximum receive timing difference requirement for inter-band NR-NR synchronous dual connectivity

Frequency Range		Maximum receive timing difference (µs)
PCell	PSCell	
FR1	FR2	33

7.7 deriveSSB-IndexFromCell tolerance

7.7.1 Minimum requirements

When *deriveSSB-IndexFromCell* is enabled, the UE assumes frame boundary alignment (including half frame, subframe and slot boundary alignment) across cells on the same frequency carrier is within a tolerance not worse than min(2 SSB symbols, 1 PDSCH symbol) and the SFN of all cells on the same frequency carrier are the same.

7.8 Maximum Allowed UE Transition Times for TDD Intra-band Carrier Aggregation

7.8.1 Requirements

A UE is not expected to transmit in the uplink to a cell earlier than $N_{\text{Rx-Tx}} T_{\text{C}}$ after the end of the last received downlink symbol from the any cell in the same TDD band where $N_{\text{Rx-Tx}}$ is given by Table 4.3.2-3 in TS 38.211 [6].

A UE is not expected to receive in the downlink from a cell earlier than $N_{\text{Tx-Rx}} T_{\text{C}}$ after the end of the last transmitted uplink symbol toward any cell in the same TDD band where $N_{\text{Tx-Rx}}$ is given by Table 4.3.2-3 in TS 38.211 [6].

8 Signalling characteristics

8.1 Radio Link Monitoring

8.1.1 Introduction

The requirements in section 8.1 apply for radio link monitoring on any of:

- PCell in SA NR, NR-DC and NE-DC operation mode,
- PSCell in NR-DC and EN-DC operation mode.

The UE shall monitor the downlink link quality based on the reference signal in the configured RLM-RS resource(s) in order to detect the downlink radio link quality of the PCell and PSCell as specified in [3]. The configured RLM-RS resources can be all SSBs, or all CSI-RSs, or a mix of SSBs and CSI-RSs. UE is not required to perform RLM outside the active DL BWP.

On each RLM-RS resource, the UE shall estimate the downlink radio link quality and compare it to the thresholds Q_{out} and Q_{in} for the purpose of monitoring downlink radio link quality of the cell.

The threshold Q_{out} is defined as the level at which the downlink radio link cannot be reliably received and shall correspond to the out-of-sync block error rate ($BLER_{out}$) as defined in Table 8.1.1-1. For SSB based radio link monitoring, Q_{out_SSB} is derived based on the hypothetical PDCCH transmission parameters listed in Table 8.1.2.1-1. For CSI-RS based radio link monitoring, Q_{out_CSI-RS} is derived based on the hypothetical PDCCH transmission parameters listed in Table 8.1.3.1-1.

The threshold Q_{in} is defined as the level at which the downlink radio link quality can be significantly more reliably received than at Q_{out} and shall correspond to the in-sync block error rate ($BLER_{in}$) as defined in Table 8.1.1-1. For SSB based radio link monitoring, Q_{in_SSB} is derived based on the hypothetical PDCCH transmission parameters listed in Table 8.1.2.1-2. For CSI-RS based radio link monitoring, Q_{in_CSI-RS} is derived based on the hypothetical PDCCH transmission parameters listed in Table 8.1.3.1-2.

The out-of-sync block error rate ($BLER_{out}$) and in-sync block error rate ($BLER_{in}$) are determined from the network configuration via parameter *rlmInSyncOutOfSyncThreshold* signalled by higher layers. When UE is not configured with *RLM-IS-OOS-thresholdConfig* from the network, UE determines out-of-sync and in-sync block error rates from Configuration #0 in Table 8.1.1-1 as default. All requirements in Section 8.1 are applicable for BLER Configuration #0 in Table 8.1.1-1.

Table 8.1.1-1: Out-of-sync and in-sync block error rates

Configuration	$BLER_{out}$	$BLER_{in}$
0	10%	2%

UE shall be able to monitor up to N_{RLM} RLM-RS resources of the same or different types in each corresponding carrier frequency range, depending on a maximum number $L_{\max}$ of candidate SSBs per half frame according to TS 38.213 [3], where N_{RLM} is specified in Table 8.1.1-2, and meet the requirements as specified in section 8.1.

Table 8.1.1-2: Maximum number of RLM-RS resources N_{RLM}

Maximum number of RLM-RS resources, N_{RLM}	$L_{\max}$	Carrier frequency range of PCell/PSCell
2	4	FR1, $\leqslant$ 3 GHz[Note]
4	8	FR1, > 3 GHz[Note]
8	64	FR2
NOTE: for unpaired spectrum operation with Case C - 30 kHz SCS, 3GHz is replaced by 2.4GHz, as specified in clause 4.1 in TS 38.213 [3].		

If different SCS is used for CSI-RS based RLM-RS and SSB, then CSI-RS based RLM-RS and SSB shall be TDMed. If same SCS is used for CSI-RS based RLM-RS and SSB, then CSI-RS based RLM-RS and SSB can be FDMed or TDMed.

8.1.2 Requirements for SSB based radio link monitoring

8.1.2.1 Introduction

The requirements in this section apply for each SSB based RLM-RS resource configured for PCell or PSCell, provided that the SSB configured for RLM are actually transmitted within UE active DL BWP during the entire evaluation period specified in section 8.1.2.2.

Table 8.1.2.1-1: PDCCH transmission parameters for out-of-sync

Attribute	Value for BLER Configuration #0
DCI format	1-0
Number of control OFDM symbols	2
Aggregation level (CCE)	8
Ratio of hypothetical PDCCH RE energy to average SSS RE energy	4dB
Ratio of hypothetical PDCCH DMRS energy to average SSS RE energy	4dB
Bandwidth (MHz)	TBD
Sub-carrier spacing (kHz)	TBD
DMRS precoder granularity	REG bundle size
REG bundle size	6
CP length	Normal
Mapping from REG to CCE	Distributed

Table 8.1.2.1-2: PDCCH transmission parameters for in-sync

Attribute	Value for BLER Configuration #0
DCI payload size	1-0
Number of control OFDM symbols	2
Aggregation level (CCE)	4
Ratio of hypothetical PDCCH RE energy to average SSS RE energy	0dB
Ratio of hypothetical PDCCH DMRS energy to average SSS RE energy	0dB
Bandwidth (MHz)	TBD
Sub-carrier spacing (kHz)	TBD
DMRS precoder granularity	REG bundle size
REG bundle size	6
CP length	Normal
Mapping from REG to CCE	Distributed

8.1.2.2 Minimum requirement

UE shall be able to evaluate whether the downlink radio link quality on the configured RLM-RS resource estimated over the last $T_{Evaluate\_out\_SSB}$ [ms] period becomes worse than the threshold Q_{out_SSB} within $T_{Evaluate\_out\_SSB}$ [ms] evaluation period.

UE shall be able to evaluate whether the downlink radio link quality on the configured RLM-RS resource estimated over the last $T_{Evaluate\_in\_SSB}$ [ms] period becomes better than the threshold Q_{in_SSB} within $T_{Evaluate\_in\_SSB}$ [ms] evaluation period.

$T_{Evaluate\_out\_SSB}$ and $T_{Evaluate\_in\_SSB}$ are defined in Table 8.1.2.2-1 for FR1.

$T_{Evaluate\_out\_SSB}$ and $T_{Evaluate\_in\_SSB}$ are defined in Table 8.1.2.2-2 for FR2 with

- N=1,

  if the SSB configured for RLM is QCL-Type D and TDMed to CSI-RS resources configured for L1-RSRP reporting, and the QCL association is known to UE;

- N=8, otherwise.

For FR1,

- P=1/(1 – T_{SSB}/MGRP), when in the monitored cell there are measurement gaps configured for intra-frequency, inter-frequency or inter-RAT measurements, which are overlapping with some but not all occasions of the SSB; and

- P=1 when in the monitored cell there are no measurement gaps overlapping with any occasion of the SSB.

For FR2,

- P=1/(1 – $T_{SSB}/T_{SMTCperiod}$), when RLM-RS is not overlapped with measurement gap and RLM-RS is partially overlapped with SMTC occasion ($T_{SSB} < T_{SMTCperiod}$).

- P is 3, when RLM-RS is not overlapped with measurement gap and RLM-RS is fully overlapped with SMTC period ($T_{SSB} = T_{SMTCperiod}$).

- P is 1/(1- T_{SSB}/MGRP - $T_{SSB}/T_{SMTCperiod}$), when RLM-RS is partially overlapped with measurement gap and RLM-RS is partially overlapped with SMTC occasion ($T_{SSB} < T_{SMTCperiod}$) and SMTC occasion is not overlapped with measurement gap and

  - $T_{SMTCperiod} \neq$ MGRP or

  - $T_{SMTCperiod}$ = MGRP and $T_{SSB} < 0.5*T_{SMTCperiod}$

- P is 1/(1- T_{SSB} /MGRP)*3, when RLM-RS is partially overlapped with measurement gap and RLM-RS is partially overlapped with SMTC occasion ($T_{SSB} < T_{SMTCperiod}$) and SMTC occasion is not overlapped with measurement gap and $T_{SMTCperiod}$ = MGRP and $T_{SSB} = 0.5*T_{SMTCperiod}$

- P is 1/{1- T_{SSB} /min ($T_{SMTCperiod}$,MGRP)}, when RLM-RS is partially overlapped with measurement gap and RLM-RS is partially overlapped with SMTC occasion ($T_{SSB} < T_{SMTCperiod}$) and SMTC occasion is partially or fully overlapped with measurement gap

- P is 1/(1- T_{SSB} /MGRP)*3, when RLM-RS is partially overlapped with measurement gap and RLM-RS is fully overlapped with SMTC occasion ($T_{SSB} = T_{SMTCperiod}$) and SMTC occasion is partially overlapped with measurement gap ($T_{SMTCperiod}$ < MGRP)

If the high layer in TS 38.331 [2] signaling of *smtc2* is present, $T_{SMTCperiod}$ follows *smtc2*; Otherwise $T_{SMTCperiod}$ follows *smtc1*.

Longer evaluation period would be expected if the combination of RLM-RS, SMTC occasion and measurement gap configurations does not meet pervious conditions.

Table 8.1.2.2-1: Evaluation period $T_{Evaluate\_out}$ and $T_{Evaluate\_in}$ for FR1

Configuration	$T_{Evaluate\_out}$ (ms)	$T_{Evaluate\_in}$ (ms)
no DRX	max(200,ceil(10*P)*T_{SSB})	max(100,ceil(5*P)*T_{SSB})
DRX cycle≤320	max(200,ceil(15*P)*max(T_{DRX},T_{SSB}))	max(100,ceil(7.5*P)*max(T_{DRX},T_{SSB}))
DRX cycle>320	ceil(10*P)*T_{DRX}	ceil(5*P)*T_{DRX}
NOTE: T_{SSB} is the periodicity of SSB configured for RLM. T_{DRX} is the DRX cycle length.		

Table 8.1.2.2-2: Evaluation period $T_{Evaluate\_out}$ and $T_{Evaluate\_in}$ for FR2

Configuration	$T_{Evaluate\_out}$ (ms)	$T_{Evaluate\_in}$ (ms)
no DRX	max(200,ceil(10*P*N)*T_{SSB})	max(100,ceil(5*P*N)*T_{SSB})
DRX cycle≤320	max(200,ceil(15*P*N)*max(T_{DRX},T_{SSB}))	max(100,ceil(7.5*P*N)*max(T_{DRX},T_{SSB}))
DRX cycle>320	ceil(10*P*N)*T_{DRX}	ceil(5*P*N)*T_{DRX}
NOTE: T_{SSB} is the periodicity of SSB configured for RLM. T_{DRX} is the DRX cycle length.		

8.1.3 Requirements for CSI-RS based radio link monitoring

8.1.3.1 Introduction

The requirements in this section apply for each CSI-RS based RLM-RS resource configured for PCell or PSCell, provided that the CSI-RS configured for RLM are actually transmitted within UE active DL BWP during the entire evaluation period specified in section 8.1.3.2. UE is not expected to perform radio link monitoring measurements on the CSI-RS configured as RLM-RS if the CSI-RS is not QCL-ed with any CORESET configured in the UE active BWP.

Editor's Note: FFS if the configured TCI state or the active TCI state of the CORESET should be considered.

Table 8.1.3.1-1: PDCCH transmission parameters for out-of-sync

Attribute	Value for BLER Configuration #0
DCI format	1-0
Number of control OFDM symbols	2
Aggregation level (CCE)	8
Ratio of hypothetical PDCCH RE energy to average CSI-RS RE energy	4dB
Ratio of hypothetical PDCCH DMRS energy to average CSI-RS RE energy	4dB
Bandwidth (MHz)	TBD
Sub-carrier spacing (kHz)	TBD
DMRS precoder granularity	REG bundle size
REG bundle size	6
CP length	Normal
Mapping from REG to CCE	Distributed

Table 8.1.3.1-2: PDCCH transmission parameters for in-sync

Attribute	Value for BLER Configuration #0
DCI payload size	1-0
Number of control OFDM symbols	2
Aggregation level (CCE)	4
Ratio of hypothetical PDCCH RE energy to average CSI-RS RE energy	0dB
Ratio of hypothetical PDCCH DMRS energy to average CSI-RS RE energy	[0]dB
Bandwidth (MHz)	TBD
Sub-carrier spacing (kHz)	TBD
DMRS precoder granularity	REG bundle size
REG bundle size	6
CP length	Normal
Mapping from REG to CCE	Distributed

8.1.3.2 Minimum requirement

UE shall be able to evaluate whether the downlink radio link quality on the configured RLM-RS resource estimated over the last $T_{Evaluate\_out\_CSI-RS}$ [ms] period becomes worse than the threshold Q_{out_CSI-RS} within $T_{Evaluate\_out\_CSI-RS}$ [ms] evaluation period.

UE shall be able to evaluate whether the downlink radio link quality on the configured RLM-RS resource estimated over the last $T_{Evaluate\_in\_CSI-RS}$ [ms] period becomes better than the threshold Q_{in_CSI-RS} within $T_{Evaluate\_in\_CSI-RS}$ [ms] evaluation period.

- $T_{Evaluate\_out\_CSI-RS}$ and $T_{Evaluate\_in\_CSI-RS}$ are defined in Table 8.1.3.2-1 for FR1.
- $T_{Evaluate\_out\_CSI-RS}$ and $T_{Evaluate\_in\_CSI-RS}$ are defined in Table 8.1.3.2-2 for FR2, where
  - N=1,

    if the CSI-RS resource configured for RLM is QCL-Type D and TDMed to CSI-RS resources configured for L1-RSRP reporting or SSBs configured for L1-RSRP reporting, all CSI-RS resources configured for RLM are mutually TDMed, and the QCL association is known to UE;
  - N=8, otherwise.

For FR1,

- $P=1/(1 – T_{CSI-RS}/MGRP)$, when in the monitored cell there are measurement gaps configured for intra-frequency, inter-frequency or inter-RAT measurements, which are overlapping with some but not all occasions of the CSI-RS; and

- $P=1$ when in the monitored cell there are no measurement gaps overlapping with any occasion of the CSI-RS.

For FR2,

- $P=1$, when RLM-RS is not overlapped with measurement gap and also not overlapped with SMTC occasion.

- $P=1/(1 – T_{CSI-RS}/MGRP)$, when RLM-RS is partially overlapped with measurement gap and RLM-RS is not overlapped with SMTC occasion ($T_{CSI-RS} < MGRP$)

- $P=1/(1 – T_{CSI-RS} /T_{SMTCperiod})$, when RLM-RS is not overlapped with measurement gap and RLM-RS is partially overlapped with SMTC occasion ($T_{CSI-RS} < T_{SMTCperiod}$).

- P is 3, when RLM-RS is not overlapped with measurement gap and RLM-RS is fully overlapped with SMTC occasion ($T_{CSI-RS} = T_{SMTCperiod}$).

- P is $1/(1- T_{CSI-RS} /MGRP - T_{CSI-RS} /T_{SMTCperiod})$, when RLM-RS is partially overlapped with measurement gap and RLM-RS is partially overlapped with SMTC occasion (TCSI-RS < $T_{SMTCperiod}$) and SMTC occasion is not overlapped with measurement gap and

  - $T_{SMTCperiod} \neq MGRP$ or

  - $T_{SMTCperiod} = MGRP$ and $T_{CSI-RS} < 0.5*T_{SMTCperiod}$

- P is $1/(1- T_{CSI-RS} /MGRP)* 3$, when RLM-RS is partially overlapped with measurement gap and RLM-RS is partially overlapped with SMTC occasion ($T_{CSI-RS} < T_{SMTCperiod}$) and SMTC occasion is not overlapped with measurement gap and $T_{SMTCperiod} = MGRP$ and $T_{CSI-RS} = 0.5*T_{SMTCperiod}$

- P is $1/\{1- T_{CSI-RS} /\min (T_{SMTCperiod} ,MGRP)\}$, when RLM-RS is partially overlapped with measurement gap and RLM-RS is partially overlapped with SMTC occasion ($T_{CSI-RS} < T_{SMTCperiod}$) and SMTC occasion is partially or fully overlapped with measurement gap

- P is $1/(1- T_{CSI-RS} /MGRP)* 3$, when RLM-RS is partially overlapped with measurement gap and RLM-RS is fully overlapped with SMTC occasion ($T_{CSI-RS} = T_{SMTCperiod}$) and SMTC occasion is partially overlapped with measurement gap ($T_{SMTCperiod} < MGRP$)

If the high layer in TS 38.331 [2] signaling of *smtc2* is present, $T_{SMTCperiod}$ follows *smtc2*; Otherwise $T_{SMTCperiod}$ follows *smtc1*.

Note: The overlap between CSI-RS RLM and SMTC means that CSI-RS based RLM is within the SMTC window duration.Longer evaluation period would be expected if the combination of RLM-RS, SMTC occasion and measurement gap configurations does not meet pervious conditions.

The values of M_{out} and M_{in} used in Table 8.1.3.2-1 and Table 8.1.3.2-2 are defined as:

- $M_{out} = 20$ and $M_{in} = 10$, if the CSI-RS resource configured for RLM is transmitted with Density =3.

Table 8.1.3.2-1: Evaluation period $T_{Evaluate\_out}$ and $T_{Evaluate\_in}$ for FR1

Configuration	$T_{Evaluate\_out}$ (ms)	$T_{Evaluate\_in}$ (ms)
no DRX	$\max(200, \text{ceil}(M_{out}\times P)\times T_{CSI-RS})$	$\max(100, \text{ceil}(M_{in}\times P) \times T_{CSI-RS})$
DRX ≤ 320ms	$\max(200, \text{ceil}(1.5\times M_{out}\times P)\times \max(T_{DRX}, T_{CSI-RS}))$	$\max(100, \text{ceil}(1.5\times M_{in}\times P)\times \max(T_{DRX}, T_{CSI-RS}))$
DRX > 320ms	$\text{ceil}(M_{out}\times P) \times T_{DRX}$	$\text{ceil}(M_{in}\times P) \times T_{DRX}$
NOTE: T_{CSI-RS} is the periodicity of CSI-RS resource configured for RLM. T_{DRX} is the DRX cycle length.		

Table 8.1.3.2-2: Evaluation period $T_{Evaluate\_out}$ and $T_{Evaluate\_in}$ for FR2

Configuration	$T_{Evaluate\_out}$ (ms)	$T_{Evaluate\_in}$ (ms)
no DRX	max(200, ceil(M_{out}×P×N)×T_{CSI-RS})	max(100, ceil(M_{in}×P×N) × T_{CSI-RS})
DRX ≤ 320ms	max(200, ceil(1.5×M_{out}×P×N)× max(T_{DRX}, T_{CSI-RS}))	max(100, ceil(1.5×M_{in}×P×N)× max(T_{DRX}, T_{CSI-RS}))
DRX > 320ms	ceil(M_{out}×P×N) × T_{DRX}	ceil(M_{in}×P×N) × T_{DRX}
NOTE: T_{CSI-RS} is the periodicity of CSI-RS resource configured for RLM. T_{DRX} is the DRX cycle length.		

8.1.4 Minimum requirement at transitions

When the UE transitions between DRX and no DRX or when DRX cycle periodicity changes, for each RLM-RS resource, for a duration of time equal to the evaluation period corresponding to the second mode after the transition occurs, the UE shall use an evaluation period that is no less than the minimum of evaluation period corresponding to the first mode and the second mode. Subsequent to this duration, the UE shall use an evaluation period corresponding to the second mode for each RLM-RS resource. This requirement shall be applied to both out-of-sync evaluation and in-sync evaluation of themonitored cell.

When the UE transitions from a first configuration of RLM-RS resources to a second configuration of RLM-RS resources that is different from the first configuration, for each RLM-RS resource present in the second configuration, for a duration of time equal to the evaluation period corresponding to the second configuration after the transition occurs, the UE shall use an evaluation period that is no less than the minimum of evaluation periods corresponding to the first configuration and the second configuration. Subsequent to this duration, the UE shall use an evaluation period corresponding to the second configuration for each RLM-RS resource present in the second configuration. This requirement shall be applied to both out-of-sync evaluation and in-sync evaluation of themonitored cell.

8.1.5 Minimum requirement for UE turning off the transmitter

The transmitter power of the UE in the monitored cell shall be turned off within 40ms after expiry of T310 timer as specified in TS 38.331 [2].

8.1.6 Minimum requirement for L1 indication

When the downlink radio link quality on all the configured RLM-RS resources is worse than Q_{out}, Layer 1 of the UE shall send an out-of-sync indication for the cell to the higher layers. A Layer 3 filter shall be applied to the out-of-sync indications as specified in TS 38.331 [2].

When the downlink radio link quality on at least one of the configured RLM-RS resources is better than Q_{in}, Layer 1 of the UE shall send an in-sync indication for the cell to the higher layers. A Layer 3 filter shall be applied to the in-sync indications as specified in TS 38.331 [2].

The out-of-sync and in-sync evaluations for the configured RLM-RS resources shall be performed as specified in clause 5 in TS 38.213 [3]. Two successive indications from Layer 1 shall be separated by at least $T_{Indication\_interval}$.

When DRX is not used $T_{Indication\_interval}$ is max(10ms, $T_{RLM-RS,M}$), where $T_{RLM,M}$ is the shortest periodicity of all configured RLM-RS resources for the monitored cell, which corresponds to T_{SSB} specified in section 8.1.2 if the RLM-RS resource is SSB, or T_{CSI-RS} specified in section 8.1.3 if the RLM-RS resource is CSI-RS.

In case DRX is used, $T_{Indication\_interval}$ is max(10ms, 1.5*DRX_cycle_length, 1.5*$T_{RLM-RS,M}$) if DRX cycle_length is less than or equal to 320ms, and $T_{Indication\_interval}$ is DRX_cycle_length if DRX cycle_length is greater than 320ms. Upon start of T310 timer as specified in TS 38.331 [2], the UE shall monitor the configured RLM-RS resources for recovery using the evaluation period and Layer 1 indication interval corresponding to the no DRX mode until the expiry or stop of T310 timer.

8.1.7 Scheduling availability of UE during radio link monitoring

When the reference signal to be measured for RLM has different subcarrier spacing than PDSCH/PDCCH and on frequency range FR2, there are restrictions on the scheduling availability as described in the following clauses.

8.1.7.1 Scheduling availability of UE performing radio link monitoring with a same subcarrier spacing as PDSCH/PDCCH on FR1

There are no scheduling restrictions due to radio link monitoring performed with a same subcarrier spacing as PDSCH/PDCCH on FR1.

8.1.7.2 Scheduling availability of UE performing radio link monitoring with a different subcarrier spacing than PDSCH/PDCCH on FR1

For UE which support *simultaneousRxDataSSB-DiffNumerology* [14] there are no restrictions on scheduling availability due to radio link monitoring based on SSB as RLM-RS. For UE which do not support *simultaneousRxDataSSB-DiffNumerology* [14] the following restrictions apply due to radio link monitoring based on SSB as RLM-RS.

- The UE is not expected to transmit PUCCH/PUSCH or receive PDCCH/PDSCH on SSB symbols to be measured for radio link monitoring.

When intra-band carrier aggregation is performed, the scheduling restrictions apply to all serving cells on the band due to radio link monitoring performed on FR1 serving PCell or PSCell in the same band. When inter-band carrier aggregation within FR1 is performed, there are no scheduling restrictions on FR1 serving cell(s) in the bands due to radio link monitoring performed on FR1 serving PCell or PSCell in different bands.

8.1.7.3 Scheduling availability of UE performing radio link monitoring on FR2

The following scheduling restriction applies due to radio link monitoring on an FR2 serving PCell and/or PSCell.

- If the RLM-RS is type-D QCLed with active TCI state for PDCCH/PDSCH, and N=1 applies for the RLM-RS as specified in section 8.1.2.2 if the RLM-RS is SSB and in section 8.1.3.2 if the RLM-RS is CSI-RS
  - There are no scheduling restrictions due to radio link monitoring based on SSB or CSI-RS with a same subcarrier spacing as PDSCH/PDCCH.
  - When performing radio link monitoring based on SSB with a different subcarrier spacing than PDSCH/PDCCH, for UE which support *simultaneousRxDataSSB-DiffNumerology* [14] there are no restrictions on scheduling availability due to radio link monitoring. For UE which do not support *simultaneousRxDataSSB-DiffNumerology* [14] the UE is not expected to transmit PUCCH/PUSCH or receive PDCCH/PDSCH on SSB symbols to be measured for radio link monitoring.
- Otherwise
  - The UE is not expected to transmit PUCCH/PUSCH or receive PDCCH/PDSCH on RLM-RS symbols to be measured for radio link monitoring.

When intra-band carrier aggregation is performed, the scheduling restrictions apply to all serving cells on the band due to radio link monitoring performed on FR2 serving PCell or PSCell in the same band.

Editor's Note: FFS scheduling restrictions for inter-band carrier aggregation will be defined depending on band combination in future.

8.1.7.4 Scheduling availability of UE performing radio link monitoring on FR1 or FR2 in case of FR1-FR2 inter-band CA and NR-DC

There are no scheduling restrictions on FR1 serving cell(s) due to radio link monitoring performed on FR2 serving PCell and/or PSCell.

There are no scheduling restrictions on FR2 serving cell(s) due to radio link monitoring performed on FR1 serving PCell and/or PSCell.

Editor's Note: NR-DC in Rel-15 only includes the scenarios where all serving cells in MCG in FR1 and all serving cells in SCG in FR2.

8.2 Interruption

8.2.1 NSA: Interruptions with EN-DC

8.2.1.1 Introduction

This section contains the requirements related to the interruptions on PSCell, and SCell, when

E-UTRA PCell transitions between active and non-active during DRX, or

E-UTRA PCell transitions from non-DRX to DRX, or

E-UTRA SCell in MCG or SCell in SCG is added or released, or

E-UTRA SCell in MCG or SCell in SCG is activated or deactivated, or

measurements on SCC with deactivated SCell in either E-UTRA MCG or NR SCG

This section also contains the requirements related to the interruptions on other active serving cells in the same frequency range wherein the UE is performing BWP switching.

The requirements shall apply for E-UTRA-NR DC with an E-UTRA PCell.

This section contains interruptions where victim cell is PSCell or SCell belonging to SCG. Requirements for interruptions requirements when the victim cell is E-UTRA PCell or E-UTRA SCell belonging to MCG are specified in [15].

For a UE which does not support per-FR measurement gaps, interruptions to the PSCell or active SCG SCells may be caused by EUTRA PCell, EUTRA SCells or SCells on any frequency range. For UE which support per-FR gaps, interruptions to the PSCell or active SCG SCells may be caused by EUTRA PCell, EUTRA SCells or SCells on the same frequency range as the victim cell.

8.2.1.2 Requirements

8.2.1.2.1 Interruptions at transitions between active and non-active during DRX

Interruption on PSCell and the activated SCell if configured due to E-UTRA PCell transitions between active and non-active druing DRX when PSCell or SCell is in non-DRX are allowed with up to 1% probability of missed ACK/NACK when the configured E-UTRA PCell DRX cycle is less than 640 ms, and 0.625% probability of missed ACK/NACK is allowed when the configured E-UTRA PCell DRX cycle is 640 ms or longer. Each interruption shall not exceed X slot as defined in table 8.2.1.2.1-1.

Each interruption shall not exceed X slot as defined in table 8.2.1.2.1-1.

Table 8.2.1.2.1-1: Interruption length X at transition between active and non-active during DRX

μ	NR Slot length (ms)	Interruption length X	
		Sync	Async
0	1	1	2
1	0.5	1	2
2	0.25	3	
3	0.125	5	

When both E-UTRA PCell and PSCell are in DRX, no interruption is allowed.

8.2.1.2.2 Interruptions at transitions from non-DRX to DRX

Interruption on PSCell and the activated SCell if configured due to E-UTRA PCell transitions from non-DRX to DRX when PSCell or SCell is in non-DRX shall not exceed X slot as defined in table 8.2.1.2.1-1.

When PSCell and the activated SCell are in DRX, no interruption due to E-UTRA PCell transitions from non-DRX to DRX is allowed.

8.2.1.2.3 Interruptions at SCell addition/release

The requirements in this clause shall apply for the UE configured with PSCell.

When one E-UTRA SCell is added or released:

- an interruption on any activated serving cell in SCG:
  - of up to X1 slot, if the activated serving cell is not in the same band as any of the E-UTRA SCells being added or released, or
  - of up to max{Y1 slot + $T_{SMTC\_duration}$, 5ms} if the activated serving cells are in the same band as any of the E-UTRA SCells being added or released, provided the cell specific reference signals from the activated serving cells and the E-UTRA SCells being added or released are available in the same slot, where $T_{SMTC\_duration}$ is the longest SMTC duration among all above activated serving cells in SCG;

    Where X1 and Y1 are specified in in Table 8.2.1.2.3-1.

When one SCell is added or released:

- an interruption on any activated serving cell in SCG:
  - of up to X1 slot, if the activated serving cell is not in the same band as any of the SCells being added or released, or
  - of up to Y1 slot + $T_{SMTC\_duration}$ if the activated serving cells are in the same band as any of the SCells being added or released, provided the cell specific reference signals from the activated serving cells and the SCells being added or released are available in the same slot, where, $T_{SMTC\_duration}$ is
    - the longest SMTC duration among all above activated serving cells in SCG and the SCell being added when one SCell is added;
    - the longest SMTC duration among all above activated serving cells in SCG when one SCell is released.

    Where X1 and Y1 are specified in in Table 8.2.1.2.3-2.

Table 8.2.1.2.3-1: Interruption length X1 and Y1 at SCell addition/Release

<table>
<tr><th rowspan="2">μ</th><th rowspan="2">NR Slot length (ms)</th><th colspan="2">Interruption length X1 slot</th><th colspan="2">Interruption length Y1 slot[Note 1]</th></tr>
<tr><th>Sync</th><th>Async</th><th>Sync</th><th>Async</th></tr>
<tr><td>0</td><td>1</td><td>1</td><td>2</td><td>1</td><td>2</td></tr>
<tr><td>1</td><td>0.5</td><td>2</td><td>3</td><td>2</td><td>3</td></tr>
<tr><td>2</td><td>0.25</td><td colspan="2">5</td><td>4</td><td>5</td></tr>
<tr><td>3</td><td>0.125</td><td colspan="2">9</td><td>8</td><td>9</td></tr>
</table>

Table 8.2.1.2.3-2: Interruption length X1 and Y1 at SCell addition/Release

<table>
<tr><th>μ</th><th>NR Slot length (ms) of victim cell</th><th colspan="2">Interruption length X1 slot</th><th>Interruption length Y1 slot[Note]</th></tr>
<tr><td>0</td><td>1</td><td colspan="2">1</td><td>1</td></tr>
<tr><td>1</td><td>0.5</td><td colspan="2">2</td><td>2</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">0.25</td><td>Aggressor cell is on FR2</td><td>4</td><td rowspan="2">4</td></tr>
<tr><td>Aggressor cell is on FR1</td><td>5</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">0.125</td><td>Aggressor cell is on FR2</td><td>8</td><td rowspan="2">8</td></tr>
<tr><td>Aggressor cell is on FR1</td><td>9</td></tr>
</table>

8.2.1.2.4 Interruptions at SCell activation/deactivation

The requirements in this clause shall apply for the UE configured with PSCell and one SCell.

When one E-UTRA SCell is activated or deactivated:

- an interruption on any activated serving cell in SCG:
  - of up to X2 slot, if the activated serving cell is not in the same band as any of the E-UTRA SCells being activated or deactivated, or
- of up to max{Y2 slot + $T_{SMTC\_duration}$, 5ms} if the activated serving cells are in the same band as any of the E-UTRA SCells being activated or deactivated, provided the cell specific reference signals from the activated serving cells and the E-UTRA SCells being activated or deactivated are available in the same slot, where $T_{SMTC\_duration}$ is the longest SMTC duration among all above activated serving cells in SCG.

  Where X2 and Y2 are specified in in Table 8.2.1.2.4-1.

When one SCell is activated or deactivated:

- an interruption on any serving cell in SCG:
  - of up to X2 slot, if the activated serving cell is not in the same band as any of the SCells being activated or deactivated, or
  - of up to Y2 slot + $T_{SMTC\_duration}$ if the activated serving cells are in the same band as any of the SCells being activated or deactivated, provided the cell specific reference signals from the activated serving cells and the SCells being activated or deactivated are available in the same slot, where, $T_{SMTC\_duration}$ is
    - the longest SMTC duration among all above activated serving cells in SCG and the SCell being activated when one SCell is activated;
    - the longest SMTC duration among all above activated serving cells in SCG when one SCell is deactivated.

  Where X2 and Y2 are specified in in Table 8.2.1.2.4-2.

Table 8.2.1.2.4-1: Interruption length X2 and Y2 at SCell activation/deactivation

μ	NR Slot length (ms)	Interruption length X2 slot		Interruption length Y2 slot[Note 1]	
		Sync	Async	Sync	Async
0	1	1	2	1	2
1	0.5	1	2	1	2
2	0.25	3		2	3
3	0.125	5		4	5

Table 8.2.1.2.4-2: Interruption length X2 and Y2 at SCell activation/deactivation

μ	NR Slot length (ms) of victim cell	Interruption length X2 slot		Interruption length Y2 slot[Note]
0	1	1		1
1	0.5	1		1
2	0.25	Aggressor cell is on FR2	2	2
		Aggressor cell is on FR1	3	
3	0.125	Aggressor cell is on FR2	4	4
		Aggressor cell is on FR1	5	

8.2.1.2.5 Interruptions during measurements on SCC

8.2.1.2.5.1 Interruptions during measurements on deactivated NR SCC

Interruption on PSCell and other active NR SCell(s) during measurement on the deactivated NR SCC shall meet requirements in clause 8.2.2.2.3, where the term PCell in clause 8.2.2.2.3 shall be deemed to be replaced with PSCell.

8.2.1.2.5.2 Interruptions during measurements on deactivated E-UTRAN SCC

When one E-UTRA SCell in MCG is deactivated, the UE is allowed due to measurements on the E-UTRA SCC with the deactivated E-UTRA SCell:

- an interruption on PSCell or any activated SCell with up to 0.5% probability of missed ACK/NACK when any of the configured *measCycleSCell* [2] for the deactivated E-UTRA SCells is 640 ms or longer.
- an interruption on PSCell or any activated SCell with up to 0.5% probability of missed ACK/NACK regardless of the configured *measCycleSCell* [2] for the deactivated E-UTRA SCells if indicated by the network using IE *allowInterruptions* [2].

Each interruption shall not exceed

- X3 slot, if the PSCell or activated SCell is not in the same band as the E-UTRA deactivated SCC being measured, or
- Y3 slot + SMTC duration, if the PSCell or activated SCell is in the same band as the E-UTRA deactivated SCC being measured, provided the cell specific reference signals from the PSCell or activated SCell and the E-UTRA deactivated SCC being measured are available in the same slot.

Table 8.2.1.2.5.2-1: Interruption length X3 and Y3 at measurements on deactivated E-UTRA SCC

μ	NR Slot length (ms)	Interruption length X3 slot		Interruption length Y3 slot[Note 1]	
		Sync	Async	Sync	Async
0	1	1	2	1	2
1	0.5	1	2	1	2
2	0.25	3		2	3
3	0.125	5		4	5

8.2.1.2.6 Interruptions at UL carrier RRC reconfiguration

The requirements in this clause shall apply when a supplementary UL carrier or an UL carrier is configured or de-configured in NR non-standalone operation as defined in [2].

When an UL carrier or supplementary UL carrier is configured or deconfigured, an interruption on E-UTRA PCell, all activated E-UTRA SCells, PSCell and all activated SCells within the same FR as the reconfigured uplink carrier of up to X4 slot, is allowed during the RRC reconfiguration procedure [2]. The interruption is for both uplink and downlink of E-UTRA PCell, all activated E-UTRA SCells, PSCell and all activated SCells within the same FR as the configured or de-configured UL.

Table 8.2.1.2.6-1: Interruption length X4 at UL carrier RRC reconfiguration

μ	NR Slot length (ms)	Interruption length X4 slot	
		Sync	Async
0	1	1	2
1	0.5	2	3
2	0.25	5	
3	0.125	9	

8.2.1.2.7 Interruption due to Active BWP switching Requirement

When UE receives a DCI indicating UE to switch its active BWP involving changes in any of the parameters listed in Table 8.2.1.2.7-2, the UE is allowed to cause interruption of up to X slot to other active serving cells if the UE is not capable of per-FR gap, or if the BWP switching involves SCS changing. When the BWP switch imposes changes in any of the parameters listed in Table 8.2.1.2.7-2 and the UE is capable of per-FR gap, the UE is allowed to cause interruption of up to X slot to other active serving cells in the same frequency range wherein the UE is performing BWP switching. X is defined in Table 8.2.1.2.7-1. The starting time of interruption is only allowed within the BWP switching delay $T_{BWPswitchDelay}$ as defined in clause 8.6.2. Interruptions are not allowed during BWP switch involving other parameter change.

When a BWP timer *bwp-InactivityTimer* defined in [2] expires, UE is allowed to cause interruption of up to X slot to other active serving cells due to switching its active BWP involving changes in any of the parameters listed in Table 8.2.1.2.7-2 if the UE is not capable of per-FR gap, or if the BWP switching involves SCS changing. When the BWP switch imposes changes in any of the parameters listed in Table 8.2.1.2.7-2 and the UE is capable of per-FR gap the UE is allowed to cause interruption of up to X slot to other active serving cells in the same frequency range wherein the UE is performing BWP switching. X is defined in Table 8.2.1.2.7-1. The starting time of interruption is only allowed within the BWP switching delay $T_{BWPswitchDelay}$ as defined in clause 8.6.2. Interruptions are not allowed during BWP switch involving other parameter change.

Editor's note: FFS if RAN4 will specify interruption requirements for RRC-based BWP switch.

Table 8.2.1.2.7-1: interruption length X

μ	NR Slot length (ms)	Interruption length X (slots[note 1])
0	1	1
1	0.5	1
2	0.25	3
3	0.125	5
Note1:	If the BWP switch involves changing of SCS, the interruption due to BWP switch is determined by the larger one between the SCS before BWP switch and the SCS after the BWP switch.	

Table 8.2.1.2.7-2: Parameters which cause interruption other than SCS

Parameters	Comment
locationAndBandwidth	From TS 38.331 [2]
nrofSRS-Ports	
Editor's note: More parameters can be added if identified	

8.2.2 SA: Interruptions with Standalone NR Carrier Aggregation

8.2.2.1 Introduction

This section contains the requirements related to the interruptions on PCell and activated SCell if configured, when up to 7 SCells are configured, deconfigured, activated or deactivated.

Note: interruptions at SCell addition/release, activation/deactivation and during measurements on SCC may not be required by all UEs.

Editor's Note: The interruptions shall not interrupt RRC signalling or ACK/NACKs related to RRC reconfiguration procedure [2] for SCell addition/release or MAC control signalling [17] for SCell activation/deactivation command. How to specify this is FFS.

This section also contains the requirements related to the interruptions on other active serving cells in the same frequency range wherein the UE is performing BWP switching.

For a UE which does not support per-FR measurement gaps, interruptions to the PCell and activated SCell may be caused by SCells on any frequency range. For UE which support per-FR gaps, interruptions to PCell and activated SCell may be caused by SCells on the same frequency range as the victim cell.

8.2.2.2 Requirements

8.2.2.2.1 Interruptions at SCell addition/release

When any number of SCells between one and 7 is added or released using the same *RRCConnectionReconfiguration* message as defined in [2], the UE is allowed an interruption on any activated serving cell during the RRC reconfiguration procedure as follows:

- an interruption on any activated serving cell:
  - of up to the duration shown in table 8.2.2.2.1-1, if the activated serving cell is not in the same band as any of the SCells being added or released, or
  - of up to the duration shown in table 8.2.2.2.1-2, if the activated serving cells are in the same band as any of the SCells being added or released, provided the cell specific reference signals from the activated serving cells and the SCells being added or released are available in the same slot.

Table 8.2.2.2.1-1: Interruption duration for SCell addition/release for inter-band CA

μ	NR Slot length (ms) of victim cell	Interruption length (slot)	
0	1	1	
1	0.5	2	
2	0.25	Aggressor cell is on FR2	4
		Aggressor cell is on FR1	5
3	0.125	Aggressor cell is on FR2	8
		Aggressor cell is on FR1	9
Note:	$T_{SMTC\_duration}$ is - the longest SMTC duration among all above activated serving cells and the SCell being added when one SCell is added; - the longest SMTC duration among all activated serving cells in the same band when one SCell is released.		

Table 8.2.2.2.1-2: Interruption duration for SCell addition/release for intra-band CA

μ	NR Slot length (ms)	Interruption length (slot)
0	1	1 + $T_{SMTC\_duration}$
1	0.5	2 + $T_{SMTC\_duration}$
2	0.25	4 + $T_{SMTC\_duration}$
3	0.125	8 + $T_{SMTC\_duration}$
Note:	$T_{SMTC\_duration}$ is - the longest SMTC duration among all above activated serving cells and the SCell being added when one SCell is added; - the longest SMTC duration among all activated serving cells in the same band when one SCell is released.	

8.2.2.2.2 Interruptions at SCell activation/deactivation

When an intra-band SCell is activated or deactivated as defined in [17], the UE is allowed

- an interruption on any activated serving cell:

- of up to the duration shown in table 8.2.2.2.2-1, if the activated serving cell is not in the same band as any of the SCells being activated or deactivated, or
- of up to the duration shown in table 8.2.2.2.2-2, if the activated serving cells are in the same band as any of the SCells being activated or deactivated provided the cell specific reference signals from the activated serving cells and the SCells being activated or deactivated are available in the same slot.

Table 8.2.2.2.2-1: Interruption duration for SCell activation/deactivation for inter-band CA

μ	NR Slot length (ms) of victim cell	Interruption length (slot)	
0	1		1
1	0.5		1
2	0.25	Aggressor cell is on FR2	2
		Aggressor cell is on FR1	3
3	0.125	Aggressor cell is on FR2	4
		Aggressor cell is on FR1	5
Note: $T_{SMTC\_duration}$ is - the longest SMTC duration among all above activated serving cells and the SCell being added when one SCell is added; - the longest SMTC duration among all activated serving cells in the same band when one SCell is released.			

Table 8.2.2.2.2-2: Interruption duration for SCell activation/deactivation for intra-band CA

μ	NR Slot length (ms)	Interruption length
0	1	1 + $T_{SMTC\_duration}$
1	0.5	1 + $T_{SMTC\_duration}$
2	0.25	2 + $T_{SMTC\_duration}$
3	0.125	4 + $T_{SMTC\_duration}$
Note: $T_{SMTC\_duration}$ is - the longest SMTC duration among all above activated serving cells and the SCell being activated when one SCell is activated; - the longest SMTC duration among all activated serving cells in the same band when one SCell is deactivated.		

8.2.2.2.3 Interruptions during measurements on SCC for intra-band CA

Interruptions on PCell due to measurements when an SCell is deactivated are allowed with up to 0.5% probability of missed ACK/NACK when the configured *measCycleSCell* [2] is 640 ms or longer. The UE is only allowed to cause interruptions immediately before and immediately after an SMTC. Each interruption shall not exceed requirement in Table 8.2.2.2.2-1 if the PCell is not in the same band as the deactivated SCell. Each interruption shall not exceed requirement in Table 8.2.2.2.2-2 if the PCell is in the same band as the deactivated SCell.

Interruptions on active SCells due to measurements when an SCell is deactivated are allowed with up to 0.5% probability of missed ACK/NACK when the configured *measCycleSCell* [2] is 640 ms or longer. The UE is only allowed to cause interruptions immediately before and immediately after an SMTC. Each interruption shall not exceed requirement in Table 8.2.2.2.2-1 if the active SCell is not in the same band as the deactivated SCell. Each interruption shall not exceed requirement in Table 8.2.2.2.2-2 if the active SCell is in the same band as the deactivated SCell.

8.2.2.2.4 Interruptions at UL carrier RRC reconfiguration

The requirements in this clause shall apply when a supplementary UL carrier or an UL carrier is configured or de-configured in NR standalone carrier aggregation as defined in [2].

When an UL carrier or supplementary UL carrier is configured or deconfigured, an interruption on PCell and all activated SCells within the same FR as the reconfigured uplink carrier of up to the duration shown in table 8.2.2.2.4-1, is allowed during the RRC reconfiguration procedure [2]. The interruption is for both uplink and downlink of PCell and all the activated SCells within the same FR as the configured or de-configured UL.

Table 8.2.2.2.4-1: Interruption duration for UL carrier RRC reconfiguration μ	NR Slot length (ms)	Interruption length
0	1	1
1	0.5	2
2	0.25	4
3	0.125	8

8.2.2.2.5 Interruption due to Active BWP switching Requirement

When UE receives a DCI indicating UE to switch its active BWP involving changes in any of the parameters listed in Table 8.2.2.2.5-2, the UE is allowed to cause interruption of up to X slot to other active serving cells if the UE is not capable of per-FR gap, or if the BWP switching involves SCS changing. When the BWP switch imposes changes in any of the parameters listed in Table 8.2.2.2.5-2 and the UE is capable of per-FR gap the UE is allowed to cause interruption of up to X slot to other active serving cells in the same frequency range wherein the UE is performing BWP switching. X is defined in Table 8.2.2.2.5-1. The starting time of interruption is only allowed within the BWP switching delay $T_{BWPswitchDelay}$ as defined in clause 8.6.2. Interruptions are not allowed during BWP switch involving other parameter change.

When a BWP timer *bwp-InactivityTimer* defined in [2] expires, UE is allowed to cause interruption of up to X slot to other active serving cells due to switching its active BWP involving changes in any of the parameters listed in Table 8.2.2.2.5-2 if the UE is not capable of per-FR gap, or if the BWP switching involves SCS changing. When the BWP switch imposes changes in any of the parameters listed in Table 8.2.2.2.5-2and the UE is capable of per-FR gap the UE is allowed to cause interruption of up to X slot to other active serving cells in the same frequency range wherein the UE is performing BWP switching. X is defined in Table 8.2.2.2.5-1. The starting time of interruption is only allowed within the BWP switching delay $T_{BWPswitchDelay}$ as defined in clause 8.6.2. Interruptions are not allowed during BWP switch involving other parameter change.

Editor's note: FFS if RAN4 will specify interruption requirements for RRC-based BWP switch.

Table 8.2.2.2.5-1: Interruption length X

μ	NR Slot length (ms)	Interruption length X (slots[note 1])
0	1	1
1	0.5	1
2	0.25	3
3	0.125	5
Note1: If the BWP switch involves changing of SCS, the interruption due to BWP switch is determined by the larger one between the SCS before BWP switch and the SCS after the BWP switch.		

Table 8.2.2.2.5-2: Parameters which cause interruption other than SCS

Parameters	Comment
locationAndBandwidth	From TS 38.331 [2]
nrofSRS-Ports	
Editor's note: More parameters can be added if identified	

8.2.3 NE-DC Interruptions

8.2.3.1 Introduction

This section contains the requirements related to the interruptions on PCell and SCell, when

E-UTRA PSCell transitions between active and non-active during DRX, or

E-UTRA PSCell transitions from non-DRX to DRX, or

E-UTRA PSCell/SCell in SCG or SCell in MCG is added or released, or

E-UTRA PSCell/SCell in SCG or SCell in MCG is activated or deactivated, or

measurements on SCC with deactivated SCell in either E-UTRA SCG or NR MCG or

PUSCH/PUCCH carrier configuration and deconfiguration in NR MCG.

This section also contains the requirements related to the interruptions on other active serving cells in the same frequency range wherein the UE is performing BWP switching.

The requirements shall apply for NE-DC with an NR PCell.

This section contains interruptions where victim cell is PCell or SCell belonging to MCG, or E-UTRA PSCell or E-UTRA SCell belonging to SCG. Requirements for interruptions requirements when the victim cell is E-UTRA PSCell or E-UTRA SCell belonging to SCG are specified in [15].

For a UE which does not support per-FR measurement gaps, interruptions to the PCell, E-UTRA PSCell or active MCG SCells may be caused by EUTRA PSCell, EUTRA SCells or SCells on any frequency range. For UE which support per-FR gaps, interruptions to the PCell, E-UTRA PSCell or active MCG SCells may be caused by EUTRA PSCell, EUTRA SCells or SCells on the same frequency range as the victim cell.

8.2.3.2 Requirements

8.2.3.2.1 Interruptions at transitions between active and non-active during DRX

Interruption on PCell and the activated SCell if configured due to E-UTRA PSCell transitions between active and non-active druing DRX when PCell or SCell is in non-DRX are allowed with up to 1% probability of missed ACK/NACK when the configured E-UTRA PSCell DRX cycle is less than 640 ms, and 0.625% probability of missed ACK/NACK is allowed when the configured E-UTRA PCell DRX cycle is 640 ms or longer. Each interruption shall not exceed X slot as defined in table 8.2.3.2.1-1.

Each interruption shall not exceed X slot as defined in table 8.2.3.2.1-1.

Table 8.2.3.2.1-1: Interruption length X at transition between active and non-active during DRX

μ	NR Slot length (ms)	Interruption length X	
		Sync	Async
0	1	1	2
1	0.5	1	2
2	0.25	3	
3	0.125	5	

When both PCell and E-UTRA PSCell are in DRX, no interruption is allowed.

8.2.3.2.2 Interruptions at transitions from non-DRX to DRX

Interruption on PCelland the activated SCell if configured due to E-UTRA PSCell transitions from non-DRX to DRX when PCell or SCell is in non-DRX shall not exceed X slot as defined in table 8.2.3.2.1-1.

8.2.3.2.3 Interruptions at PSCell/SCell addition/release

The requirements in this clause shall apply for the UE configured with E-UTRA PSCell.

When one E-UTRA PSCell/SCell is added or released:

- an interruption on any activated serving cell in MCG:
  - of up to X1 slot, if the activated serving cell is not in the same band as any of the E-UTRA PSCell/SCells being added or released, or
  - of up to max{Y1 slot + $T_{SMTC\_duration}$, 5ms} if the activated serving cells are in the same band as any of the E-UTRA PSCell/SCells being added or released, provided the cell specific reference signals from the activated serving cells and the E-UTRA PSCell/SCells being added or released are available in the same slot, where $T_{SMTC\_duration}$ is the longest SMTC duration among all above activated serving cellsin MCG;

    Where X1 and Y1 are specified in in Table 8.2.3.2.3-1.

When one SCell is added or released:

- an interruption on any activated serving cell in MCG:
  - of up to X1 slot, if the activated serving cell is not in the same band as any of the SCells being added or released, or
  - of up to Y1 slot + $T_{SMTC\_duration}$ if the activated serving cells are in the same band as any of the SCells being added or released, provided the cell specific reference signals from the activated serving cells and the SCells being added or released are available in the same slot, where, $T_{SMTC\_duration}$ is
    - the longest SMTC duration among all above activated serving cells in MCG and the SCell being added when one SCell is added;
    - the longest SMTC duration among all above activated serving cells in MCG when one SCell is released.

    Where X1 and Y1 are specified in in Table 8.2.3.2.3-2.

Table 8.2.3.2.3-1: Interruption length X1 and Y1 at SCell/E-UTRA PSCell addition/release

μ	NR Slot length (ms)	Interruption length X1 slot		Interruption length Y1 slot[Note 1]
		Sync	Async	
0	1	1	2	1
1	0.5	2	3	2
2	0.25	5		4
3	0.125	9		8

Table 8.2.3.2.3-2: Interruption length X1 and Y1 at SCell addition/Release

μ	NR Slot length (ms)	Interruption length X1 slot	Interruption length Y1 slot[Note]
0	1	1	1
1	0.5	2	2
2	0.25	4	4
3	0.125	8	8

8.2.3.2.4 Interruptions at SCell activation/deactivation

The requirements in this clause shall apply for the UE configured with E-UTRA PSCell and one SCell.

When one E-UTRA SCell is activated or deactivated:

- an interruption on any activated serving cell in MCG:
  - of up to X2 slot, if the activated serving cell is not in the same band as any of the E-UTRA SCells being activated or deactivated, or

- of up to max{Y2 slot + $T_{SMTC\_duration}$, 5ms} if the activated serving cells are in the same band as any of the E-UTRA SCells being activated or deactivated, provided the cell specific reference signals from the activated serving cells and the E-UTRA SCells being activated or deactivated are available in the same slot, where $T_{SMTC\_duration}$ is the longest SMTC duration among all above activated serving cells in MCG.

  Where X2 and Y2 are specified in in Table 8.2.3.2.4-1.

When one SCell is activated or deactivated:

- an interruption on any serving cell in MCG:
  - of up to X2 slot, if the activated serving cell is not in the same band as any of the SCells being activated or deactivated, or
  - of up to Y2 slot + $T_{SMTC\_duration}$ if the activated serving cells are in the same band as any of the SCells being activated or deactivated, provided the cell specific reference signals from the activated serving cells and the SCells being activated or deactivated are available in the same slot, where, $T_{SMTC\_duration}$ is
    - the longest SMTC duration among all above activated serving cells in MCGand the SCell being activated when one SCell is activated;
    - the longest SMTC duration among all above activated serving cells in MCG when one SCell is deactivated.

  Where X2 and Y2 are specified in in Table 8.2.3.2.4-2.

Table 8.2.3.2.4-1: Interruption length X2 and Y2 at SCell activation/deactivation

μ	NR Slot length (ms)	Interruption length X2 slot		Interruption length Y2 slot
		Sync	Async	
0	1	1	2	1
1	0.5	1	2	1
2	0.25	3		2
3	0.125	5		4

Table 8.2.3.2.4-2: Interruption length X2 and Y2 at SCell activation/deactivation

μ	NR Slot length (ms)	Interruption length X2 slot	Interruption length Y2 slot
0	1	1	1
1	0.5	1	1
2	0.25	2	2
3	0.125	4	4

8.2.3.2.5 Interruptions during measurements on SCC

8.2.3.2.5.1 Interruptions during measurements on deactivated NR SCC

Interruption on PCell and other active SCell(s) during measurement on the deactivated NR SCC shall meet requirements in clause 8.2.2.2.3.

8.2.3.2.5.2 Interruptions during measurements on deactivated E-UTRAN SCC

When one E-UTRA SCell in SCG is deactivated, the UE is allowed due to measurements on the E-UTRA SCC with the deactivated E-UTRA SCell:

- an interruption on PCell or any activated SCell with up to 0.5% probability of missed ACK/NACK when any of the configured *measCycleSCell* [2] for the deactivated E-UTRA SCells is 640 ms or longer.
- an interruption on PCell or any activated SCell with up to 0.5% probability of missed ACK/NACK regardless of the configured *measCycleSCell* [2] for the deactivated E-UTRA SCells if indicated by the network using IE *allowInterruptions* [2].

Each interruption shall not exceed

- X3 slot, if the PCell or activated SCell is not in the same band as the E-UTRA deactivated SCC being measured, or

- Y3 slot + SMTC duration, if the PCell or activated SCell is in the same band as the E-UTRA deactivated SCC being measured, provided the cell specific reference signals from the PCell or activated SCell and the E-UTRA deactivated SCC being measured are available in the same slot.

  Where X3 and Y3 are specified in in Table 8.2.3.2.5-1

Table 8.2.3.2.5-1: Interruption length X3 and Y3 at measurements on deactivated E-UTRA SCC

μ	NR Slot length (ms)	Interruption length X3 slot	Interruption length Y3 slot
0	1	1	1
1	0.5	1	1
2	0.25	2	2
3	0.125	4	4

8.2.3.2.6 Interruptions at UL carrier RRC reconfiguration

The requirements in this clause shall apply when a supplementary UL carrier or an UL carrier is configured or de-configured in NE-DC.

When an UL carrier or supplementary UL carrier is configured or deconfigured, an interruption on PCell, all activated SCells within the same FR as the reconfigured uplink carrier of up to X4 slot as specified in Table 8.2.3.2.6-1, is allowed during the RRC reconfiguration procedure [2]. The interruption is for both uplink and downlink of PCell, all activated within the same FR as the configured or de-configured UL.

Table 8.2.3.2.6-1: Interruption length X4 at UL carrier RRC reconfiguration

μ	NR Slot length (ms)	Interruption length X4 slot	
		Sync	Async
0	1	1	2
1	0.5	2	3
2	0.25	5	
3	0.125	9	

8.2.3.2.7 Interruption due to Active BWP switching Requirement

When UE receives a DCI indicating the UE to switch its active BWP, or when a BWP timer *bwp-InactivityTimer* defined in [2] expires, or when the UE receives an RRC command indicating the UE to switch its active BWP, the UE is allowed an interruption on PCell and any activated SCells as defined in section 8.2.2.2.5.

8.2.4 NR-NR DC: Interruptions

8.2.4.1 Introduction

This section contains the requirements related to the interruptions on PCell, PSCell and activated SCell if configured, when up to TBD SCells are configured, deconfigured, activated or deactivated.

Note: interruptions at SCell addition/release, activation/deactivation and during measurements on SCC may not be required by all UEs.

Editor’s Note: The interruptions shall not interrupt RRC signalling or ACK/NACKs related to RRC reconfiguration procedure [2] for SCell addition/release or MAC control signalling [17] for SCell activation/deactivation command. How to specify this is FFS.

The requirements shall apply for NR-NR DC with a NR PCell, PSCell or SCell.

This section also contains the requirements related to the interruptions on other active serving cells in the same frequency range wherein the UE is performing BWP switching.

For a UE which does not support per-FR measurement gaps, interruptions to the PCell and activated SCell may be caused by SCells on any frequency range. For UE which support per-FR gaps, interruptions to PCell, PSCell and activated SCell may be caused by SCells on the same frequency range as the victim cell.

8.2.4.2 Requirements

8.2.4.2.1 Interruptions at PSCell/SCell addition/release

When PSCell or any number of SCells between one and TBD is added or released using the same *RRCConnectionReconfiguration* message as defined in [2], the UE is allowed an interruption on any activated serving cell during the RRC reconfiguration procedure as follows:

- an interruption on any activated serving cell:
  - of up to the duration shown in table 8.2.4.2.1-1, if the activated serving cell is not in the same band as any of the SCells being added or released, or
  - of up to the duration shown in table 8.2.4.2.1-2, if the activated serving cells are in the same band as any of the SCells being added or released, provided the cell specific reference signals from the activated serving cells and the SCells being added or released are available in the same slot.

Table 8.2.4.2.1-1: Interruption duration for PSCell/SCell addition/release

μ	NR Slot length (ms)	Interruption length (slot)
0	1	1
1	0.5	2
2	0.25	4
3	0.125	8

Table 8.2.4.2.1-2: Interruption duration for SCell addition/release

μ	NR Slot length (ms)	Interruption length (slot)
0	1	$1 + T_{SMTC\_duration}$
1	0.5	$2 + T_{SMTC\_duration}$
2	0.25	$4 + T_{SMTC\_duration}$
3	0.125	$8 + T_{SMTC\_duration}$
Note: $T_{SMTC\_duration}$ is - the longest SMTC duration among all above activated serving cells and the SCell being added when one SCell is added; - the longest SMTC duration among all activated serving cells in the same band when one SCell is released.		

8.2.4.2.2 Interruptions at SCell activation/deactivation

When a SCell is activated or deactivated as defined in [17], the UE is allowed

- an interruption on any activated serving cell:
  - of up to the duration shown in table 8.2.4.2.2-1, if the activated serving cell is not in the same band as any of the SCells being activated or deactivated, or

- of up to the duration shown in table 8.2.4.2.2-2, if the activated serving cells are in the same band as any of the SCells being activated or deactivated provided the cell specific reference signals from the activated serving cells and the SCells being activated or deactivated are available in the same slot.

Table 8.2.4.2.2-1: Interruption duration for SCell activation/deactivation for inter-band CA

μ	NR Slot length (ms)	Interruption length
0	1	1
1	0.5	1
2	0.25	2
3	0.125	4

Table 8.2.4.2.2-2: Interruption duration for SCell activation/deactivation for intra-band CA

μ	NR Slot length (ms)	Interruption length
0	1	1 + $T_{SMTC\_duration}$
1	0.5	1 + $T_{SMTC\_duration}$
2	0.25	2 + $T_{SMTC\_duration}$
3	0.125	4 + $T_{SMTC\_duration}$
Note: $T_{SMTC\_duration}$ is - the longest SMTC duration among all above activated serving cells and the SCell being activated when one SCell is activated; - the longest SMTC duration among all activated serving cells in the same band when one SCell is deactivated.		

8.2.4.2.3 Interruptions during measurements on SCC

Interruptions on PCell due to measurements when an SCell is deactivated are allowed with up to 0.5% probability of missed ACK/NACK when the configured *measCycleSCell* [2] is 640 ms or longer. The UE is only allowed to cause interruptions immediately before and immediately after an SMTC. Each interruption shall not exceed requirement in Table 8.2.2.2.2-1 if the PCell is not in the same band as the deactivated SCell. Each interruption shall not exceed requirement in Table 8.2.2.2.2-2 if the PCell is in the same band as the deactivated SCell.

Interruptions on active SCell due to measurements when an SCell is deactivated are allowed with up to 0.5% probability of missed ACK/NACK when the configured *measCycleSCell* [2] is 640 ms or longer. The UE is only allowed to cause interruptions immediately before and immediately after an SMTC. Each interruption shall not exceed requirement in Table 8.2.2.2.2-1 if the active SCell is not in the same band as the deactivated SCell. Each interruption shall not exceed requirement in Table 8.2.2.2.2-2 if the active SCell is in the same band as the deactivated SCell.

8.2.4.2.4 Interruptions at UL carrier RRC reconfiguration

The requirements in this clause shall apply when a supplementary UL carrier or an UL carrier is configured or de-configured in NR-DC as defined in [2].

When an UL carrier or supplementary UL carrier is configured or deconfigured, an interruption on all the other activated serving cells within the same FR as the reconfigured uplink carrier of up to the duration shown in table 8.2.4.2.4-1, is allowed during the RRC reconfiguration procedure [2]. The interruption is for both uplink and downlink of all the other serving cells within the same FR as the configured or de-configured UL.

Table 8.2.4.2.4-1: Interruption duration for UL carrier RRC reconfiguration

μ	NR Slot length (ms)	Interruption length
0	1	1
1	0.5	2
2	0.25	4
3	0.125	8

8.2.4.2.5 Interruption due to Active BWP switching Requirement

When UE receives a DCI indicating the UE to switch its active BWP, or when a BWP timer bwp-InactivityTimer defined in [2] expires, or when the UE receives an RRC command indicating the UE to switch its active BWP, the UE is allowed to cause an interruption on any other serving cells as defined in section 8.2.2.2.5.

8.3 SCell Activation and Deactivation Delay

8.3.1 Introduction

This section defines requirements for the delay within which the UE shall be able to activate a deactivated SCell and deactivate an activated SCell in EN-DC, or in standalone NR carrier aggregation, or in NE-DC, or in NR-DC.

The requirements shall apply for EN-DC, standalone NR carrier aggregation, NE-DC, and NR-DC.

8.3.2 SCell Activation Delay Requirement for Deactivated SCell

The requirements in this section shall apply for the UE configured with one downlink SCell in EN-DC, or in standalone NR carrier aggregation or in NE-DC or in NR-DC and when one SCell is being activated.

The delay within which the UE shall be able to activate the deactivated SCell depends upon the specified conditions.

Upon receiving SCell activation command in slot n, the UE shall be capable to transmit valid CSI report and apply actions related to the activation command for the SCell being activated no later than in slot n+ [T_{HARQ} + $T_{activation\_time}$ + $T_{CSI\_Reporting}$], where:

T_{HARQ} is the timing between DL data transmission and acknowledgement as specified in [7].

$T_{activation\_time}$ is the SCell activation delay. If the SCell is known and belongs to FR1, $T_{activation\_time}$ is:

- [T_{SMTC_SCell} + 5ms], if the SCell measurement cycle is equal to or smaller than [160ms].
- [T_{SMTC_MAX} + T_{SMTC_SCell} + 5ms], if the SCell measurement cycle is larger than [160ms].

If the SCell is unknown and belongs to FR1, $T_{activation\_time}$ is:

- [2*T_{SMTC_MAX} + 2*T_{SMTC_SCell} + 5ms] provided the SCell can be successfully detected on the first attempt.

If the SCell being activated belongs to FR2, $T_{activation\_time}$ is:

- [T_{SMTC_SCell} + 5ms] if there is at least one active serving cell on that FR2 band, provided that the SSBs in the serving cell(s) and the SSBs in the SCell fulfil the condition defined in section 3.6.3.
- [TBD* T_{SMTC_SCell} + 5ms] if there is no active serving cell on that FR2 band provided that PCell or PSCell is FR1.

Where,

T_{SMTC_MAX}:

- In FR1, in case of intra-band SCell activation, T_{SMTC_MAX} is the longer SMTC periodicity between active serving cells and SCell being activated provided the cell specific reference signals from the active serving cells and the SCells being activated or released are available in the same slot; in case of inter-band SCell activation, T_{SMTC_MAX} is the SMTC periodicity of SCell being activated.
- In FR2, T_{SMTC_MAX} is the longer SMTC periodicity between active serving cells and SCell being activated provided that in Rel-15 only support FR2 intra-band CA.
- T_{SMTC_MAX} is bounded to a minimum value of 10ms.

T_{SMTC_SCell}: SMTC periodicity of SCell being activated and the minimum value is 10ms.

$T_{CSI\_reporting}$ is the delay including uncertainty in acquiring the first available downlink CSI reference resource, UE processing time for CSI reporting and uncertainty in acquiring the first available CSI reporting resources as specified in [2].

SCell in FR1 is known if it has been meeting the following conditions:

- During the period equal to max([5] measCycleSCell, [5] DRX cycles) for FR1 before the reception of the SCell activation command:
  - the UE has sent a valid measurement report for the SCell being activated and
  - the SSB measured remains detectable according to the cell identification conditions specified in section 9.2 and 9.3.
- the SSB measured during the period equal to max([5] measCycleSCell, [5] DRX cycles) also remains detectable during the SCell activation delay according to the cell identification conditions specified in section 9.2 and 9.3.

Otherwise SCell in FR1 is unknown.

If the UE has been provided with higher layer in TS 38.331 [2] signaling of *smtc2* prior to the activation command, T_{SMTC_Scell} follows *smtc1* or *smtc2* according to the physical cell ID of the target cell being activated. T_{SMTC_MAX} follows *smtc1* or *smtc2* according to the physical cell IDs of the target cells being activated and the active serving cells.

In addition to CSI reporting defined above, UE shall also apply other actions related to the activation command specified in [2] for an SCell at the first opportunities for the corresponding actions once the SCell is activated.

The interruption on PSCell or any activated SCell in SCG for EN-DC mode specified in section 8.2 shall not occur before slot n+1+[T_{HARQ}] and not occur after slot n+1+[T_{HARQ} +3ms + T_{SMTC_MAX} + $T_{SMTC\_duration}$].

The interruption on PCell or any activated SCell in MCG for NR standalone mode specified in section 8.2 shall not occur before slot n+1+[T_{HARQ}] and not occur after slot n+1+[T_{HARQ} +3ms + T_{SMTC_MAX} + $T_{SMTC\_duration}$].

The interruption on PCell or any activated SCell in MCG for NE-DC specified in section 8.2 and the interruption on E-UTRA PSCell or any activated E-UTRA SCell in SCG for NE-DC specified in section 7.36 of [15] shall not occur before slot n+1+[T_{HARQ}] and not occur after slot n+1+[T_{HARQ} +3ms + T_{SMTC_MAX} + $T_{SMTC\_duration}$].

The interruption on PCell, PSCell or any activated SCell in MCG or SCG for NR-DC specified in section 8.2 shall not occur before slot n+1+[T_{HARQ}] and not occur after slot n+1+[T_{HARQ} +3ms + T_{SMTC_MAX} + $T_{SMTC\_duration}$].

Starting from the slot specified in section 4.3 of [3] (timing for secondary Cell activation/deactivation) and until the UE has completed the SCell activation, the UE shall report out of range if the UE has available uplink resources to report CQI for the SCell.

8.3.3 SCell Deactivation Delay Requirement for Activated SCell

The requirements in this section shall apply for the UE configured with one downlink SCell in EN-DC, or in standalone NR carrier aggregation, or in NE-DC, or in NR-DC.

Upon receiving SCell deactivation command or upon expiry of the *sCellDeactivationTimer* in slot *n*, the UE shall accomplish the deactivation actions for the SCell being deactivated no later than in slot *n*+[T_{HARQ} +3ms].

The interruption on PSCell or any activated SCell in SCG for EN-DC mode specified in section 8.2 shall not occur before slot n+1+[T_{HARQ}] and not occur after slot n+1+[T_{HARQ} +3ms].

The interruption on PCell or any activated SCell in MCG for NR standalone mode specified in section 8.2 shall not occur before slot n+1+[T_{HARQ}] and not occur after slot n+1+[T_{HARQ} +3ms].

The interruption on PCell or any activated SCell in MCG for NE-DC specified in section 8.2 and the interruption on E-UTRA PSCell or any activated E-UTRA SCell in SCG for NE-DC specified in section -7.36 of [15] shall not occur before slot n+1+[T_{HARQ}] and not occur after slot n+1+[T_{HARQ} +3ms].

The interruption on PCell, PSCell or any activated SCell in MCG or SCG for NR standalone mode specified in section 8.2 shall not occur before slot n+1+[T_{HARQ}] and not occur after slot n+1+[T_{HARQ} +3ms].

8.4 UE UL carrier RRC reconfiguration Delay

8.4.1 Introduction

The requirements in this section apply for a UE being configured or deconfigured with a supplementary UL carrier or NR UL carrier.

8.4.2 UE UL carrier configuration Delay Requirement

When the UE receives a RRC message implying NR UL or Supplementary UL carrier configuration, the UE shall be ready to start transmission on the newly configured carrier within $T_{UL\_carrier\_config}$ from the end of the last slot containing the RRC command.

$T_{UL\_carrier\_config}$ equals the maximum RRC procedure delay defined in section 12 in TS 38.331 [2].

8.4.3 UE UL carrier deconfiguration Delay Requirement

When the UE receives a RRC message implying NR UL or Supplementary UL carrier deconfiguration RRC signalling, the UE shall stop UL signalling on the deconfigured UL carrier within $T_{UL\_carrier\_deconfig}$ from the end of the last slot containing the RRC command.

$T_{UL\_carrier\_deconfig}$ equals the maximum RRC procedure delay defined in section 12 in TS 38.331 [2].

8.5 Link Recovery Procedures

8.5.1 Introduction

The UE shall assess the downlink link quality of a serving cell based on the reference signal in the set $\overline{q}_0$ as specified in TS 38.213 [3] in order to detect beam failure instance for any of:

- PCell in SA, NR-DC, or NE-DC operation mode,
- PSCell in NR-DC and EN-DC operation mode,
- FFS: SCell when the UE is configured wih NR CA in any operation mode.

The RS resources in the set $\overline{q}_0$ can be periodic CSI-RS resources and/or SSBs. UE is not required to perform beam failure detection outside the active DL BWP.

On each RS resource in the set $\overline{q}_0$, the UE shall estimate the radio link quality and compare it to the threshold Q_{out_LR} for the purpose of accessing downlink radio link quality of the serving cell.

The threshold Q_{out_LR} is defined as the level at which the downlink radio level link cannot be reliably received and shall correspond to the $BLER_{out}$=10% block error rate of a hypothetical PDCCH transmission. For SSB based beam failure detection, $Q_{out\_LR\_SSB}$ is derived based on the hypothetical PDCCH transmission parameters listed in Table 8.5.2.1-1. For CSI-RS based beam failure detection, $Q_{out\_LR\_CSI-RS}$ is derived based on the hypothetical PDCCH transmission parameters listed in Table 8.5.3.1-1.

The UE shall perform L1-RSRP measurements based on the reference signal in the set $\overline{q}_1$ as specified in TS 38.213 [3] in order to detect candidate beam with L1-RSRP measurement that is better than the threshold indicated by higher layer parameter rsrp-ThresholdSSB and rsrp-ThresholdCSI-rs (rsrp-ThresholdSSB + powerControlOffsetSS). The RS resources in the set $\overline{q}_1$ can be periodic CSI-RS resources or SSBs or both SSB and CSI-RS. UE is not required to perform candidate beam detection outside the active DL BWP.

On each RS resource in the set $\overline{q}_1$, the UE shall perform L1-RSRP measurements and compare it to the threshold rsrp-ThresholdSSB or rsrp-ThresholdCSI-rs for the purpose of selecting new beam(s) for beam failure recovery.

UE is not expected to perform beam failure detection measurements if the SCS of the CSI-RS used for beam failure detection and the SCS of the SSB used for beam failure detection are different, and the CSI-RS and SSB are FDM-ed in the same OFDM symbol.

Editor's Note: FFS: whether UE supporting simultaneousRxDataSSB-DiffNumerology can perform BFD on SSB and CSI-RS simultaneously.

8.5.2 Requirements for SSB based beam failure detection

8.5.2.1 Introduction

The requirements in this section apply for each SSB resource in the set $\overline{q}_0$ configured for a serving cell, provided that the SSB configured for beam failure detection are actually transmitted within the UE active DL BWP during the entire evaluation period specified in section 8.5.2.2.

Table 8.5.2.1-1: PDCCH transmission parameters for beam failure instance

Attribute	Value for BLER
DCI format	1-0
Number of control OFDM symbols	2
Aggregation level (CCE)	8
Ratio of hypothetical PDCCH RE energy to average SSS RE energy	0dB
Ratio of hypothetical PDCCH DMRS energy to average SSS RE energy	0dB
Bandwidth (MHz)	TBD
Sub-carrier spacing (kHz)	Same as the SCS of RMSI CORESET
DMRS precoder granularity	REG bundle size
REG bundle size	6
CP length	Normal
Mapping from REG to CCE	Distributed

8.5.2.2 Minimum requirement

UE shall be able to evaluate whether the downlink radio link quality on the configured SSB resource in set $\overline{q}_0$ estimated over the last $T_{Evaluate\_BFD\_SSB}$ [ms] period becomes worse than the threshold $Q_{out\_LR\_SSB}$ within $T_{Evaluate\_BFD\_SSB}$ [ms] period.

The value of $T_{Evaluate\_BFD\_SSB}$ is defined in Table 8.5.2.2-1 for FR1.

The value of $T_{Evaluate\_BFD\_SSB}$ is defined in Table 8.5.2.2-2 for FR2 with N=8

For FR1,

- P=1/(1 – T_{SSB}/MGRP), when in the monitored cell there are measurement gaps configured for intra-frequency, inter-frequency or inter-RAT measurements, which are overlapping with some but not all occasions of the SSB; and

- P=1 when in the monitored cell there are no measurement gaps overlapping with any occasion of the SSB.

For FR2,

- $P=1/(1 – T_{SSB}/T_{SMTCperiod})$, when BFD-RS is not overlapped with measurement gap and BFD-RS is partially overlapped with SMTC occasion ($T_{SSB} < T_{SMTCperiod}$).
- P is $P_{sharing\ factor}$, when BFD-RS is not overlapped with measurement gap and BFD-RS is fully overlapped with SMTC period ($T_{SSB} = T_{SMTCperiod}$).
- P is $1/(1- T_{SSB}/MGRP - T_{SSB}/T_{SMTCperiod})$, when BFD-RS is partially overlapped with measurement gap and BFD-RS is partially overlapped with SMTC occasion ($T_{SSB} < T_{SMTCperiod}$) and SMTC occasion is not overlapped with measurement gap and
  - $T_{SMTCperiod} \neq$ MGRP or
  - $T_{SMTCperiod}$ = MGRP and $T_{SSB} < 0.5*T_{SMTCperiod}$
- P is $1/(1- T_{SSB} /MGRP)* P_{sharing\ factor}$, when BFD-RS is partially overlapped with measurement gap and BFD-RS is partially overlapped with SMTC occasion ($T_{SSB} < T_{SMTCperiod}$) and SMTC occasion is not overlapped with measurement gap and $T_{SMTCperiod}$ = MGRP and $T_{SSB} = 0.5*T_{SMTCperiod}$
- P is $1/\{1- T_{SSB} /\min (T_{SMTCperiod} ,MGRP)\}$, when BFD-RS is partially overlapped with measurement gap (T_{SSB} <MGRP) and BFD-RS is partially overlapped with SMTC occasion ($T_{SSB} < T_{SMTCperiod}$) and SMTC occasion is partially or fully overlapped with measurement gap.
- P is $1/(1- T_{SSB} /MGRP)* P_{sharing\ factor}$, when BFD-RS is partially overlapped with measurement gap and BFD-RS is fully overlapped with SMTC occasion ($T_{SSB} = T_{SMTCperiod}$) and SMTC occasion is partially overlapped with measurement gap ($T_{SMTCperiod}$ < MGRP)
- $P_{sharing\ factor} = 3$.

If the high layer in TS 38.331 [2] signaling of *smtc2* is configured, $T_{SMTCperiod}$ corresponds to the value of higher layer parameter *smtc2*; Otherwise $T_{SMTCperiod}$ corresponds to the value of higher layer parameter *smtc1*.

Longer evaluation period would be expected if the combination of BFD-RS, SMTC occasion and measurement gap configurations does not meet pervious conditions.

Table 8.5.2.2-1: Evaluation period $T_{Evaluate\_BFD\_SSB}$ for FR1

Configuration	$T_{Evaluate\_BFD\_SSB}$ (ms)
no DRX	max([50], ceil(5*P)*T_{SSB})
DRX cycle ≤ 320ms	max([50], ceil(7.5*P)*max(T_{DRX},T_{SSB}))
DRX cycle > 320ms	ceil(5*P)*T_{DRX}
Note: T_{SSB} is the periodicity of SSB in the set $\overline{q}_0$. T_{DRX} is the DRX cycle length.	

Table 8.5.2.2-2: Evaluation period $T_{Evaluate\_BFD\_out}$ for FR2

Configuration	$T_{Evaluate\_BFD\_SSB}$ (ms)
no DRX	max([50], ceil(5*P*N)*T_{SSB})
DRX cycle ≤ 320ms	max([50], ceil(7.5*P*N)*max(T_{DRX},T_{SSB}))
DRX cycle > 320ms	ceil(5*P*N)*T_{DRX}
Note: T_{SSB} is the periodicity of SSB in the set $\overline{q}_0$. T_{DRX} is the DRX cycle length.	

8.5.3 Requirements for CSI-RS based beam failure detection

8.5.3.1 Introduction

The requirements in this section apply for each CSI-RS resource in the set $\overline{q}_0$ configured for a serving cell, provided that the CSI-RS resource configured for beam failure detection are actually transmitted within the UE active DL BWP during the entire evaluation period specified in section 8.5.3.2. UE is not expected to perform beam failure detection measurements on the CSI-RS configured as BFD-RS if the CSI-RS is not QCL-ed with the RS in the active TCI state of any CORESET configured in the UE active BWP.

Table 8.5.3.1-1: PDCCH transmission parameters for beam failure instance

Attribute	Value for BLER
DCI format	1-0
Number of control OFDM symbols	2
Aggregation level (CCE)	8
Ratio of hypothetical PDCCH RE energy to average CSI-RS RE energy	0dB
Ratio of hypothetical PDCCH DMRS energy to average CSI-RS RE energy	0dB
Bandwidth (PRBs)	48
Sub-carrier spacing (kHz)	SCS of the active DL BWP
DMRS precoder granularity	REG bundle size
REG bundle size	6
CP length	Normal
Mapping from REG to CCE	Distributed

8.5.3.2 Minimum requirement

UE shall be able to evaluate whether the downlink radio link quality on the configured CSI-RS resource in set $\overline{q}_0$ estimated over the last $T_{Evaluate\_BFD\_CSI-RS}$ [ms] period becomes worse than the threshold $Q_{out\_LR\_CSI-RS}$ within $T_{Evaluate\_BFD\_CSI-RS}$ [ms] period.

The value of $T_{Evaluate\_BFD\_CSI-RS}$ is defined in Table 8.5.3.2-1 for FR1.

The value of $T_{Evaluate\_BFD\_CSI-RS}$ is defined in Table 8.5.3.2-2 for FR2 with N=1

Editor's Note: It is FFS if a CSI-RS resource in the resource set with repetition "ON" can be configured as a BFD-RS. If CSI-RS for BFD can be in the resource set with repetition "ON", N=8 may apply.

Editor's Note: FFS if there are other conditions with N=8.

For FR1,

- P=1/(1 – T_{CSI-RS}/MGRP), when in the monitored cell there are measurement gaps configured for intra-frequency, inter-frequency or inter-RAT measurements, which are overlapping with some but not all occasions of the CSI-RS; and
- P=1 when in the monitored cell there are no measurement gaps overlapping with any occasion of the CSI-RS.

For FR2,

- P=1, when BFD-RS is not overlapped with measurement gap and also not overlapped with SMTC occasion.
- P=1/(1 – T_{CSI-RS}/MGRP) , when BFD-RS is partially overlapped with measurement gap and BFD-RS is not overlapped with SMTC occasion (T_{CSI-RS} < MGRP)
- P=1/(1 – T_{CSI-RS} /$T_{SMTCperiod}$), when BFD-RS is not overlapped with measurement gap and BFD-RS is partially overlapped with SMTC occasion ($T_{CSI-RS} < T_{SMTCperiod}$).
- P is $P_{sharing\ factor}$, when BFD-RS is not overlapped with measurement gap and BFD-RS is fully overlapped with SMTC occasion ($T_{CSI-RS} = T_{SMTCperiod}$).
- P is 1/(1- T_{CSI-RS} /MGRP - T_{CSI-RS} /$T_{SMTCperiod}$), when BFD-RS is partially overlapped with measurement gap and BFD-RS is partially overlapped with SMTC occasion (TCSI-RS < $T_{SMTCperiod}$) and SMTC occasion is not overlapped with measurement gap and

  - $T_{SMTCperiod} \neq$ MGRP or
  - $T_{SMTCperiod}$ = MGRP and $T_{CSI-RS} < 0.5*T_{SMTCperiod}$

- P is 1/(1- T_{CSI-RS} /MGRP)* $P_{sharing\ factor}$, when BFD-RS is partially overlapped with measurement gap and BFD-RS is partially overlapped with SMTC occasion ($T_{CSI-RS} < T_{SMTCperiod}$) and SMTC occasion is not overlapped with measurement gap and $T_{SMTCperiod}$ = MGRP and $T_{CSI-RS} = 0.5*T_{SMTCperiod}$
- P is 1/{1- T_{CSI-RS} /min ($T_{SMTCperiod}$,MGRP)}, when BFD-RS is partially overlapped with measurement gap (T_{CSI-RS} < MGRP) and BFD-RS is partially overlapped with SMTC occasion ($T_{CSI-RS} < T_{SMTCperiod}$) and SMTC occasion is partially or fully overlapped with measurement gap.
- P is 1/(1- T_{CSI-RS} /MGRP)* $P_{sharing\ factor}$, when BFD-RS is partially overlapped with measurement gap and BFD-RS is fully overlapped with SMTC occasion ($T_{CSI-RS} = T_{SMTCperiod}$) and SMTC occasion is partially overlapped with measurement gap ($T_{SMTCperiod}$ < MGRP)
- $P_{sharing\ factor}$ is 3**.**

If the high layer in TS 38.331 [2] signaling of *smtc2* is configured, $T_{SMTCperiod}$ corresponds to the value of higher layer parameter *smtc2*; Otherwise $T_{SMTCperiod}$ corresponds to the value of higher layer parameter *smtc1*.

Note: The overlap between CSI-RS for BFD and SMTC means that CSI-RS for BFD is within the SMTC window duration.

Longer evaluation period would be expected if the combination of BFD-RS, SMTC occasion and measurement gap configurations does not meet pervious conditions.

The values of M_{BFD} used in Table 8.5.3.2-1 and Table 8.5.3.2-2 are defined as

- M_{BFD} = 10, if the CSI-RS resource configured for BFD is transmitted with Density = 3.

Table 8.5.3.2-1: Evaluation period $T_{Evaluate\_BFD\_CSI-RS}$ for FR1

Configuration	$T_{Evaluate\_BFD\_CSI-RS}$ (ms)
no DRX	max([50], [M_{BFD} *P] * T_{CSI-RS})
DRX cycle ≤ 320ms	max([50], [1.5×M_{BFD} *P]*max(T_{DRX}, T_{CSI-RS}))
DRX cycle > 320ms	[M_{BFD}*P] * T_{DRX}
Note: T_{CSI-RS} is the periodicity of CSI-RS resource in the set $\overline{q}_0$. T_{DRX} is the DRX cycle length.	

Table 8.5.3.2-2: Evaluation period $T_{Evaluate\_BFD\_CSI-RS}$ for FR2

Configuration	$T_{Evaluate\_BFD\_CSI-RS}$ (ms)
no DRX	max([50], [M_{BFD} *P*N] * T_{CSI-RS})
DRX cycle ≤ 320ms	max([50], [1.5×M_{BFD}*P*N]*max(T_{DRX}, T_{CSI-RS}))
DRX cycle > 320ms	[M_{BFD} *P*N] * T_{DRX}
Note: T_{CSI-RS} is the periodicity of CSI-RS resource in the set $\overline{q}_0$. T_{DRX} is the DRX cycle length.	

8.5.4 Minimum requirement for L1 indication

When the radio link quality on all the configured RS resources in set $\overline{q}_0$ is worse than Q_{out_LR}, Layer 1 of the UE shall send a beam failure instance indication to the higher layers. A Layer 3 filter may be applied to the beam failure instance indications as specified in [2].

The beam failure instance evaluation for the configured RS resources in set $\overline{q}_0$ shall be performed as specified in section 6 in [3]. Two successive indications from Layer 1 shall be separated by at least $T_{Indication\_interval\_BFD}$.

When DRX is not used, $T_{Indication\_interval\_BFD}$ is max(2ms, $T_{BFD-RS,M}$), where $T_{BFD-RS,M}$ is the shortest periodicity of all configured RS resources in set $\overline{q}_0$ for the accessed cell, corresponding to either the shortest periodicity of the SSB in the set $\overline{q}_0$ or CSI-RS resource in the set $\overline{q}_0$.

When DRX is used, $T_{Indication\_interval\_BFD}$ is max(1.5*DRX_cycle_length, 1.5*$T_{BFD-RS,M}$) if DRX cycle_length is less than or equal to 320ms, and $T_{Indication\_interval}$ is DRX_cycle_length if DRX cycle_length is greater than 320ms.

8.5.5 Requirements for SSB based candidate beam detection

8.5.5.1 Introduction

The requirements in this section apply for each SSB resource in the set $\overline{q}_1$ configured for a serving cell, provided that the SSBs configured for candidate beam detection are actually transmitted within UE active DL BWP during the entire evaluation period specified in section 8.5.5.2.

8.5.5.2 Minimum requirement

UE shall be able to evaluate whether the L1-RSRP measured on the configured SSB resource in set $\overline{q}_1$ estimated over the last $T_{Evaluate\_CBD\_SSB}$ [ms] period becomes better than the threshold Q_{in_LR} provided SSB_RP and SSB Ês/Iot are according to Annex Table B.2.4.1 for a corresponding band.

The value of $T_{Evaluate\_CBD\_SSB}$ is defined in Table 8.5.5.2-1 for FR1.

The value of $T_{Evaluate\_CBD\_SSB}$ is defined in Table 8.5.5.2-2 for FR2 with N=8.

Where,

For FR1,

- P=1/(1 – T_{SSB}/MGRP), when in the monitored cell there are measurement gaps configured for intra-frequency, inter-frequency or inter-RAT measurements, which are overlapping with some but not all occasions of the SSB; and
- P=1 when in the monitored cell there are no measurement gaps overlapping with any occasion of the SSB.

For FR2,

- P=1/(1 – T_{SSB}/$T_{SMTCperiod}$), when candidate beam detection RS is not overlapped with measurement gap and candidate beam detection RS is partially overlapped with SMTC occasion (T_{SSB} < $T_{SMTCperiod}$).
- P is 3, when candidate beam detection RS is not overlapped with measurement gap and candidate beam detection RS is fully overlapped with SMTC period (T_{SSB} = $T_{SMTCperiod}$).
- P is 1/(1- T_{SSB}/MGRP - T_{SSB}/$T_{SMTCperiod}$), when candidate beam detection RS is partially overlapped with measurement gap and candidate beam detection RS is partially overlapped with SMTC occasion (T_{SSB} < $T_{SMTCperiod}$) and SMTC occasion is not overlapped with measurement gap and
  - $T_{SMTCperiod} \neq$ MGRP or
  - $T_{SMTCperiod}$ = MGRP and T_{SSB} < 0.5*$T_{SMTCperiod}$
- P is 1/(1- T_{SSB} /MGRP)*3, when candidate beam detection RS is partially overlapped with measurement gap and candidate beam detection RS is partially overlapped with SMTC occasion (T_{SSB} < $T_{SMTCperiod}$) and SMTC occasion is not overlapped with measurement gap and $T_{SMTCperiod}$ = MGRP and T_{SSB} = 0.5*$T_{SMTCperiod}$
- P is 1/{1- T_{SSB} /min ($T_{SMTCperiod}$,MGRP)}, when candidate beam detection RS is partially overlapped with measurement gap and candidate beam detection RS is partially overlapped with SMTC occasion (T_{SSB} < $T_{SMTCperiod}$) and SMTC occasion is partially or fully overlapped with measurement gap
- P is 1/(1- T_{SSB} /MGRP)*3, when candidate beam detection RS is partially overlapped with measurement gap and candidate beam detection RS is fully overlapped with SMTC occasion (T_{SSB} = $T_{SMTCperiod}$) and SMTC occasion is partially overlapped with measurement gap ($T_{SMTCperiod}$ < MGRP)

In both FR1 and FR2, if different SCS is used for SSB and CSI-RS, and the UE does not support *simultaneousRxDataSSB-DiffNumerology*, it is assumed that the SSB configured for candidate beam detection and each CSI-RS resource shall be TDMed transmited.

In FR2, it is assumed that the SSB configured for candidate beam detection and each CSI-RS resource shall be TDMed transmited.

Table 8.5.5.2-1: Evaluation period $T_{Evaluate\_CBD\_SSB}$ for FR1

Configuration	$T_{Evaluate\_CBD\_SSB}$ (ms)
non-DRX	ceil([3]*P) * T_{SSB}
DRX cycle ≤ 320ms	ceil([3]*P*1.5) * max(T_{DRX},T_{SSB})
DRX cycle > 320ms	ceil([3]*P) * T_{DRX}
Note: T_{SSB} is the periodicity of SSB in the set $\overline{q}_1$. T_{DRX} is the DRX cycle length.	

Table 8.5.5.2-2: Evaluation period $T_{Evaluate\_CBD\_out}$ for FR2

Configuration	$T_{Evaluate\_CBD\_SSB}$ (ms)
non-DRX	ceil([3]*P*N) * T_{SSB}
DRX cycle ≤ 320ms	ceil([3]*P*N*1.5) * max(T_{DRX},T_{SSB})
DRX cycle > 320ms	ceil([3]*P*N) * T_{DRX}
Note: T_{SSB} is the periodicity of SSB in the set $\overline{q}_1$. T_{DRX} is the DRX cycle length.	

8.5.6 Requirements for CSI-RS based candidate beam detection

8.5.6.1 Introduction

The requirements in this section apply for each CSI-RS resource in the set $\overline{q}_1$ configured for a serving cell, provided that the CSI-RS resources configured for candidate beam detection are actually transmitted within UE active DL BWP during the entire evaluation period specified in section 8.5.6.2.

8.5.6.2 Minimum requirement

UE shall be able to evaluate whether the L1-RSRP measured on the configured CSI-RS resource in set $\overline{q}_1$ estimated over the last $T_{Evaluate\_CBD\_CSI-RS}$ [ms] period becomes better than the threshold Q_{in_LR} within $T_{Evaluate\_CBD\_CSI-RS}$ [ms] period provided CSI-RS Ês/Iot is according to Annex Table B.2.4.2 for a corresponding band.

The value of $T_{Evaluate\_CBD\_CSI-RS}$ is defined in Table 8.5.6.2-1 for FR1.

The value of $T_{Evaluate\_CBD\_CSI-RS}$ is defined in Table 8.5.6.2-2 for FR2 with N=8.

Editor's Note: FFS whether N=1 need to be applied for CSI-RS based candidate beam detection in FR2.

For FR1,

- P=1/(1 – T_{CSI-RS}/MGRP), when in the monitored cell there are measurement gaps configured for intra-frequency, inter-frequency or inter-RAT measurements, which are overlapping with some but not all occasions of the CSI-RS; and

- P=1 when in the monitored cell there are no measurement gaps overlapping with any occasion of the CSI-RS.

For FR2,

- P=1, when candidate beam detection RS is not overlapped with measurement gap and also not overlapped with SMTC occasion.

- P=1/(1 – T_{CSI-RS}/MGRP) , when candidate beam detection RS is partially overlapped with measurement gap and candidate beam detection RS is not overlapped with SMTC occasion (T_{CSI-RS} < MGRP)

- $P=1/(1 - T_{CSI-RS} / T_{SMTCperiod})$, when candidate beam detection RS is not overlapped with measurement gap and candidate beam detection RS is partially overlapped with SMTC occasion ($T_{CSI-RS} < T_{SMTCperiod}$).
- P is 3, when candidate beam detection RS is not overlapped with measurement gap and candidate beam detection RS is fully overlapped with SMTC occasion ($T_{CSI-RS} = T_{SMTCperiod}$).
- P is $1/(1- T_{CSI-RS} /MGRP - T_{CSI-RS} /T_{SMTCperiod})$, when candidate beam detection RS is partially overlapped with measurement gap and candidate beam detection RS is partially overlapped with SMTC occasion (TCSI-RS < $T_{SMTCperiod}$) and SMTC occasion is not overlapped with measurement gap and
  - $T_{SMTCperiod} \neq$ MGRP or
  - $T_{SMTCperiod}$ = MGRP and $T_{CSI-RS} < 0.5*T_{SMTCperiod}$
- P is $1/(1- T_{CSI-RS} /MGRP)* 3$, when candidate beam detection RS is partially overlapped with measurement gap and candidate beam detection RS is partially overlapped with SMTC occasion ($T_{CSI-RS} < T_{SMTCperiod}$) and SMTC occasion is not overlapped with measurement gap and $T_{SMTCperiod}$ = MGRP and $T_{CSI-RS} = 0.5*T_{SMTCperiod}$
- P is $1/\{1- T_{CSI-RS} /\min (T_{SMTCperiod} ,MGRP)\}$, when candidate beam detection RS is partially overlapped with measurement gap and candidate beam detection RS is partially overlapped with SMTC occasion ($T_{CSI-RS} < T_{SMTCperiod}$) and SMTC occasion is partially or fully overlapped with measurement gap
- P is $1/(1- T_{CSI-RS} /MGRP)* 3$, when candidate beam detection RS is partially overlapped with measurement gap and candidate beam detection RS is fully overlapped with SMTC occasion ($T_{CSI-RS} = T_{SMTCperiod}$) and SMTC occasion is partially overlapped with measurement gap ($T_{SMTCperiod}$ < MGRP) [Longer evaluation period would be expected if the CSI-RS is on the same OFDM symbols with RLM/BFD/BM-RS, or other CBD-RS, according to the measurement restrictions defined in section TBD.]

In both FR1 and FR2, if different SCS is used for SSB and CSI-RS, and the UE does not support *simultaneousRxDataSSB-DiffNumerology*, it iss assumed that the CSI-RS configured for candidate beam detection and each SSB shall be TDMed transmitted.

In FR2, It is assumed that the CSI-RS configured for candidate beam detection with N=1 shall be TDMed with any RS resources configured for RLM/BFD/CBD/L1-RSRP reporting which is not is QCL-Type D with this CSI-RS resource or under the conditions of N>1 as specified in section 8.1.2.2, 8.1.2.3, 8.5.2.2, 8.5.2.3, 8.5.2.5, 8.5.2.6, 9.5.4.1 and 9,5,4,2.

The values of M_{CBD} used in Table 8.5.6.2-1 and Table 8.5.6.2-2 are defined as

- M_{CBD} = 3, if the CSI-RS resource configured in the set $\overline{q}_1$ is transmitted with Density = 3.

Table 8.5.6.2-1: Evaluation period $T_{Evaluate\_CBD\_CSI-RS}$ for FR1

Configuration	$T_{Evaluate\_CBD\_CSI-RS}$ (ms)
non-DRX	max([25], ceil(M_{CBD} *P) * T_{CSI-RS})
DRX cycle ≤ 320ms	ceil(M_{CBD} *P) * max(T_{DRX}, T_{CSI-RS})
DRX cycle > 320ms	ceil(M_{CBD} *P) *T_{DRX}
Note: T_{CSI-RS} is the periodicity of CSI-RS resource in the set $\overline{q}_1$. T_{DRX} is the DRX cycle length.	

Table 8.5.6.2-2: Evaluation period $T_{Evaluate\_CBD\_CSI-RS}$ for FR2

Configuration	$T_{Evaluate\_CBD\_CSI-RS}$ (ms)
non-DRX	max([25], ceil(M_{CBD} *P*N) * T_{CSI-RS})
DRX cycle ≤ 320ms	ceil(M_{CBD} *P*N*1.5) * max(T_{DRX}, T_{CSI-RS})
DRX cycle > 320ms	ceil(M_{CBD} *P*N) *T_{DRX}
Note: T_{CSI-RS} is the periodicity of CSI-RS resource in the set $\overline{q}_1$. T_{DRX} is the DRX cycle length.	

8.5.7 Scheduling availability of UE during beam failure detection

Scheduling availability restrictions when the UE is performing beam failure detection are described in the following clauses.

8.5.7.1 Scheduling availability of UE performing beam failure detection with a same subcarrier spacing as PDSCH/PDCCH on FR1

There are no scheduling restrictions due to beam failure detection performed on SSB and CSI-RS configured as BFD-RS with the same SCS as PDSCH/PDCCH in FR1.

8.5.7.2 Scheduling availability of UE performing beam failure detection with a different subcarrier spacing than PDSCH/PDCCH on FR1

For UEs which support *simultaneousRxDataSSB-DiffNumerology* [14] there are no restrictions on scheduling availability due to beam failure detection based on SSB as BFD-RS. For UEs which do not support *simultaneousRxDataSSB-DiffNumerology* [14] the following restrictions apply due to beam failure detection based on SSB configured as BFD-RS.

- The UE is not expected to transmit PUCCH/PUSCH/SRS or receive PDCCH/PDSCH/TRS/CSI-RS for CQI on SSB symbols to be measured for beam failure detection.

When intra-band carrier aggregation in FR1 is configured, the scheduling restrictions apply to all SCells that are aggregated in the same band as the PCell or PSCell. When inter-band carrier aggregation within FR1 is configured, there are no scheduling restrictions on FR1 serving cell(s) configured in other bands than the bands in which PCell or PSCell is configured.

8.5.7.3 Scheduling availability of UE performing beam failure detection on FR2

The following scheduling restriction applies due to beam failure detection.

- For the case where no RSs are provided for BFD, or where BFD-RS is explicitly configured and is QCLed with active TCI state for PDCCH/PDSCH, and N=1 applies for the BFD-RS as specified in section 8.5.2.2 if the BFD-RS is SSB and in section 8.5.3.2 if the BFD-RS is CSI-RS
    - There are no scheduling restrictions due to beam failure detection performed based on SSB or CSI-RS with a same SCS as PDSCH/PDCCH.
    - When performing beam failure detection based on SSB with a different SCS than PDSCH/PDCCH, for UEs which support *simultaneousRxDataSSB-DiffNumerology* [14] there are no restrictions on scheduling availability due to beam failure detection. For UEs which do not support *simultaneousRxDataSSB-DiffNumerology* [14] the UE is not expected to transmit PUCCH/PUSCH/SRS or receive PDCCH/PDSCH/TRS/CSI-RS for CQI on SSB symbols to be measured for beam failure detection.
- Otherwise
    - The UE is not expected to transmit PUCCH/PUSCH/SRS or receive PDCCH/PDSCH/TRS/CSI-RS for CQI on BFD-RS symbols to be measured for beam failure detection.

When intra-band carrier aggregation is performed, the scheduling restrictions apply to all serving cells on the band due to beam failure detection performed on FR2 PCell or PSCell in the same band.

Editor’s Note: FFS scheduling restrictions for inter-band carrier aggregation will be defined depending on band combination in future.

8.5.7.4 Scheduling availability of UE performing beam failure detection on FR1 or FR2 in case of FR1-FR2 inter-band CA and NR DC

There are no scheduling restrictions on FR1 serving cell(s) due to beam failure detection performed on FR2 serving PCell and/or PSCell.

There are no scheduling restrictions on FR2 serving cell(s) due to beam failure detection performed on FR1 serving PCell and/or PSCell.

Editor's Note: NR-DC in Rel-15 only includes the scenarios where all serving cells in MCG in FR1 and all serving cells in SCG in FR2.

8.5.8 Scheduling availability of UE during candidate beam detection

Scheduling availability restrictions when the UE is performing L1-RSRP measurement for candidate beam detection are described in the following clauses.

8.5.8.1 Scheduling availability of UE performing L1-RSRP measurement with a same subcarrier spacing as PDSCH/PDCCH on FR1

There are no scheduling restrictions due to L1-RSRP measurement performed on SSB and CSI-RS configured as link recovery detection resourcewith the same SCS as PDSCH/PDCCH in FR1.

8.5.8.2 Scheduling availability of UE performing L1-RSRP measurement with a different subcarrier spacing than PDSCH/PDCCH on FR1

For UEs which support *simultaneousRxDataSSB-DiffNumerology* [14] there are no restrictions on scheduling availability due to L1-RSRP measurement based on SSB as link recovery detection resource. For UEs which do not support *simultaneousRxDataSSB-DiffNumerology* [14] the following restrictions apply due to L1-RSRP measurement based on SSB configured as link recovery detection resource.

- The UE is not expected to transmit PUCCH/PUSCH/SRS or receive PDCCH/PDSCH/TRS/CSI-RS for CQI on SSB symbols to be measured for L1-RSRP.

When intra-band carrier aggregation in FR1 is configured, the scheduling restrictions apply to all serving cells that are aggregated in the same band as the cell where L1-RSRP measurement is performed. When inter-band carrier aggregation within FR1 is configured, there are no scheduling restrictions on FR1 serving cell(s) configured in other bands.

8.5.8.3 Scheduling availability of UE performing L1-RSRP measurement on FR2

The following scheduling restriction applies due to beam failure detection

- For the case where no RSs are provided for beam failure detection, or where beam failure detection RS is explicitly configured and is QCLed with active TCI state for PDCCH/PDSCH, and N=1 applies for the beam failure detection RS as specified in section 8.5.2.2 if the beam failure detection RS is SSB and in section 8.5.3.2 if the beam failure detection RS is CSI-RS
    - There are no scheduling restrictions due to beam failure detection performed based on SSB or CSI-RS with a same SCS as PDSCH/PDCCH.
    - When performing beam failure detection based on SSB with a different SCS than PDSCH/PDCCH, for UEs which support *simultaneousRxDataSSB-DiffNumerology* [14] there are no restrictions on scheduling availability due to beam failure detection. For UEs which do not support *simultaneousRxDataSSB-DiffNumerology* [14] the UE is not expected to transmit PUCCH/PUSCH or receive PDCCH/PDSCH on SSB symbols to be measured for beam failure detection.
- Otherwise
    - The UE is not expected to transmit PUCCH/PUSCH or receive PDCCH/PDSCH on BFD-RS symbols to be measured for beam failure detection.

When intra-band carrier aggregation is configured, the scheduling restrictions apply to all serving cells that are aggregated in the same band as the serving cell where L1-RSRP measurement for candidate beam detection is performed.

Editor's Note: FFS scheduling restrictions for inter-band carrier aggregation will be defined depending on band combination in future.

8.5.8.4 Scheduling availability of UE performing L1-RSRP measurement on FR1 or FR2 in case of FR1-FR2 inter-band CA and NR-DC

There are no scheduling restrictions on FR1 serving cell(s) due to L1-RSRP measurement performed on FR2 serving cell(s).

There are no scheduling restrictions on FR2 serving cell(s) due to L1-RSRP measurement performed on FR1 serving cell(s).

Editor's Note: NR-DC in Rel-15 only includes the scenarios where all serving cells in MCG in FR1 and all serving cells in SCG in FR2.

8.6 Active BWP switch delay

8.6.1 Introduction

The requirements in this section apply for a UE configured with more than one BWP on PCell or any activated SCell in standalone NR or NE-DC, PCell, PSCell or any activated SCell in MCG or SCG in NR-DC, or PSCell or any activated SCell in SCG in EN-DC. UE shall complete the switch of active DL and/or UL BWP within the delay defined in this section.

8.6.2 DCI and timer based BWP switch delay

For DCI-based BWP switch, after the UE receives BWP switching request at DL slot n on a serving cell, UE shall be able to receive PDSCH (for DL active BWP switch) or transmit PUSCH (for UL active BWP switch) on the new BWP on the serving cell on which BWP switch on the first DL or UL slot occurs right after the beginning of DLslot n+ $T_{BWPswitchDelay}$.

The UE is not required to follow the requirements defined in this section when performing a DCI-based BWP switch between the BWPs in disjoint channel bandwidths or in partially overlapping channel bandwidths.

For timer-based BWP switch, the UE shall start BWP switch at DL slot n, where n is the beginning of a DL subframe (FR1) or DL half-subframe (FR2) immediately after a BWP-inactivity timer *bwp-InactivityTimer* [2] expires on a serving cell, and the UE shall be able to receive PDSCH (for DL active BWP switch) or transmit PUSCH (for UL active BWP switch) on the new BWP on the serving cell on which BWP switch on the first DL or UL slot occurs right after the beginning of DLslot n+ $T_{BWPswitchDelay}$.

The UE is not required to transmit UL signals or receive DL signals during time duration $T_{BWPswitchDelay}$ on the cell where DCI-based BWP switch or timer-based BWP switch occurs.

Depending on UE capability *bwp-SwitchingDelay* [2], UE shall finish BWP switch within the time duration $T_{BWPswitchDelay}$ defined in Table 8.6.2-1.

Table 8.6.2-1: BWP switch delay

μ	NR Slot length (ms)	BWP switch delay $T_{BWPswitchDelay}$ (slots)	
		Type 1^Note 1	Type 2^Note 1
0	1	1	3
1	0.5	2	5
2	0.25	3	9
3	0.125	6	17
Note 1: Depends on UE capability. Note 2: If the BWP switch involves changing of SCS, the BWP switch delay is determined by the larger one between the SCS before BWP switch and the SCS after BWP switch.			

8.6.3 RRC based BWP switch delay

For RRC-based BWP switch, after the UE receives BWP switching request, UE shall be able to receive PDSCH (for DL active BWP switch) or transmit PUSCH (for UL active BWP switch) on the new BWP on the serving cell on which BWP switch on the first DL or UL slot right after the beginning of DLslot n+ $T_{RRCprocessingDelay}$ + $T_{BWPswitchDelayRRC}$, where DL slot n is the last slot containing the RRC command, and $T_{RRCprocessingDelay}$ is the length of the RRC procedure delay in slots defined in clause 12 in TS 38.331 [2], and $T_{BWPswitchDelayRRC}$ is the BWP switching delay for RRC based BWP switch.

Editor's Note: $T_{BWPswitchDelayRRC}$ is going to be defined based one of the following options: Option 1) single requirement based on the worst scenario, Option 2) two sets of requirement. One set of requirement would be same as option1 and the other requirement might be tightened.

8.7 Void

8.8 NE-DC: E-UTRAN PSCell Addition and Release Delay

8.8.1 Introduction

This section defines requirements for the delay within which the UE shall be able to configure an E-UTRAN PSCell in NR - E-UTRA dual connectivity. The requirements are applicable to an NR - E-UTRA dual connectivity capable UE.

8.8.2 E-UTRAN PSCell Addition Delay Requirement

The requirements in this section shall apply for the UE which is configured with PCell, and may also be configured with one or more SCells.

Upon receiving E-UTRAN PSCell addition in subframe *n*, the UE shall be capable to transmit PRACH preamble towards E-UTRAN PSCell no later than in subframe *n*+ $T_{config\_EUTRAN\text{-}PSCell}$:

Where:

$T_{config\_EUTRAN\text{-}PSCell}$ = 20ms + $T_{activation\_time}$ + 50ms + T_{PCell_DU} + $T_{E\text{-}UTRAN\text{-}PSCell\_DU}$

$T_{activation\_time}$ is the E-UTRAN PSCell activation delay. If the E-UTRAN PSCell is known, then $T_{activation\_time}$ is 20ms. If the E-UTRAN PSCell is unknown, then $T_{activation\_time}$ is 30ms provided the E-UTRAN PSCell can be successfully detected on the first attempt.

T_{PCell_DU} is the delay uncertainty due to PCell PRACH preamble transmission. T_{PCell_DU} is up to 20ms if E-UTRAN PSCell activation is interrupted by a PCell PRACH preamble transmission, otherwise it is 0.

$T_{E\text{-}UTRAN\text{-}PSCell\_DU}$ is the delay uncertainty in acquiring the first available PRACH occasion in the E-UTRAN PSCell. $T_{E\text{-}UTRAN\text{-}PSCell\_DU}$ is up to 30ms.

E-UTRAN PSCell is known if it has been meeting the following conditions:

During the last [5] seconds before the reception of the E-UTRAN PSCell configuration command:

- the UE has sent a valid measurement report for the E-UTRAN PSCell being configured and
- the E-UTRAN PSCell being configured remains detectable according to the cell identification conditions specified in section 8.8 of [15],

- E-UTRAN PSCell being configured also remains detectable during the E-UTRAN PSCell configuration delay according to the cell identification conditions specified in section 8.8 of [15].

otherwise it is unknown.

The PCell interruption specified in section 8.2 is allowed only during the RRC reconfiguration procedure [2].

8.8.3 E-UTRAN PSCell Release Delay Requirement

The requirements in this section shall apply for a UE which is configured with PCell and E-UTRAN PSCell, and may also be configured with one or more SCells and/or E-UTRAN SCells.

Upon receiving E-UTRAN PSCell release in subframe *n*, the UE shall accomplish the release actions specified in [2] no later than in subframe *n*+20.

The PCell interruption specified in section 8.2 is allowed only during the RRC reconfiguration procedure [2].

8.9 NR-DC: PSCell Addition and Release Delay

8.9.1 Introduction

This section defines requirements for the delay within which the UE shall be able to configure an PSCell in NR dual connectivity. The requirements are applicable to an NR dual connectivity capable UE.

8.9.2 PSCell Addition Delay Requirement

The requirements in this section shall apply for the UE configured with only PCell.

Upon receiving PSCell addition in subframe *n*, the UE shall be capable to transmit PRACH preamble towards PSCell no later than in subframe n + $T_{config\ PSCell}$:

Where:

$T_{config\_PSCell} = T_{RRC\_delay} + T_{processing} + T_{search} + T_{\Delta} + T_{PSCell\_DU} + 2$ ms

T_{RRC_delay} is the RRC procedure delay as specified in [2].

$T_{processing}$ is the SW processing time needed by UE, including RF warm up period. $T_{processing}$ = 20 ms if PSCell is in FR1, $T_{processing}$ = 40 ms if PSCell is in FR2.

T_{search} is the time for AGC settling and PSS/SSS detection.

- For PSCell in FR1: if the target cell is known, then T_{search} = 0 ms. If the target cell is an unknown intra-frequency cell and signal quality is sufficient for successful cell detection on the first attempt, then T_{search} = SMTC periodicity + 5 ms. If the target cell is an unknown inter-frequency cell and signal quality is sufficient for successful cell detection on the first attempt, then T_{search} = [TBD*SMTC periodicity + 5] ms;
- For PSCell in FR2: if the target cell is an unknown intra-frequency cell and signal quality is sufficient for successful cell detection on the first attempt, then T_{search} = [N1*SMTC periodicity + 5] ms. If the target cell is an unkown inter-frequency cell and signal quality is sufficient for successful cell detection on the first attempt, then T_{search} = [N1*TBD* SMTC periodicity + 5] ms, else T_{search} = [TBD* SMTC periodicity + 5] ms.

T_{Δ} is time for fine time tracking and acquiring full timing information of the target cell. T_{Δ} = 1 SMTC periodicity ms.

T_{PSCell_DU} is the delay uncertainty in acquiring the first available PRACH occasion in the PSCell. T_{PSCell_DU} is up to x*10 +10 ms. x is defined in the table 6.3.3.2-2 of [6].

In FR1, the PSCell is known if it has been meeting the following conditions:

During the last 5 seconds before the reception of the PSCell configuration command:

- the UE has sent a valid measurement report for the PSCell being configured and
- One of the SSBs measured from the PSCell being configured remains detectable according to the cell identification conditions specified in section 9.3,

- One of the SSBs measured from PSCell being configured also remains detectable during the PSCell configuration delay according to the cell identification conditions specified in section 9.3.

otherwise it is unknown.

The PCell interruption specified in section 8.2 is allowed only during the RRC reconfiguration procedure [2].

Editor's note: The definition of known cell in FR2 is TBD.

Editor's note: It is FFS whether SRS carrier based switching during PSCell addition procedure impacts PSCell addition delay requirement.

Editor's note: It is FFS whether delay uncertainty due to PCell PRACH preamble transmission has an impact on T_{config_PSCell}.

8.9.3 PSCell Release Delay Requirement

The requirements in this section shall apply for a UE which is configured with PCell and one PSCell.

Upon receiving PSCell release in subframe *n*, the UE shall accomplish the release actions specified in [2] no later than in subframe $n+ T_{RRC\_delay}$:

Where

T_{RRC_delay} is the RRC procedure delay as specified in [2].

The PCell interruption specified in section 8.2 is allowed only during the RRC reconfiguration procedure [2].

Editor's note: It is FFS whether SRS carrier based switching during PSCell release procedure impacts PSCell release delay requirement.

9 Measurement Procedure

9.1 General measurement requirement

9.1.1 Introduction

This clause contains general requirements on the UE regarding measurement reporting in RRC_CONNECTED state. The requirements are split in intra-frequency, inter-frequency, inter-RAT E-UTRAN FDD, inter-RAT E-UTRAN TDD, and L1-RSRP measurements requirements. These measurements may be used by the NG-RAN. The measurement quantities are defined in TS38.215[4], the measurement model is defined in TS38.300[10], TS37.340[17] and measurement accuracies are specified in clause 10. Control of measurement reporting is specified in [16].

In the requirements of Section 9, the exceptions for side conditions apply as follows:

- for the UE capable of CA but not configured with any SCell, the applicable exceptions for side conditions are specified in Annex B, Section B.3.2.1 for UE supporting CA in FR1, and Section B.3.2.3 for UE supporting CA in FR2, respectively;
- for the UE capable of CA and configured with at least one SCell, the applicable exceptions for side conditions are specified in Annex B, Section B.3.2.2 for UE configured with CA in FR1, and Section B.3.2.4 for UE supporting CA in FR2 respectively;
- for the UE capable of SUL but not configured with SUL, the applicable exceptions for side conditions are specified in Annex B, Section B.3.4.1 for UE supporting SUL in FR1;
- for the UE capable of SUL and configured with at least one SUL, the applicable exceptions for side conditions are specified in Annex B, Section B.3.4.2 for UE configured with SUL in FR1.

9.1.2 Measurement gap

If the UE requires measurement gaps to identify and measure intra-frequency cells and/or inter-frequency cells and/or inter-RAT E-UTRAN cells, and the UE does not support independent measurement gap patterns for different frequency ranges as specified in Table 5.1-1 in [18, 19, 20], in order for the requirements in the following subsections to apply the network must provide a single per-UE measurement gap pattern for concurrent monitoring of all frequency layers.

If the UE requires measurement gaps to identify and measure intra-frequency cells and/or inter-frequency cells and/or inter-RAT E-UTRAN cells, and the UE supports independent measurement gap patterns for different frequency ranges as specified in Table 5.1-1 in [18, 19, 20], in order for the requirements in the following subsections to apply the network must provide either per-FR measurement gap patterns for frequency range where UE requires per-FR measurement gap for concurrent monitoring of all frequency layers of each frequency range independently, or a single per-UE measurement gap pattern for concurrent monitoring of all frequency layers of all frequency ranges.

During the per-UE measurement gaps the UE:

- is not required to conduct reception/transmission from/to the corresponding E-UTRAN PCell, E-UTRAN SCell(s) and NR serving cells for E-UTRA-NR dual connectivity except the reception of signals used for RRM measurement
- is not required to conduct reception/transimssion from/to the corresponding NR serving cells for SA (with single carrier or CA configured) except the reception of signals used for RRM measurement
- is not required to conduct reception/transmission from/to the corresponding PCell, SCell(s) and E-UTRAN serving cells for NR-E-UTRA dual connectivity except the reception of signals used for RRM measurement
- is not required to conduct reception/transimssion from/to the corresponding NR serving cells for NR-DC except the reception of signals used for RRM measurement

During the per-FR measurement gaps the UE:

- is not required to conduct reception/transmission from/to the corresponding E-UTRAN PCell, E-UTRAN SCell(s) and NR serving cells in the corresponding frequency range for E-UTRA-NR dual connectivity except the reception of signals used for RRM measurement
- is not required to conduct reception/transmission from/to the corresponding NR serving cells in the corresponding frequency range for SA (with single carrier or CA configured) except the reception of signals used for RRM measurement
- is not required to conduct reception/transmission from/to the corresponding PCell, SCell(s) and E-UTRAN serving cells in the corresponding frequency range for NR-E-UTRA dual connectivity except the reception of signals used for RRM measurement
- is not required to conduct reception/transmission from/to the corresponding NR serving cells in the corresponding frequency range for NR-DC except the reception of signals used for RRM measurement

UEs shall support the measurement gap patterns listed in Table 9.1.2-1 based on the applicability specified in table 9.1.2-2 and 9.1.2-3. UE determines measurement gap timing based on gap offset configuration and measurement gap timing advance configuration provided by higher layer signalling as specified in [2] and [16].

Table 9.1.2-1: Gap Pattern Configurations

Gap Pattern Id	Measurement Gap Length (MGL, ms)	Measurement Gap Repetition Period (MGRP, ms)
0	6	40
1	6	80
2	3	40
3	3	80
4	6	20
5	6	160
6	4	20
7	4	40
8	4	80
9	4	160
10	3	20
11	3	160
12	5.5	20
13	5.5	40
14	5.5	80
15	5.5	160
16	3.5	20
17	3.5	40
18	3.5	80
19	3.5	160
20	1.5	20
21	1.5	40
22	1.5	80
23	1.5	160

Table 9.1.2-2: Applicability for Gap Pattern Configurations supported by the E-UTRA-NR dual connectivity UE or NR-E-UTRA dual connectivity UE

<table>
<tr><th>Measurement gap pattern configuration</th><th>Serving cell</th><th>Measurement Purpose</th><th>Applicable Gap Pattern Id</th></tr>
<tr><td rowspan="3">Per-UE measurement gap</td><td rowspan="3">E-UTRA + FR1, or E-UTRA + FR2, or E-UTRA + FR1 + FR2</td><td>non-NR RAT Note1,2</td><td>0,1,2,3</td></tr>
<tr><td>FR1 and/or FR2</td><td>0-11</td></tr>
<tr><td>non-NR RAT Note1,2 and FR1 and/or FR2</td><td>0, 1, 2, 3, 4, 6, 7, 8,10</td></tr>
<tr><td rowspan="14">Per FR measurement gap</td><td>E-UTRA and, FR1 if configured</td><td rowspan="2">non-NR RAT Note1,2</td><td>0,1,2,3</td></tr>
<tr><td>FR2 if configured</td><td>No gap</td></tr>
<tr><td>E-UTRA and, FR1 if configured</td><td rowspan="2">FR1 only</td><td>0-11</td></tr>
<tr><td>FR2 if configured</td><td>No gap</td></tr>
<tr><td>E-UTRA and, FR1 if configured</td><td rowspan="2">FR2 only</td><td>No gap</td></tr>
<tr><td>FR2 if configured</td><td>12-23</td></tr>
<tr><td>E-UTRA and, FR1 if configured</td><td rowspan="2">non-NR RAT Note1,2 and FR1</td><td>0, 1, 2, 3, 4, 6, 7, 8,10</td></tr>
<tr><td>FR2 if configured</td><td>No gap</td></tr>
<tr><td>E-UTRA and, FR1 if configured</td><td rowspan="2">FR1 and FR2</td><td>0-11</td></tr>
<tr><td>FR2 if configured</td><td>12-23</td></tr>
<tr><td>E-UTRA and, FR1 if configured</td><td rowspan="2">non-NR RAT Note1,2 and FR2</td><td>0, 1, 2, 3, 4, 6, 7, 8,10</td></tr>
<tr><td>FR2 if configured</td><td>12-23</td></tr>
<tr><td>E-UTRA and, FR1 if configured</td><td rowspan="2">non-NR RAT Note1,2 and FR1 and FR2</td><td>0, 1, 2, 3, 4, 6, 7, 8,10</td></tr>
<tr><td>FR2 if configured</td><td>12-23</td></tr>
</table>

Note: In E-UTRA-NR dual connectivity mode, *if GSM or UTRA TDD or UTRA FDD inter-RAT frequency layer is configured to be monitered, only measurement gap pattern #0 and #1 can be used for per-FR gap in E-UTRA and FR1 if configured, or for per-UE gap.*

NOTE 1: In E-UTRA-NR dual connectivity mode, non-NR RAT includes E-UTRA, UTRA and/or GSM. In NR-E-UTRA dual connectivity mode, non-NR RAT means E-UTRA.

NOTE 2: In E-UTRA-NR dual connectivity mode, the gap patterns with short MGL (gap pattern #2, 3, 6, 7, 8, 10) are supported by UEs which support shortMeasurementGap-r14. In NR-E-UTRA dual connectivity mode, the measurement gap pattern #2, 3, 6, 7, 8, 10 are supported by the UEs which indicate the capability signalling of supportedGapPattern to network.

NOTE 3: When E-UTRA inter-frequency RSTD measurements are configured and the UE requires measurement gaps for performing such measurements, only Gap Pattern #0 can be used.

In E-UTRA-NR dual connectivity mode,

- if per-UE measurement gap is configured with MG timing advance of T_{MG} ms, the measurement gap starts at time T_{MG} ms advanced to the end of the latest E-UTRA subframe occurring immediately before the configured measurement gap among MCG serving cells subframes.

- if per-FR measurenet gap for FR1 is configured with MG timing advance of T_{MG} ms, the measurement gap for FR1 starts at time T_{MG} ms advanced to the end of the latest E-UTRA subframe occurring immediately before the configured measurement gap among MCG serving cells subframes.

- if per-FR measurenet gap for FR2 is configured with MG timing advance of T_{MG} ms, the measurement gap for FR2 starts at time T_{MG} ms advanced to the end of the latest NR subframe occurring immediately before the configured measurement gap among SCG serving cells subframes in FR2.

In NR-E-UTRA dual connectivity mode,

- if per-UE measurement gap is configured with MG timing advance of T_{MG} ms, the measurement gap starts at time T_{MG} ms advanced to the end of the latest NR subframe occurring immediately before the configured measurement gap among MCG serving cells subframes.

- if per-FR measurement gap for FR1 is configured with MG timing advance of T_{MG} ms and UE has NR serving cell in FR1, the measurement gap for FR1 starts at time T_{MG} ms advanced to the end of the latest NR subframe occurring immediately before the configured measurement gap among MCG serving cells subframes in FR1.

- if per-FR measurement gap for FR1 is configured with MG timing advance of T_{MG} ms and UE doesn't have NR serving cell in FR1, the measurement gap for FR1 starts at time T_{MG} ms advanced to the end of the latest E-UTRA subframe occurring immediately before the configured measurement gap among SCG serving cells subframes.

- if per-FR measurenet gap for FR2 is configured with MG timing advance of T_{MG} ms, the measurement gap for FR2 starts at time T_{MG} ms advanced to the end of the latest NR subframe occurring immediately before the configured measurement gap among MCG serving cells subframes in FR2.

T_{MG} is the MG timing advance value provided in mgta according to [2].

In determining the measurement gap starting point, UE shall use the DL timing of the latest E-UTRA or NR subframe occurring immediately before the configured measurement gap among E-UTRA or NR serving cells.

In NR-NR dual connectivity mode,

- If per-UE measurement gap is configured with MG timing advance of T_{MG} ms, the measurement gap starts at time T_{MG} ms advanced to the end of the latest MCG subframe occurring immediately before the configured measurement gap among MCG serving cells subframes.

- If per-FR measurenet gap for FR1 is configured with MG timing advance of T_{MG} ms, the measurement gap for FR1 starts at time T_{MG} ms advanced to the end of the latest MCG subframe occurring immediately before the configured measurement gap among MCG serving cells subframes.

- If per-FR measurenet gap for FR2 is configured with MG timing advance of T_{MG} ms, the measurement gap for FR2 starts at time T_{MG} ms advanced to the end of the latest SCG subframe occurring immediately before the configured measurement gap among SCG serving cells subframes in FR2.

Editor's Note: NR-DC in Rel-15 only includes the scenarios where all serving cells in MCG in FR1 and all serving cells in SCG in FR2.

For per-FR measurement gap capable UE configured with E-UTRA-NR dual connectivity or NR-E-UTRA dual connectivity, when serving cells are in E-UTRA and FR1, measurement objects are in both E-UTRA /FR1 and FR2,

- If MN indicates UE that the measurement gap from MN applies to E-UTRA/FR1/FR2 serving cells, UE fulfils the per-UE measurement requirements for both E-UTRA/FR1 and FR2 measurement objects based on the measurement gap pattern configured by MN;
- If MN indicates UE that the measurement gap from MN applies to only LTE/FR1 serving cell(s),
  - UE fulfils the measurement requirements for FR1/LTE measurement objects based on the configured measurement gap pattern;
  - UE fulfils the requirements for FR2 measurement objects based on effective MGRP=20ms;

For per-FR measurement gap capable configured with E-UTRA-NR dual connectivity, NR-E-UTRA dual connectivity or NR-NR dual connectivity, when serving cells are in E-UTRA, FR1 and FR2, or in E-UTRA and FR2, or in FR1 and FR2, measurement objects are in both E-UTRA /FR1 and FR2,

- If MN indicates UE that the measurement gap from MN applies to E-UTRA/FR1/FR2 serving cells, UE fulfils the per-UE measurement requirements for both E-UTRA/FR1 and FR2 measurement objects based on the measurement gap pattern configured by MN.

Table 9.1.2-3: Applicability for Gap Pattern Configurations supported by the UE with NR standalone operation (with single carrier, NR CA and NR-DC configuration)

Measurement gap pattern configuration	Serving cell	Measurement Purpose NOTE 2	Applicable Gap Pattern Id
Per-UE measurement gap	FR1 NOTE5, or FR1 + FR2	E-UTRA only NOTE3	0,1,2,3
		FR1 and/or FR2	0-11
		E-UTRAN and FR1 and/or FR2 NOTE3	0, 1, 2, 3, 4, 6, 7, 8,10
	FR2 NOTE5	E-UTRA only NOTE3	0,1,2,3
		FR1 only	0-11
		FR1 and FR2	0-11
		E-UTRAN and FR1 and/or FR2 NOTE3	0, 1, 2, 3, 4, 6, 7, 8,10
		FR2 only	12-23
Per FR measurement gap	FR1 if configured	E-UTRA only NOTE3	0,1,2,3
	FR2 if configured		No gap
	FR1 if configured	FR1 only	0-11
	FR2 if configured		No gap
	FR1 if configured	FR2 only	No gap
	FR2 if configured		12-23
	FR1 if configured	E-UTRA and FR1 NOTE3	0, 1, 2, 3, 4, 6, 7, 8,10
	FR2 if configured		No gap
	FR1 if configured	FR1 and FR2	0-11
	FR2 if configured		12-23
	FR1 if configured	E-UTRA and FR2 NOTE3	0, 1, 2, 3, 4, 6, 7, 8,10
	FR2 if configured		12-23
	FR1 if configured	E-UTRA and FR1 and FR2 NOTE3	0, 1, 2, 3, 4, 6, 7, 8,10
	FR2 if configured		12-23

NOTE 1:	When E-UTRA inter-RAT RSTD measurements are configured and the UE requires measurement gaps for performing such measurements, only Gap Pattern #0 can be used.
NOTE 2:	Measurement purpose which includes E-UTRA measurements includes also inter-RAT E-UTRA RSRP and RSRQ measurements for E-CID
NOTE 3:	The measurement gap pattern #2, 3, 6, 7, 8, 10 are supported by the UEs which indicate the capability signalling of supportedGapPattern to network.
NOTE4:	If per-UE measurement gap is configured with MG timing advance of T_{MG} ms, the measurement gap starts at time T_{MG} ms advanced to the end of the latest subframe occurring immediately before the configured measurement gap among all serving cells subframes. If per-FR measurenet gap for FR1 is configured with MG timing advance of T_{MG} ms, the measurement gap for FR1 starts at time T_{MG} ms advanced to the end of the latest subframe occurring immediately before the configured measurement gap among serving cells subframes in FR1. If per-FR measurenet gap for FR2 is configured with MG timing advance of T_{MG} ms, the measurement gap for FR2 starts at time T_{MG} ms advanced to the end of the latest subframe occurring immediately before the configured measurement gap among serving cells subframes in FR2. T_{MG} is the MG timing advance value provided in *mgta* according to [2]. In determining the measurement gap starting point, UE shall use the DL timing of the latest subframe occurring immediately before the configured measurement gap among serving cells.
NOTE 5:	NR-DC in Rel-15 only includes the scenarios where all serving cells in MCG in FR1 and all serving cells in SCG in FR2.

For per-FR measurement gap capable UE in NR standalone operation (with single carrier, NR CA and NR-DC configuration), for per-FR gap based measurement,when there is no serving cell in a particular FR, where measurements objects are configured, regardless if explicit per-FR measurement gap is configured in this FR, the effective MGRP in this FR used to determine requirements;

- 20ms for FR2 NR measurements
- 40ms for FR1 NR measurements
- 40ms for LTE measurements
- 40ms for FR1+LTE measurements

For per-FR measurement gap capable UE in NR standalone operation (with single carrier, NR CA and NR-DC configuration), when serving cells are in FR1 or FR2, measurement objects are in both E-UTRA /FR1 and FR2,

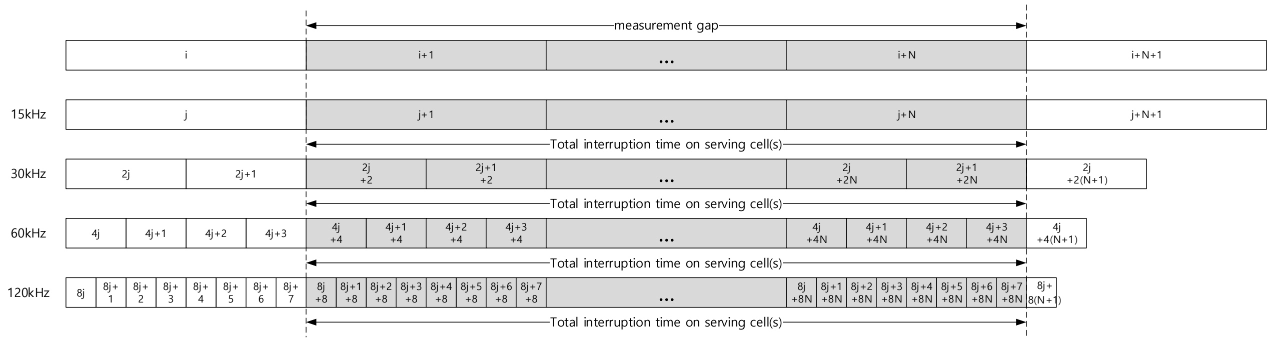
- If MN indicates UE that the measurement gap from MN applies to E-UTRA/FR1/FR2 serving cells, UE fulfils the per-UE measurement requirements for both E-UTRA/FR1 and FR2 measurement objects based on the measurement gap pattern configured by MN;

If measurement gap is configured in one FR but measurement object is not configured in the FR, the scheduling opportunity in the FR depends on the configured measurement gap pattern.

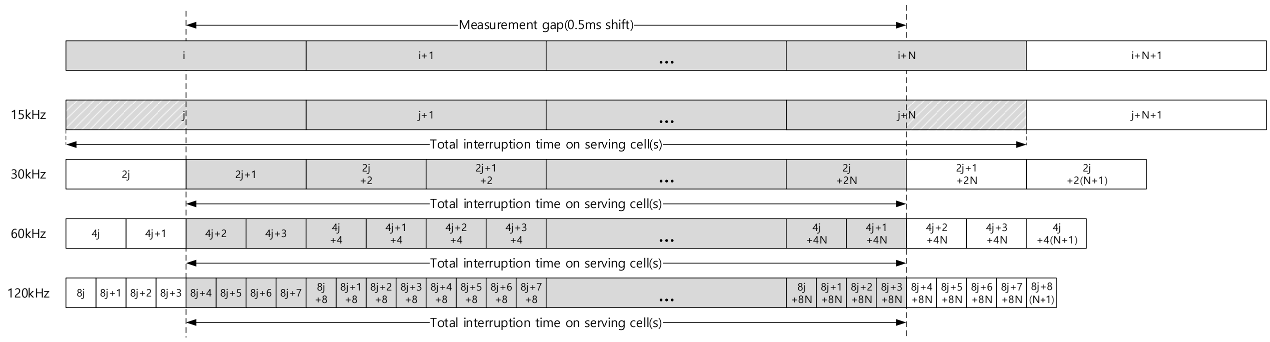
For E-UTRA-NR dual connectivity, if UE is not capable of per-FR-gap, total interruption time on SCG during MGL is defined only when MGL(N) = 6ms, 4ms and 3ms. And if UE is capable of per-FR-gap, total interruption time on FR1 serving cells in SCG during MGL is defined only when MGL(N) = 6ms, 4ms and 3ms, and total interruption time on FR2 serving cells in SCG during MGL is defined only when MGL(N) = 5.5ms, 3.5ms and 1.5ms, given that the reference time for per-FR gap in FR2 is based on an FR2 serving cell.

For NR standalone operation (with single carrier, NR CA and NR-DC configuration), if UE is not capable of per-FR-gap, total interruption time on a serving cell during MGL is defined when MGL(N) = 6ms, 5.5ms, 4ms, 3.5ms, 3ms, and 1.5ms. And if UE is capable of per-FR-gap, total interruption time on FR1 serving cells during MGL is defined only when MGL(N) = 6ms, 4ms and 3ms, and total interruption time on FR2 serving cells during MGL is defined only when MGL(N) = 5.5ms, 3.5ms and 1.5ms, given that the reference time for per-FR gap in FR2 is based on an FR2 serving cell.

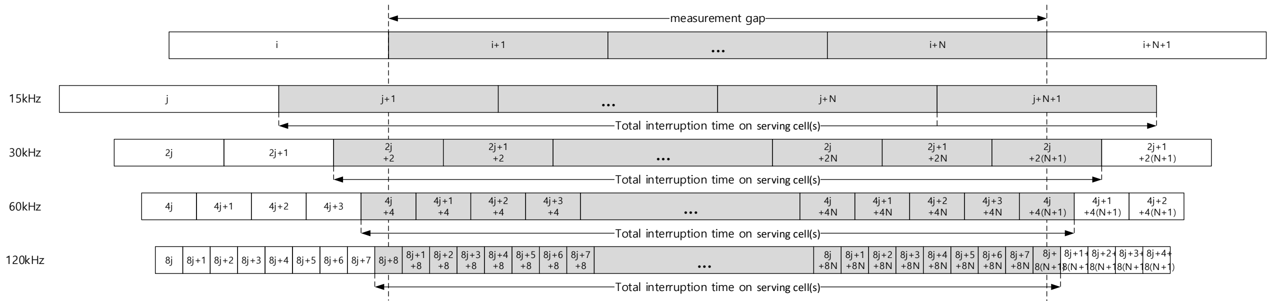
For NR-E-UTRA dual connectivity, if UE is not capable of per-FR-gap, total interruption time on MCG during MGL is defined only when MGL(N) = 6ms, 4ms and 3ms. And if UE is capable of per-FR-gap, total interruption time on FR1 serving cells in MCG during MGL is defined only when MGL(N) = 6ms, 4ms and 3ms, and total interruption time on FR2 serving cells in MCG during MGL is defined only when MGL(N) = 5.5ms, 3.5ms and 1.5ms, given that the reference time for per-FR gap in FR2 is based on an FR2 serving cell.



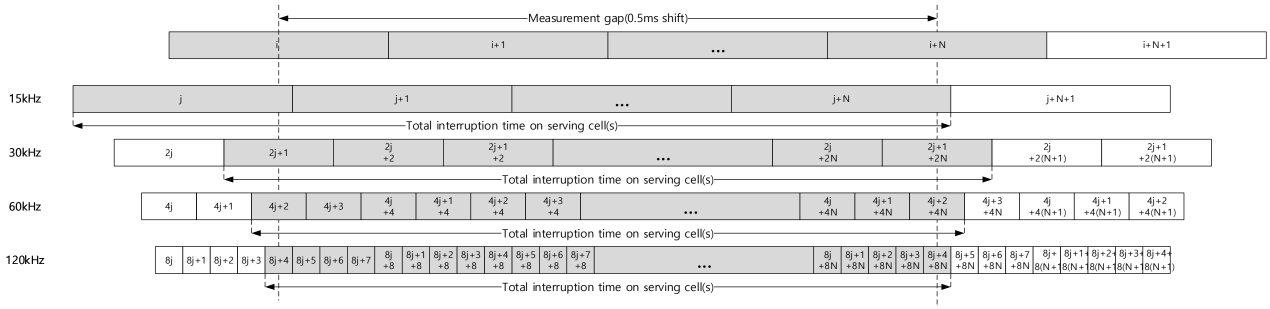
(a) Measurement gap with MGL = N(ms) with MG timing advance of 0ms for synchronous EN-DC, NR standalone operation (with single carrier, NR CA and NR-DC configuration) and synchronous NE-DC



(b) Measurement gap with MGL = N(ms) with MG timing advance of 0.5ms for synchronous EN-DC, NR standalone operation (with single carrier, NR CA and NR-DC configuration) and synchronous NE-DC



(c) Measurement gap with MGL = N(ms) with MG timing advance of 0ms for asynchronous EN-DC and asynchronous NE-DC



(d) Measurement gap with MGL = N(ms) with MG timing advance of 0.5ms for asynchronous EN-DC and asynchronous NE-DC

Figure 9.1.2-1: Measurement GAP and total interruption time on serving cells for EN-DC, NR standalone operation (with single carrier, NR CA and NR-DC configuration) and NE-DC

The corresponding total number of interrupted slots on serving cells is listed in Table9.1.2-4 and Table9.1.2-4a for synchronous EN-DC, NR standalone and synchronous NE-DC, and asynchronous EN-DC and asynchronous NE-DC respectively.

Table 9.1.2-4: Total number of interrupted slots on serving cells during MGL for Synchronous EN-DC ,NR standalone operation (with single carrier, NR CA and NR-DC configuration) and Synchronous NE-DC with per-UE measurement gap or per-FR measurement gap for FR1

NR SCS (kHz)	Total number of interrupted slots on serving cells					
	When MG timing advance of 0ms is applied			When MG timing advance of 0.5ms is applied		
	MGL=6ms	MGL=4ms	MGL=3ms	MGL=6ms	MGL=4ms	MGL=3ms
15	6	4	3	7[Note3]	5[Note3]	4[Note3]
30	12	8	6	12	8	6
60	24	16	12	24	16	12
120	48	32	24	48	32	24
NOTE 1: For Gap Pattern ID 0, 1, 2 and 3, total number of interrupted subframes on MCG is MGL subframes when MG timing advance of 0ms is applied, and (MGL+1) subframes when MG timing advance of 0.5ms is applied. NOTE 2: NR SCS of 120 kHz is only applicable to the case with per-UE measurement gap. NOTE 3: Non-overlapped half-slots occur before and after the measurement gap. Whether a Rel-15 UE can receive and/or transmit in those half-slots is up to UE implementation.						

Table 9.1.2-4a: Total number of interrupted slots on serving cells during MGL for Asynchronous EN-DC and Asynchronous NE-DC with per-UE measurement gap or per-FR measurement gap for FR1

NR SCS (kHz)	Total number of interrupted slots on serving cells					
	When MG timing advance of 0ms is applied			When MG timing advance of 0.5ms is applied		
	MGL=6ms	MGL=4ms	MGL=3ms	MGL=6ms	MGL=4ms	MGL=3ms
15	7	5	4	7	5	4
30	13	9	7	13	9	7
60	25	17	13	25	17	13
120	49	33	25	49	33	25
NOTE 1: For Gap Pattern ID 0, 1, 2 and 3, total number of interrupted subframes on MCG is MGL subframes when MG timing advance of 0ms is applied, and (MGL+1) subframes when MG timing advance of 0.5ms is applied. NOTE 2: NR SCS of 120 kHz is only applicable to the case with per-UE measurement gap.						

In case that UE capable of per-FR measurement gap is configured with per-FR measurement gap for FR2 serving cells, total number of interrupted slots on FR2 serving cells during MGL is listed in Table9.1.2-4b.

Table 9.1.2-4b: Total number of interrupted slots on FR2 serving cells during MGL for EN-DC, NR standalone operation (with single carrier, NR CA and NR-DC configuration) and NE-DC with per-UE measurement gap or per-FR measurement gap for FR2

NR SCS (kHz)	Total number of interrupted slots on FR2 serving cells					
	When MG timing advance of 0ms is applied			When MG timing advance of 0.25ms is applied		
	MGL=5.5ms	MGL=3.5ms	MGL=1.5ms	MGL=5.5ms	MGL=3.5ms	MGL=1.5ms
60	22	14	6	22	14	6
120	44	28	12	44	28	12

When MGTA is not applied, in the slot with respect to the SCS of each UL carrier occurring immediately after measurement gap and fully non-overlapped with measurement gap, or

When MGTA is applied, in the slot with respect to the SCS of each UL carrier occurring immediately after the slot partially overlapped with measurement gap,

- It is up to UE implementation whether or not the UE is able to conduct transmission if all the symbols in the slot are uplink symbols.

Editor notes: FFS if very large TA is applied.

Table 9.1.2-5: (Void)

9.1.2.1 NSA: Measurement Gap Sharing

For E-UTRA-NR dual connectivity UE configured with per-UE measurement gap, measurement gap sharing shall be applies when UE requires measurement gaps to identify and measure cells on intra-frequency carriers or when SMTC configured for intra-frequency measurement are fully overlapping with per-UE measurement gaps, and when UE is configured to identify and measure cells on inter-frequency carriers, E-UTRA gap-needed inter-frequency carriers and inter-RAT UTRAN carriers and/or inter-RAT GSM carriers.

For E-UTRA-NR dual connectivity UE configured with per-FR1 measurement gap, measurement gap sharing shall be applied when UE requires measurement gaps to identify and measure cells on FR1 intra-frequency carriers or when SMTC configured for FR1 intra-frequency measurement are fully overlapping with per-FR1 measurement gaps, and when UE is configured to identify and measure cells on FR1 inter-frequency carriers, E-UTRA gap-needed inter-frequency carriers, inter-RAT UTRAN carriers and/or inter-RAT GSM carriers.

For E-UTRA-NR dual connectivity UE configured with per-FR2 measurement gap, measurement gap sharing shall be applied when UE requires measurement gaps to identify and measure cells on FR2 intra-frequency carriers or when SMTC configured for FR2 intra-frequency measurement are fully overlapping with per-FR2 measurement gaps, and when UE is configured to identify and measure cells on FR2 inter-frequency carriers.

When network signals “01”, “10” or “11” with RRC parameter *MeasGapSharingScheme* [2][16]and the value of X is defined as in Table 9.1.2.1-1, and

- K_{intra} = 1 / X * 100,
- K_{inter} = 1 / (100 – X) * 100,

When network signals “00” indicating equal splitting gap sharing, X is not applied.

The RRC parameter *MeasGapSharingScheme* shall be applied to the calculation of carrier specific scaling factor as specified in clause 9.1.5.2.1.

Table 9.1.2.1-1: Value of parameter X for EN-DC measurement gap sharing

measGapSharingScheme	**Value of X (%)**
‘00’	Equal splitting
‘01’	25
‘10’	50
‘11’	75

9.1.2.1a SA: Measurement Gap Sharing

For NR standalone UE without NR-DC operation and configured with per-UE measurement gap, measurement gap sharing shall be applies when UE requires measurement gaps to identify and measure cells on intra-frequency carriers or when SMTC configured for intra-frequency measurement are fully overlapping with per-UE measurement gaps, and when UE is configured to identify and measure cells on inter-frequency carriers, and/or inter-RAT E-UTRAN carriers.

For NR standalone UE without NR-DC operation and configured with per-FR1 measurement gap, measurement gap sharing shall be applied when UE requires measurement gaps to identify and measure cells on FR1 intra-frequency carriers or when SMTC configured for FR1 intra-frequency measurement are fully overlapping with per-FR1 measurement gaps, and when UE is configured to identify and measure cells on FR1 inter-frequency carriers and/or inter-RAT E-UTRAN carriers.

For NR standalone UE without NR-DC operation and configured with per-FR2 measurement gap, measurement gap sharing shall be applied when UE requires measurement gaps to identify and measure cells on FR2 intra-frequency carriers or when SMTC configured for FR2 intra-frequency measurement are fully overlapping with per-FR2 measurement gaps, and when UE is configured to identify and measure cells on FR2 inter-frequency carriers.

When network signals “01”, “10” or “11” with RRC parameter *MeasGapSharingScheme* [2] and the value of X is defined as in Table 9.1.2.1a-1, and

- $K_{intra} = 1 / X * 100$,
- $K_{inter} = 1 / (100 – X) * 100$,

When network signals “00” indicating equal splitting gap sharing, X is not applied.

The RRC parameter *MeasGapSharingScheme* shall be applied to the calculation of carrier specific scaling factor as specified in clause 9.1.5.2.2.

Table 9.1.2.1a-1: Value of parameter X for NR standalone measurement gap sharing

measGapSharingScheme	**Value of X (%)**
‘00’	Equal splitting
‘01’	25
‘10’	50
‘11’	75

9.1.2.1b NE-DC: Measurement Gap Sharing

Editor notes: the measurement gap mechanism for NE-DC is FFS.

9.1.2.1c NR-DC: Measurement Gap Sharing

Editor notes: the measurement gap mechanism for NR-DC is FFS.

9.1.3 UE Measurement capability

9.1.3.1 NSA: Monitoring of multiple layers using gaps

The requirements in this section are applicable for UE capable of and configured with the EN-DC operation mode.

When monitoring of multiple inter-frequency E-UTRAN, inter-RAT NR, GSM, UTRA FDD and UTRA TDD carriers as configured by E-UTRA PCell, and inter-frequency NR carriers as configured by PSCell using gaps (or without using gaps provided the UE supports such capability) is configured, the UE shall be capable of performing one measurement of the configured measurement type (SS-RSRP, SS-RSRQ, SS-SINR, SFTD, E-UTRAN RSRP, E-UTRAN RSRQ, E-UTRAN RS-SINR measurements, UTRAN TDD P-CCPCH RSCP, UTRAN FDD CPICH measurements, GSM carrier RSSI, etc.) of detected cells on all the layers.

For UE configured with the EN-DC operation, the effective total number of frequencies excluding the frequencies of the PSCell, SCells, E-UTRA PCell, and E-UTRA SCells being monitored is $N_{freq,\ EN\text{-}DC}$, which is defined as:

$$N_{freq,\ EN\text{-}DC} = N_{freq,\ EN\text{-}DC,\ NR} + N_{freq,\ EN\text{-}DC,\ E\text{-}UTRA} + N_{freq,\ EN\text{-}DC,\ UTRA} + M_{EN\text{-}DC,\ GSM},$$

where

$N_{freq,\ EN\text{-}DC,\ E\text{-}UTRA}$ is the number of E-UTRA inter-frequency carriers being monitored (FDD and TDD) as configured by E-UTRA PCell or via LPP [22],

$$N_{freq,\ EN\text{-}DC,\ NR} \le N_{freq,\ EN\text{-}DC,\ NR,\ inter\text{-}RAT} + N_{freq,\ EN\text{-}DC,\ NR,\ inter\text{-}freq}$$

where

$N_{freq,\ EN\text{-}DC,\ NR,\ inter\text{-}RAT}$ is the number of NR inter-RAT carriers excluding NR serving carrier(s) being monitored as configured by E-UTRA PCell [15],

$N_{freq,\ EN\text{-}DC,\ NR,\ inter\text{-}freq}$ is the number of NR inter-frequency carriers being monitored as configured by PSCell,

$N_{freq,\ EN\text{-}DC,\ UTRA}$ is the number of UTRA inter-RAT carriers being monitored as configured by E-UTRA PCell (FDD and TDD).

$M_{EN\text{-}DC,\ GSM}$ is an integer which is a function of the number of GSM inter-RAT carriers as configured by E-UTRA PCell on which measurements are being performed. $M_{EN\text{-}DC,\ GSM}$ is equal to 0 if no GSM carrier is being monitored. For a MGRP of 40 ms, $M_{EN\text{-}DC,\ GSM}$ is equal to 1 if cells on up to 32 GSM carriers are being measured. For a MGRP of 80 ms, $M_{EN\text{-}DC,\ GSM}$ is equal to ceil($N_{carriers,GSM}$ /20) where $N_{carriers,GSM}$ is the number of GSM carriers on which cells are being measured.

9.1.3.1a SA: Monitoring of multiple layers using gaps

The requirements in this section are applicable for UE configured with SA NR operation mode.

When monitoring of multiple inter-RAT E-UTRAN carriers and inter-frequency NR carriers using gaps (or without using gaps provided the UE supports such capability) is configured by PCell, the UE shall be capable of performing one measurement of the configured measurement type (SS-RSRP, SS-RSRQ, SS-SINR, E-UTRAN RSRP, E-UTRAN RSRQ, E-UTRAN RS-SINR measurements, etc.) of detected cells on all the layers.

For UE configured with the NR SA operation, the effective total number of frequencies, excluding the frequencies of the PCell, PSCell and SCells being monitored, is $N_{freq,\ SA}$, which is defined as:

$N_{freq,\ SA} = N_{freq,\ SA,\ NR} + N_{freq,\ SA,\ E\text{-}UTRA}$,

where

$N_{freq,\ SA,\ E\text{-}UTRA}$ is the number of E-UTRA inter-RAT carriers being monitored (FDD and TDD) as configured by PCell or via LPP [22],

$N_{freq,\ SA,\ NR}$ is the number of NR inter-frequency carriers being monitored as configured by PCell.

9.1.3.1b NE-DC: Monitoring of multiple layers using gaps

The requirements in this section are applicable for UE capable of and configured with the NE-DC operation mode.

When monitoring of multiple inter-frequency E-UTRAN carriers as configured by E-UTRA PSCell, inter-RAT E-UTRAN carriers as configured by PCell, and inter-frequency NR carriers as configured by PCell using gaps (or without using gaps provided the UE supports such capability) is configured, the UE shall be capable of performing one measurement of the configured measurement type (SS-RSRP, SS-RSRQ, SS-SINR, SFTD, E-UTRAN RSRP, E-UTRAN RSRQ, and E-UTRAN RS-SINR measurements, etc.) of detected cells on all the layers.

For UE configured with the NE-DC operation, the effective total number of frequencies excluding the frequencies of the PCell, SCells, E-UTRA PSCell, and E-UTRA SCells being monitored is $N_{freq,\ NE\text{-}DC}$, which is defined as:

$N_{freq,\ NE\text{-}DC} = N_{freq,\ NE\text{-}DC,\ NR} + N_{freq,\ NE\text{-}DC,\ E\text{-}UTRA}$,

where

$N_{freq,\ NE\text{-}DC,\ NR}$ is the number of NR inter-frequency carriers being monitored as configured by PCell,

$N_{freq,\ NE\text{-}DC,\ E\text{-}UTRA} \leq N_{freq,\ NE\text{-}DC,\ E\text{-}UTRA,\ inter\text{-}RAT} + N_{freq,\ NE\text{-}DC,\ E\text{-}UTRA,\ inter\text{-}freq}$

where

$N_{freq,\ NE\text{-}DC,\ E\text{-}UTRA,\ inter\text{-}RAT}$ is the number of E-UTRA inter-RAT carriers (FDD and TDD) excluding E-UTRA serving carrier(s) being monitored as configured by E-UTRA PSCell [15] or via LPP [22],

$N_{freq,\ NE\text{-}DC,\ E\text{-}UTRA,\ inter\text{-}freq}$ is the number of E-UTRA inter-frequency carriers (FDD and TDD) being monitored as configured by PCell or via LPP [22].

9.1.3.1c NR-DC: Monitoring of multiple layers using gaps

The requirements in this section are applicable for UE configured with NR-DC operation mode.

When monitoring of multiple inter-RAT E-UTRAN carriers and inter-frequency NR carriers using gaps (or without using gaps provided the UE supports such capability) is configured by PCell, the UE shall be capable of performing one measurement of the configured measurement type (SS-RSRP, SS-RSRQ, SS-SINR, E-UTRAN RSRP, E-UTRAN RSRQ, E-UTRAN RS-SINR measurements, etc.) of detected cells on all the layers.

For UE configured with the NR-DC operation, the effective total number of frequencies, excluding the frequencies of the PCell, PSCell and SCells being monitored, is $N_{freq,\ NR\text{-}DC}$, which is defined as:

$N_{freq,\ NR\text{-}DC} = N_{freq,\ NR\text{-}DC,\ NR} + N_{freq,\ NR\text{-}DC,\ E\text{-}UTRA}$,

where

$N_{freq,\ NR\text{-}DC,\ E\text{-}UTRA}$ is the number of E-UTRA inter-RAT carriers being monitored (FDD and TDD) as configured by PCell or via LPP [22].

$N_{freq,\ NR\text{-}DC,\ NR}$ is the number of NR inter-frequency carriers being monitored as configured by PCell and PSCell.

9.1.3.2 NSA: Maximum allowed layers for multiple monitoring

If a UE is configured with EN-DC operation, the UE shall be capable of monitoring at least:

- Depending on UE capability, 7 NR inter-frequency carriers configured by PScell, and
- Depending on UE capability, 7 NR inter-RAT carriers excluding NR serving carrier(s) configured by E-UTRA PCell [15], and
- Depending on UE capability, 6 E-UTRA TDD inter-frequency carriers configured by E-UTRA PCell [15], and
- Depending on UE capability, 6 E-UTRA FDD inter-frequency carriers configured by E-UTRA PCell [15], and
- Depending on UE capability, 3 FDD UTRA carriers, and
- Depending on UE capability, 3 TDD UTRA carriers, and
- Depending on UE capability, 32 GSM carriers (one GSM layer corresponds to 32 carriers), and
- Depending on UE capability, 1 E-UTRA FDD inter-frequency carrier for RSTD measurements configured via LPP [22], and
- Depending on UE capability, 1 E-UTRA TDD inter-frequency carrier for RSTD measurements configured via LPP [22].

In addition to the requirements defined above, the UE shall be capable of monitoring a total of at least 13 effective carrier frequency layers comprising of any above defined combination of NR, E-UTRA FDD, E-UTRA TDD, UTRA FDD, UTRA TDD and GSM (one GSM layer corresponds to 32 carriers) layers. The UE shall be capable of monitoring a total of at least 7 effective NR carrier frequency layers excluding NR serving carrier(s), comprising of any above defined combination of NR inter-RAT carriers excluding NR serving carrier(s) configured by E-UTRA PCell and NR inter-frequency carriers configured by PSCell.

When the E-UTRA PCell and PSCell configure the same NR carrier frequency layer to be monitored by the UE in synchronous intra-band EN-DC, this layer shall be counted only once to the total number of effective carrier frequency layers provided that the SFN-s and slot boundries are aligned, unless the configured NR carrier frequency layers to be monitored have

- different RSSI measurement resources or
- different deriveSSB-IndexFromCell indications or
- different SMTC configurations.

Note 1: The E-UTRA-NR dual connectivity capable UE configured with PSCell shall fulfil the requirements defined in only one of Section 9.1.3.2 and Section 8.1.2.1.1b.1 of [15].

Editor's note: FFS when the E-UTRA PCell and PSCell configure the same NR carrier frequency layer to be monitored, whether this layer shall be counted only once under the condition that the UE is configured with differences in SMTC configurations or different useServingCellTimingForSync indications.

9.1.3.2a SA: Maximum allowed layers for multiple monitoring

If a UE is configured with SA NR operation mode, the UE shall be capable of monitoring at least:

- Depending on UE capability, 7 NR inter-frequency carriers configured by PCell, and
- Depending on UE capability, 7 E-UTRA TDD inter-RAT carriers configured by PCell, and
- Depending on UE capability, 7 E-UTRA FDD inter-RAT carriers configured by PCell, and
- Depending on UE capability, 1 E-UTRA FDD inter-RAT carrier for RSTD measurements configured via LPP [22], and
- Depending on UE capability, 1 E-UTRA TDD inter-RAT carrier for RSTD measurements configured via LPP [22].

In addition to the requirements defined above, the UE shall be capable of monitoring a total of at least [13] effective carrier frequency layers comprising of any above defined combination of NR, E-UTRA FDD and E-UTRA TDD layers.

9.1.3.2b NE-DC: Maximum allowed layers for multiple monitoring

If a UE is configured with NE-DC operation mode, the UE shall be capable of monitoring at least:

- Depending on UE capability, 7 NR inter-frequency carriers configured by PCell, and
- Depending on UE capability, 6 E-UTRA TDD inter-frequency carriers configured by E-UTRA PSCell [15], and
- Depending on UE capability, 6 E-UTRA FDD inter-frequency carriers configured by E-UTRA PSCell [15], and
- Depending on UE capability, 1 E-UTRA FDD inter-frequency carrier for RSTD measurements configured via LPP [22], and
- Depending on UE capability, 1 E-UTRA TDD inter-frequency carrier for RSTD measurements configured via LPP [22].

In addition to the requirements defined above, the UE shall be capable of monitoring a total of at least 13 effective carrier frequency layers comprising of any above defined combination of NR, E-UTRA FDD, and E-UTRA TDD layers. The UE shall be capable of monitoring a total of at least 6 effective E-UTRA carrier frequency layers, excluding E-UTRA serving carrier(s), comprising of any above defined combination of E-UTRA inter-RAT carriers excluding E-UTRA serving carrier(s) configured by PCell and E-UTRA inter-frequency carriers configured by E-UTRA PSCell.

Editor's note: FFS when the PCell and E-UTRA PSCell configure the same E-UTRA carrier frequency layer to be monitored.

9.1.3.2c NR-DC: Maximum allowed layers for multiple monitoring

If a UE is configured with PCell and PSCell, the UE shall be capable of monitoring at least:

- Depending on UE capability, 7 NR inter-frequency carriers configured by PCell, and
- Depending on UE capability, 7 NR inter-frequency carriers configured by PSCell, and
- Depending on UE capability, 7 E-UTRA TDD inter-RAT carriers configured by PCell, and
- Depending on UE capability, 7 E-UTRA FDD inter-RAT carriers configured by PCell, and
- Depending on UE capability, 1 E-UTRA FDD inter-RAT carrier for RSTD measurements configured via LPP [22], and
- Depending on UE capability, 1 E-UTRA TDD inter-RAT carrier for RSTD measurements configured via LPP [22].

In addition to the requirements defined above, the UE shall be capable of monitoring a total of at least [TBD] effective carrier frequency layers comprising of any above defined combination of NR, E-UTRA FDD and E-UTRA TDD layers.

Editor's note: FFS when the PCell and PSCell configure the same carrier frequency layer to be monitored.

9.1.4 Capabilities for Support of Event Triggering and Reporting Criteria

9.1.4.1 Introduction

This clause contains requirements on UE capabilities for support of event triggering and reporting criteria. As long as the measurement configuration does not exceed the requirements stated in Section 9.1.4.2, the UE shall meet all other performance requirements defined in Section 9 and Section 10.

The UE can be requested to make measurements under different measurement identities defined in TS 38.331 [2]. Each measurement identity corresponds to either event based reporting, periodic reporting, or no reporting. In case of event based reporting, each measurement identity is associated with an event triggering criterion. In case of periodic reporting, a measurement identity is associated with one periodic reporting criterion. In case of no reporting, a measurement identity is associated with one no reporting criterion.

The purpose of this clause is to set some limits on the number of different event triggering, periodic, and no reporting criteria the UE may be requested to track in parallel.

9.1.4.2 Requirements

In this section a reporting criterion corresponds to either one event (in the case of event based reporting), or one periodic reporting criterion (in case of periodic reporting), or one no reporting criterion (in case of no reporting). For event based reporting, each instance of event, with the same or different event identities, is counted as separate reporting criterion in Table 9.1.4.2-1.

The UE shall be able to support in parallel per category up to E_{cat} reporting criteria according to Table 9.1.4.2-1. For the measurement categories belonging to intra-frequency, inter-frequency, and inter-RAT measurements (i.e. without counting other categories that the UE shall always support in parallel), the UE need not support more than the total number of reporting criteria as follows:

- For UE configured with EN-DC: $E_{cat,NSA,NR} + E_{cat,NSA,E-UTRA}$, where

  $E_{cat,NSA,NR} = 10 + 9 \times n$ is the total number of NR reporting criteria applicable for UE configured with EN-DC according to Table 9.1.4.2-1, and n is the number of configured NR serving frequencies, including PSCell and SCells carrier frequencies,

  $E_{cat,NSA,E-UTRA}$ is the total number of reporting criteria for E-UTRA PCell as specified in TS 36.133 [15] for UE configured with EN-DC,

- For UE configured with NE-DC: $E_{cat,NE-DC,NR} + E_{cat,NE-DC,E-UTRA}$, where

  $E_{cat,NE-DC,NR} = 10 + 9 \times n$ is the total number of NR reporting criteria according to Table 9.1.4.2-1, and n is the number of configured NR serving frequencies, including PCell and SCells carrier frequencies,

  $E_{cat,NE-DC,E-UTRA} = E_{cat,NE-DC,E-UTRA,inter-RAT} + E_{cat,NE-DC,E-UTRA,inter-freq}$,

  $E_{cat,NE-DC,E-UTRA,inter-RAT}$ is the total number of E-UTRA inter-RAT reporting criteria for PCell according to Table 9.1.4.2-1,

  $E_{cat,NE-DC,E-UTRA,inter-freq}$ is the total number of reporting criteria for E-UTRA PSCell as specified in TS 36.133 [15] for UE configured with NE-DC,

- For UE not configured of EN-DC or NE-DC: $E_{cat,SA,NR} + E_{cat,SA,E-UTRA}$, where

  $E_{cat,SA,NR} = 10 + 9 \times n$ is the total number of NR reporting criteria according to Table 9.1.4.2-1, and n is the number of configured NR serving frequencies, including PCell, PSCell and SCells carrier frequencies,

  $E_{cat,SA,E-UTRA}$ is the total number of E-UTRA inter-RAT reporting criteria according to Table 9.1.4.2-1.

Table 9.1.4.2-1: Requirements for reporting criteria per measurement category

Measurement category	E_{cat}	Note
Intra-frequency Note 1	9	Events for any one or a combination of intra-frequency SS-RSRP, SS-RSRQ, and SS-SINR for NG-RAN intra-frequency cells
Inter-frequency	10	Events for any one or a combination of inter-frequency SS-RSRP, SS-RSRQ, and SS-SINR for NG-RAN inter-frequency cells
Inter-RAT (E-UTRA FDD, E-UTRA TDD)	10	Only applicable for UE with this (inter-RAT) capability when the UE is not configured with EN-DC operation.
Inter-RAT (E-UTRA FDD, E-UTRA TDD) RSTD	1	Inter-RAT RSTD measurement reporting for UE supporting OTDOA; 1 report capable of minimum 16 inter-RAT cell measurements. Only applicable for UE with this (inter-RAT RSTD via LPP [22]) capability and when the UE is not configured with EN-DC or NE-DC operation.
Inter-RAT (E-UTRA FDD, E-UTRA TDD) RSRP and RSRQ measurements for E-CID	1	Inter-RAT RSRP and RSRQ measurements for E-CID reported to E-SMLC via LPP [22]. One report capable of at least in total 10 inter-RAT RSRP and RSRQ measurements. Applicable to UE capable of reporting inter-RAT RSRP and RSRQ to E-SMLC via LPP and when the UE is not configured with EN-DC operation.
NOTE 1: When the UE is configured with PSCell and SCell carrier frequencies, E_{cat} for Intra-frequency is applied per serving frequency.		

9.1.5 Carrier-specific scaling factor

This clause specifies the derivation of carrier-specific scaling factor (CSSF) values, which scale the measurement delay requirements given in Section 9.2, 9.3 and 9.4 when UE is configured to monitor multiple measurement objects. The CSSF values are categorized into $CSSF_{outside\_gap,i}$ and $CSSF_{within\_gap,i}$, for the measurements conducted outside measurement gaps and within measurement gaps, respectively.

9.1.5.1 Monitoring of multiple layers outside gaps

The carrier-specific scaling factor $CSSF_{outside\_gap,i}$ for measurement object *i* derived in this chapter is applied to following measurement types:

- Intra-frequency measurement with no measurement gap in Section 9.2.5, when none of the SMTC occasions of this intra-frequency measurement object are overlapped by the measurement gap.

- Intra-frequency measurement with no measurement gap in Section 9.2.5, when part of the SMTC occasions of this intra-frequency measurement object are overlapped by the measurement gap.

UE is expected to conduct the measurement of this measurement object *i* only outside the measurement gaps.

If the higher layer signaling in TS 38.331 [2] signaling of *smtc2* is present and smtc1 is fully overlapping with measurement gaps and smtc2 is partially overlapping with measurement gaps, $CSSF_{outside\_gap\_i}$ and requirements derivied from $CSSF_{outside\_gap\_i}$ are not specified.

9.1.5.1.1 NSA mode: carrier-specific scaling factor for SSB-based measurements performed outside gaps

For UE configured with the E-UTRA-NR dual connectivity operation, the carrier-specific scaling factor $CSSF_{outside\_gap,i}$ for intra-frequency SSB-based measurements performed outside measurements gaps will be as specified in Table 9.1.5.1.1-1.

Table 9.1.5.1.1-1: $CSSF_{outside\_gap,i}$ scaling factor in NSA mode

Scenario	$CSSF_{outside\_gap,i}$ for FR1 PSCC	$CSSF_{outside\_gap,i}$ for FR1 SCC	$CSSF_{outside\_gap,i}$ for FR2 PSCC	$CSSF_{outside\_gap,i}$ for FR2 SCC where neighbour cell measurement is required Note 2	$CSSF_{outside\_gap,i}$ for FR2 SCC where neighbour cell measurement is not required
EN-DC with FR1 only CA	1	Number of configured FR1 SCell(s)	N/A	N/A	N/A
EN-DC with FR2 only intra band CA	N/A	N/A	1	N/A	Number of configured FR2 SCells
EN-DC with FR1 +FR2 CA (FR1 PSCell) Note 1	1	2×(Number of configured SCell(s)-1)	N/A	2	2×(Number of configured SCell(s)-1)
EN-DC with FR1 +FR2 CA (FR2 PSCell) Note 1	N/A	Number of configured SCell(s)	1	N/A	Number of configured SCell(s)
Note 1: Only one NR FR1 operating band and one NR FR2 operating band are included for FR1+FR2 inter-band EN-DC. Note 2: Selection of FR2 SCC where neighbour cell measurement is required follows section 9.2.3.2.					

9.1.5.1.2 SA mode: carrier-specific scaling factor for SSB-based measurements performed outside gaps without NR-DC operation

For UE not configured with NR-DC operation in SA mode, the carrier-specific scaling factor $CSSF_{outside\_gap,i}$ for intra-frequency SSB-based measurements performed outside measurements gaps will be as specified in Table 9.1.5.1.2-1, which shall also be applied for a UE configured with NE-DC operation.

Table 9.1.5.1.2-1: $CSSF_{outside\_gap,i}$ scaling factor without NR-DC operation in SA mode

Scenario	$CSSF_{outside\_gap,i}$ for FR1 PCC	$CSSF_{outside\_gap,i}$ for FR1 SCC	$CSSF_{outside\_gap,i}$ for FR2 PCC	$CSSF_{outside\_gap,i}$ for FR2 SCC where neighbour cell measurement is required	$CSSF_{outside\_gap,i}$ for FR2 SCC where neighbour cell measurement is not required
FR1 only CA	1	Number of configured FR1 SCell(s)	N/A	N/A	N/A
FR2 only intra band CA	N/A	N/A	1	N/A	Number of configured FR2 SCell(s)
FR1 +FR2 CA (FR1 PCell) Note 1	1	2×(Number of configured SCell(s)-1)	N/A	2	2×(Number of configured SCell(s)-1)
Note 1: Only one FR1 operating band and one FR2 operating band are included for FR1+FR2 inter-band CA. Note 2: Selection of FR2 SCC where neighbour cell measurement is required follows section 9.2.3.2.					

9.1.5.1.3 SA mode: carrier-specific scaling factor for SSB-based measurements performed outside gaps with NR-DC operation

For UE configured with NR-DC operation in SA mode, the carrier-specific scaling factor $CSSF_{outside\_gap,i}$ for intra-frequency SSB-based measurements performed outside measurements gaps will be as specified in Table 9.1.5.1.3-1.

Table 9.1.5.1.3-1: $CSSF_{outside\_gap,i}$ scaling factor with NR-DC operation in SA mode

Scenario	*$CSSF_{outside\_gap,i}$* for FR1 PCC	*$CSSF_{outside\_gap,i}$* for FR1 SCC	*$CSSF_{outside\_gap,i}$* for FR2 PSCC	*$CSSF_{outside\_gap,i}$* for FR2 SCC where neighbour cell measurement is not required
FR1 + FR2 NR-DC (FR1 PCell and FR2 PScell) Note 1	1	2×(Number of configured SCell(s))	2	2×(Number of configured SCell(s))
Note 1: NR-DC in Rel-15 only includes the scenarios where all serving cells in MCG in FR1 and all serving cells in SCG in FR2.				

9.1.5.2 Monitoring of multiple layers within gaps

The carrier-specific scaling factor $CSSF_{within\_gap,i}$ for measurement object *i* derived in this chapter is applied to following measurement types:

- Intra-frequency measurement with no measurement gap in Section 9.2.5, when all of the SMTC occasions of this intra-frequency measurement object are overlapped by the measurement gap.

- Intra-frequency measurement with measurement gap in Section 9.2.6.

- Inter-frequency measurement in Section 9.3

- Inter-RAT measurement in Section 9.4

UE is expected to conduct the measurement of this measurement object *i* only within the measurement gaps.

If the higher layer signaling in TS 38.331 [2] signaling of *smtc2* is present and smtc1 is fully overlapping with measurement gaps and smtc2 is partially overlapping with measurement gaps, $CSSF_{within\_gap\_i}$ and requirements derivied from $CSSF_{outside\_gap\_i}$ are not specified.

9.1.5.2.1 NSA mode: carrier-specific scaling factor for SSB-based measurements performed within gaps

Editor's note: The scaling value $CSSF_{within\_gap,i}$ below has been derived without considering GSM inter-RAT carriers.

When one or more measurement objects are monitored within measurement gaps, the carrier specific scaling factor for a target measurement object with index *i* is designated as $CSSF_{within\_gap,i}$ and is derived as described in this section.

If measurement object *i* refers to an RSTD measurement with periodicity Tprs>160ms or with periodicity Tprs=160ms but *prs-MutingInfo-r9* is configured, $CSSF_{within\_gap,i}$=1. Otherwise, the the $CSSF_{within\_gap,i}$ for other measurement objects (including RSTD measurement with periodicity Tprs=160ms) participate in the gap competition are derived as below.

For each measurement gap *j* not used for an RSTD measurement with periodicity Tprs>160ms or with periodicity Tprs=160ms but *prs-MutingInfo-r9* is configured within an arbitrary 160ms period, count the total number of intrafrequency measurement objects and interfrequency/interRAT measurement objects which are candidates to be measured within the gap *j*.

- An NR carrier is a candidate to be measured in a gap if its SMTC duration is fully covered by the MGL excluding RF switching time. For intrafrequency NR carriers, if the high layer in TS 38.331 [2] signaling of *smtc2* is configured, the assumed periodicity of SMTC occasions corresponds to the value of higher layer parameter *smtc2*; Otherwise the assumed periodicity of SMTC occasions corresponds to the value of higher layer parameter *smtc1*.

- An interRAT measurement object is a candidate to be measured in all meausrement gaps.

R_i is the maximal ratio of the number of measurement gap where measurement object *i* is a candidate to be measured over the number of measurement gap where measurement object *i* is a candidate and not used for RSTD measurement with periodicity Tprs>160ms or with periodicity Tprs=160ms but *prs-MutingInfo-r9* is configured within an arbitrary 1280ms period.

For UEs which support and are configured with per FR gaps, the counting is done on a per FR basis, and for UEs which are configured with per UE gaps the counting is done on a per UE basis.

Per gap *j*:

$M_{intra,i,j}$: Number of intrafrequency measurement objects which are candidates to be measured in gap *j* where the measurement object *i* is also a candidate. Otherwise $M_{intra,i,j}$ equals 0.

$M_{inter,i,j}$: Number of NR interfrequency measurement objects or NR interRAT measurement objects configured by E-UTRA PCell, EUTRA interfrequency measurement objects configured by E-UTRA PCell, UTRA inter-RAT measurement objects and GSM interRAT measurement objects configured by E-UTRA PCell which are candidates to be measured in gap *j* where the measurement object *i* is also a candidate. Otherwise $M_{inter,i,j}$ equals 0.

$M_{tot,i,j} = M_{intra,i,j} + M_{inter,i,j}$: Total number of intrafrequency, interfrequency and interRAT measurement objects which are candidates to be measured in gap *j* where the measurement object *i* is also a candidate. Otherwise $M_{tot,i,j}$ equals 0.

The carrier specific scaling factor $CSSF_{within\_gap,i}$ is given by:

If *measGapSharingScheme* is equal sharing, $CSSF_{within\_gap,i}= \max(\text{ceil}(R_i \times M_{tot,i,j}))$, where j=0…(160/MGRP)-1

If *measGapSharingScheme* is not equal sharing and

- measurement object *i* is an intrafrequency measurement object, $CSSF_{within\_gap,i}$ is the maximum among
  - $\text{ceil}(R_i \times K_{intra} \times M_{intra,i,j})$ in gaps where $M_{inter,i,j} \neq 0$, where j=0…(160/MGRP)-1
  - $\text{ceil}(R_i \times M_{intra,i,j})$ in gaps where $M_{inter,i,j}=0$, where j=0…(160/MGRP)-1
- measurement object *i* is an interfrequency or interRAT measurement object, $CSSF_{within\_gap,i}$ is the maximum among
  - $\text{ceil}(R_i \times K_{inter} \times M_{inter,i,j})$ in gaps where $M_{intra,i,j} \neq 0$, where j=0…(160/MGRP)-1
  - $\text{ceil}(R_i \times M_{inter,i,j})$ in gaps where $M_{intra,i,j}=0$, where j=0…(160/MGRP)-1

9.1.5.2.2 SA mode: carrier-specific scaling factor for SSB-based measurements performed within gaps

When one or more measurement objects are monitored within measurement gaps, the carrier specific scaling factor for a target measurement object with index *i* is designated as $CSSF_{within\_gap,i}$ and is derived as described in this section.

If measurement object *i* refers to an RSTD measurement with periodicity Tprs>160ms or with periodicity Tprs=160ms but *prs-MutingInfo-r9* is configured, $CSSF_{within\_gap,i}$=1. Otherwise, the the $CSSF_{within\_gap,i}$ for other measurement objects (including RSTD measurement with periodicity Tprs=160ms) participate in the gap competition and the $CSSF_{within\_gap,i}$ are derived as below.

For each measurement gap *j* not used for an RSTD measurement with periodicity Tprs>160ms or with periodicity Tprs=160ms but *prs-MutingInfo-r9* is configured within an arbitrary 160ms period, count the total number of intrafrequency measurement objects and interfrequency/interRAT measurement objects which are candidates to be measured within the gap *j*.

- An NR carrier is a candidate to be measured in a gap if its SMTC duration is fully covered by the MGL excluding RF switching time. For intrafrequency NR carriers, if the high layer in TS 38.331 [2] signaling of *smtc2* is configured, the assumed periodicity of SMTC occasions corresponds to the value of higher layer parameter *smtc2*; Otherwise the assumed periodicity of SMTC occasions corresponds to the value of higher layer parameter *smtc1*.
- An interRAT measurement object is a candidate to be measured in all meausrement gaps.

R_i is the maximal ratio of the number of measurement gap where measurement object *i* is a candidate to be measured over the number of measurement gap where measurement object *i* is a candidate and not used for RSTD measurement with periodicity Tprs>160ms or with periodicity Tprs=160ms but *prs-MutingInfo-r9* is configured within an arbitrary 1280ms period.

For UEs which support and are configured with per FR gaps, the counting is done on a per FR basis, and for UEs which are configured with per UE gaps the counting is done on a per UE basis.

Per gap *j*:

$M_{intra,i,j}$: Number of intrafrequency measurement objects which are candidates to be measured in gap *j* where the measurement object *i* is also a candidate. Otherwise $M_{intra,i,j}$ equals 0.

$M_{inter,i,j}$: Number of NR interfrequency and EUTRA interRAT measurement objects which are candidates to be measured in gap *j* where the measurement object *i* is also a candidate. Otherwise $M_{inter,i,j}$ equals 0.

$M_{tot,i,j} = M_{intra,i,j} + M_{inter,i,j}$: Total number of intrafrequency, interfrequency and interRAT measurement objects which are candidates to be measured in gap *j* where the measurement object *i* is also a candidate. Otherwise $M_{tot,i,j}$ equals 0.

The carrier specific scaling factor $CSSF_{within\_gap,i}$ is given by:

If *measGapSharingScheme* is equal sharing, $CSSF_{within\_gap,i}= \max(\text{ceil}(R_i \times M_{tot,i,j}))$, where j=0…(160/MGRP)-1

If *measGapSharingScheme* is not equal sharing and

- measurement object *i* is an intrafrequency measurement object, $CSSF_{within\_gap,i}$ is the maximum among
  - $\text{ceil}(R_i \times K_{intra} \times M_{intra,i,j})$ in gaps where $M_{inter,i,j} \neq 0$, where j=0…(160/MGRP)-1
  - $\text{ceil}(R_i \times M_{intra,i,j})$ in gaps where $M_{inter,i,j}=0$, where j=0…(160/MGRP)-1
- measurement object *i* is an interfrequency or interRAT measurement object, $CSSF_{within\_gap,i}$ is the maximum among
  - $\text{ceil}(R_i \times K_{inter} \times M_{inter,i,j})$ in gaps where $M_{intra,i,j} \neq 0$, where j=0…(160/MGRP)-1
  - $\text{ceil}(R_i \times M_{inter,i,j})$ in gaps where $M_{intra,i,j}=0$, where j=0…(160/MGRP)-1

9.1.6 Minimum requirement at transitions

When the measurement on one intra-frequency measurement object transitions from measurements performed outside gaps to measurements performed within gaps or vice versa during one measurement period, the cell identification and measurement period requirements with the longer delay apply.

The carrier-specific scaling factor specified in Section 9.1.5 that applies to the other impacted measurement objects will also apply based on the longer measurement or cell identification delay before or after the transition.

When the UE transitions between DRX and non-DRX or when DRX cycle periodicity changes, the cell identification and measurement period requirements apply based on the longer delay before or after the transition.

Subsequent to this measurement period, the cell identification and measurement period requirements on each measurement object are corresponding to the second mode after transition.

9.2 NR intra-frequency measurements

9.2.1 Introduction

A measurement is defined as a SSB based intra-frequency measurement provided the centre frequency of the SSB of the serving cell indicated for measurement and the centre frequency of the SSB of the neighbour cell are the same, and the subcarrier spacing of the two SSB are also the same.

The UE shall be able to identify new intra-frequency cells and perform SS-RSRP, SS-RSRQ, and SS-SINR measurements of identified intra-frequency cells if carrier frequency information is provided by PCell or the PSCell, even if no explicit neighbour list with physical layer cell identities is provided.

The UE can perform intra-frequency SSB based measurements without measurement gaps if

- the SSB is completely contained in the active BWP of the UE, or
- the active downlink BWP is initial BWP[3].

For intra-frequency SSB based measurements without measurement gaps, UE may cause scheduling restriction as specified in section 9.2.5.3.

SSB based measurements are configured along with one or two measurement timing configuration(s) (SMTC) which provides periodicity, duration and offset information on a window of up to 5ms where the measurements are to be performed. For intra-frequency connected mode measurements, up to two measurement window periodicities may be configured. A single measurement window offset and measurement duration are configured per intra-frequency measurement object.

When measurement gaps are needed, the UE is not expected to detect SSB which start earlier than the gap starting time + switching time, nor detect SSB which end later than the gap end – switching time. Switching time is 0.5ms for frequency range FR1 and 0.25ms for frequency range FR2.

9.2.2 Requirements applicability

The requirements in Section 9.2 apply, provided:

- The cell being identified or measured is detectable.

An intra-frequency cell shall be considered detectable when for each relevant SSB:

- SS-RSRP related side conditions given in Sections 10.1.2 and 10.1.3 for FR1 and FR2, respectively, for a corresponding Band,
- SS-RSRQ related side conditions given in Sections 10.1.7 and 10.1.8 for FR1 and FR2, respectively, for a corresponding Band,
- SS-SINR related side conditions given in Sections 10.1.12 and 10.1.13 for FR1 and FR2, respectively, for a corresponding Band,
- SSB_RP and SSB Ês/Iot according to Annex B.2.2 for a corresponding Band.

9.2.3 Number of cells and number of SSB

9.2.3.1 Requirements for FR1

For each intra-frequency layer, during each layer 1 measurement period, the UE shall be capable of performing SS-RSRP, SS-RSRQ, and SS-SINR measurements forat least:

- 8 identified cells, and
- 14 SSBs with different SSB index and/or PCI on the intra-frequency layer, where the number of SSBs in the serving cell (except for the SCell) is no smaller than the number of configured RLM-RS SSB resources.

9.2.3.2 Requirements for FR2

For each intra-frequency layer, during each Layer 1 measurement period, the UE shall be capable of performing SS-RSRP, SS-RSRQ, and SS-SINR measurements for at least:

- 6 identfied cells, and
- 24 SSBs with different SSB index and/or PCI,

where the single serving carrier shall be:

- PCC when UE is configured with SA NR operation mode with PCC in the band; or
- PSCC when UE is configured with EN-DC with PSCC in the band; or
- One of the SCCs on which UE is configured to report SSB based measurements when neither PCC nor PSCC is in the same band, so that the selected SCC shall be an SCC where the UE is configured with SS-RSRP measurement reporting if such SCC exists, otherwise the selected SCC is up to the UE

UE shall also be capable of performing SS-RSRP, SS-RSRQ, and SS-SINR measurements for at least 2 SSBs on serving cell for each of the other serving carrier(s) in the same band.

9.2.4 Measurement Reporting Requirements

9.2.4.1 Periodic Reporting

Reported RSRP, RSRQ, and RS-SINR measurements contained in periodically triggered measurement reports shall meet the requirements in sections 10.1.2.1, 10.1.3.1, 10.1.7.1, 10.1.8.1, 10.1.12.1 and 10.1.13.1, respectively.

9.2.4.2 Event-triggered Periodic Reporting

Reported RSRP, RSRQ, and RS-SINR measurements contained in periodically triggered measurement reports shall meet the requirements in sections 10.1.2.1, 10.1.3.1, 10.1.7.1, 10.1.8.1, 10.1.12.1 and 10.1.13.1, respectively.

The first report in event triggered periodic measurement reporting shall meet the requirements specified in clause 9.2.4.3.

9.2.4.3 Event Triggered Reporting

Reported RSRP, RSRQ, and RS-SINR measurements contained in periodically triggered measurement reports shall meet the requirements in sections 10.1.2.1, 10.1.3.1, 10.1.7.1, 10.1.8.1, 10.1.12.1 and 10.1.13.1, respectively.

The UE shall not send any event triggered measurement reports as long as no reporting criteria are fulfilled.

The measurement reporting delay is defined as the time between an event that will trigger a measurement report and the point when the UE starts to transmit the measurement report over the air interface. This requirement assumes that the measurement report is not delayed by other RRC signalling on the DCCH. This measurement reporting delay excludes a delay uncertainty resulted when inserting the measurement report to the TTI of the uplink DCCH. The delay uncertainty is: 2 x TTI_{DCCH}. This measurement reporting delay excludes a delay which caused by no UL resoureces for UE to send the measurement report.

The event triggered measurement reporting delay, measured without L3 filtering shall be less than $T_{\text{identify intra with index}}$ or $T_{\text{identify intra without index}}$ defined in clause 9.2.5.1 or clause 9.2.6.2. When L3 filtering is used an additional delay can be expected.

If a cell which has been detectable at least for the time period $T_{\text{identify intra without index}}$ or $T_{\text{identify intra with index}}$ defined in clause 9.2.5.1 or clause 9.2.6.2 becomes undetectable for a period and then the cell becomes detectable again and triggers an event, the event triggered measurement reporting delay shall be less than $T_{\text{Measurement\_Period, Intra}}$ provided the timing to that cell has not changed more than ± 3200 Tc while the measurement gap has not been available and the L3 filter has not been used. When L3 filtering is used, an additional delay can be expected.

9.2.5 Intrafrequency measurements without measurement gaps

9.2.5.1 Intrafrequency cell identification

The UE shall be able to identify a new detectable intra frequency cell within $T_{\text{identify\_intra\_without\_index}}$ if UE is not indicated to report SSB based RRM measurement result with the associated SSB index(*reportQuantityRsIndexes* or *maxNrofRSIndexesToReport* is not configured), or the UE is indicated that the neighbour cell is synchronous with the serving cell (*deriveSSB-IndexFromCell* is enabled). Otherwise UE shall be able to identify a new detectable intra frequency cell within $T_{\text{identify\_intra\_with\_index}}$. The UE shall be able to identify a new detectable intra frequency SS block of an already detected cell within $T_{\text{identify\_intra\_without\_index.}}$ It is assumed that *deriveSSB-IndexFromCell* is always enabled for FR1 TDD and FR2.

$$T_{\text{identify\_intra\_without\_index}} = (T_{\text{PSS/SSS\_sync\_intra}} + T_{\text{SSB\_measurement\_period\_intra}}) \text{ ms}$$

$$T_{\text{identify\_intra\_with\_index}} = (T_{\text{PSS/SSS\_sync\_intra}} + T_{\text{SSB\_measurement\_period\_intra}} + T_{\text{SSB\_time\_index\_intra}}) \text{ ms}$$

Where:

$T_{\text{PSS/SSS\_sync\_intra}}$: it is the time period used in PSS/SSS detection given in table 9.2.5.1-1, 9.2.5.1-2, 9.2.5.1-4 (deactivated Scell) or 9.2.5.1-5 (deactivated SCell)

$T_{SSB\_time\_index\_intra}$: it is the time period used to acquire the index of the SSB being measured given in table 9.2.5.1-3 or 9.2.5.1-6 (deactivated SCell)

$T_{SSB\_measurement\_period\_intra}$: equal to a measurement period of SSB based measurement given in table 9.2.5.2-1, table 9.2.5.2-2 table 9.2.5.2-3 (deactivated Scell) or 9.2.5.2-4(deactivated SCell)

$CSSF_{intra}$: it is a carrier specific scaling factor and is determined

- according to $CSSF_{outside\_gap,i}$ in section 9.1.5.1 for measurement conducted outside measurement gaps, i.e. when intrafrequency SMTC is fully non overlapping or partially overlapping with measurement gaps, or according to $CSSF_{within\_gap,i}$ in section 9.1.5.2 for measurement conducted within measurement gaps, i.e. when intrafrequency SMTC is fully overlapping with measurement gaps.
  - if the high layer in TS 38.331 [2] signaling of *smtc2* is configured, the assumed periodicity of intrafrequency SMTC occasions corresponds to the value of higher layer parameter *smtc2*; Otherwise the assumed periodicity of intrafrequency SMTC occasions corresponds to the value of higher layer parameter *smtc1*.

$M_{pss/sss\_sync\_w/o\_gaps}$: For a UE supporting FR2 power class 1, M_{pss/sss_sync}=40. For a UE supporting power class 2, $M_{pss/sss\_sync\_w/o\_gaps}$ =24. For a UE supporting FR2 power class 3, $M_{pss/sss\_sync\_w/o\_gaps}$ =24. For a UE supporting FR2 power class 4, $M_{pss/sss\_sync\_w/o\_gaps}$ =24

$M_{meas\_period\_w/o\_gaps}$: For a UE supporting power class 1, $M_{meas\_period\_w/o\_gaps}$ =40. For a UE supporting FR2 power class 2, $M_{meas\_period\_w/o\_gaps}$ =24. For a UE supporting power class 3, $M_{meas\_period\_w/o\_gaps}$ =24. For a UE supporting power class 4, $M_{meas\_period\_w/o\_gaps}$ =24.

When intrafrequency SMTC is fully non overlapping with measurement gaps or intrafrequency SMTC is fully overlapping with MGs, Kp=1

When intrafrequency SMTC is partially overlapping with measurent gaps, Kp = 1/(1- (SMTC period /MGRP)), where SMTC period < MGRP

If the higher layer signaling in TS38.331 [2] signaling of *smtc2* is present and smtc1 is fully overlapping with measurement gaps and smtc2 is partially overlapping with measurement gaps, requirements are not specified for $T_{identify\_intra\_without\_index}$ or $T_{identify\_intra\_with\_index}$

For FR2 when any of the reference signals configured for RLM, BFD, CBD or L1-RSRP for beam reporting outside measurement gap is fully overlapping with intra-frequency SMTC, $K_{layer1\_measurement}$= 1.5, otherwise $K_{layer1\_measurement}$=1.

If SCG DRX is in use, intrafrequency cell identification requirements specified in Table 9.2.5.1-1, Table 9.2.5.1-2, Table 9.2.5.1-3, Table 9.2.5.1-4, Table 9.2.5.1-5 and Table 9.2.5.1-6 shall depend on the SCG DRX cycle. Otherwise, the requirements for when DRX is not in use shall apply.

Table 9.2.5.1-1: Time period for PSS/SSS detection, (Frequency range FR1)

DRX cycle	T_{PSS/SSS_sync_intra}
No DRX	max[600ms, ceil(5 x K_p) x SMTC period]$^{Note\ 1}$ x $CSSF_{intra}$
DRX cycle≤ 320ms	max[600ms, ceil(1.5x 5 x K_p) x max(SMTC period,DRX cycle)] x $CSSF_{intra}$
DRX cycle>320ms	ceil[5] x K_p) x DRX cycle x $CSSF_{intra}$
NOTE 1: If different SMTC periodicities are configured for different cells, the SMTC period in the requirement is the one used by the cell being identified	

Table 9.2.5.1-2: Time period for PSS/SSS detection, (Frequency range FR2)

DRX cycle	T_{PSS/SSS_sync_intra}
No DRX	max(600ms, ceil($M_{pss/sss\_sync\_w/o\_gaps}$ x K_p x $K_{layer1\_measurement}$) x SMTC period)$^{Note\ 1}$ x $CSSF_{intra}$
DRX cycle≤ 320ms	max(600ms, ceil(1.5 x $M_{pss/sss\_sync\_w/o\_gaps}$ x K_p x $K_{layer1\_measurement}$) x max(SMTC period,DRX cycle)) x $CSSF_{intra}$
DRX cycle>320ms	ceil($M_{pss/sss\_sync\_w/o\_gaps}$ x K_p x $K_{layer1\_measurement}$) x DRX cycle x $CSSF_{intra}$
NOTE 1: If different SMTC periodicities are configured for different cells, the SMTC period in the requirement is the one used by the cell being identified	

Table 9.2.5.1-3: Time period for time index detection (Frequency range FR1)

DRX cycle	$T_{SSB\_time\_index\_intra}$
No DRX	max(120ms, ceil(3 x K_p) x SMTC period)$^{Note\ 1}$ x $CSSF_{intra}$
DRX cycle≤ 320ms	max(120ms, ceil (1.5 x 3 x K_p) x max(SMTC period,DRX cycle)) x $CSSF_{intra}$
DRX cycle>320ms	Ceil(3 x K_p) x DRX cycle x $CSSF_{intra}$
NOTE 1: If different SMTC periodicities are configured for different cells, the SMTC period in the requirement is the one used by the cell being identified	

Table 9.2.5.1-4: Time period for PSS/SSS detection, deactivated SCell (Frequency range FR1)

DRX cycle	T_{PSS/SSS_sync_intra}
No DRX	5 x measCycleSCell x $CSSF_{intra}$
DRX cycle≤ 320ms	5 x max(measCycleSCell, 1.5xDRX cycle) x $CSSF_{intra}$
DRX cycle> 320ms	5 x max(measCycleSCell, DRX cycle) x $CSSF_{intra}$

Table 9.2.5.1-5: Time period for PSS/SSS detection, deactivated SCell (Frequency range FR2)

DRX cycle	T_{PSS/SSS_sync_intra}
No DRX	$M_{pss/sss\_sync\_w/o\_gaps}$ x measCycleSCell x $CSSF_{intra}$
DRX cycle≤ 320ms	$M_{pss/sss\_sync\_w/o\_gaps}$ x max(measCycleSCell, 1.5xDRX cycle) x $CSSF_{intra}$
DRX cycle> 320ms	$M_{pss/sss\_sync\_w/o\_gaps}$ x max(measCycleSCell, DRX cycle) x $CSSF_{intra}$

Table 9.2.5.1-6: Time period for time index detection, deactivated SCell (Frequency range FR1)

DRX cycle	$T_{SSB\_time\_index\_intra}$
No DRX	3 x measCycleSCell x $CSSF_{intra}$
DRX cycle≤ 320ms	3 x max(measCycleSCell, 1.5xDRX cycle) x $CSSF_{intra}$
DRX cycle> 320ms	3 x max(measCycleSCell, DRX cycle) x $CSSF_{intra}$

Table 9.2.5.1-7: Void

Table 9.2.5.1-8: Void

9.2.5.2 Measurement period

The measurement period for intrafrequency measurements without gaps is as shown in table 9.2.5.2-1, 9.2.5.2-2, 9.2.5.2-3 (deactivated SCell) or 9.2.5.2-4(deactivated SCell). If the higher layer signaling in TS38.331 [2] signaling of *smtc2* is present and smtc1 is fully overlapping with measurement and smtc2 is partially overlapping with measurement gaps, requirements are not specified for $T_{SSB\_measurement\_period\_intra}$

If SCG DRX is in use, intrafrequency measurement period requirements specified in Table 9.2.5.2-1, Table 9.2.5.2-2, Table 9.2.5.2-3 and Table 9.2.5.2-4 shall depend on the SCG DRX cycle. Otherwise, the requirements for when DRX is not in use shall apply.

Table 9.2.5.2-1: Measurement period for intrafrequency measurements without gaps(Frequency FR1)

DRX cycle	$T_{SSB\_measurement\_period\_intra}$
No DRX	max(200ms, ceil(5 x K_p) x SMTC period)$^{Note\ 1}$ x $CSSF_{intra}$
DRX cycle≤ 320ms	ma(200ms, ceil(1.5x 5 x K_p) x max(SMTC period,DRX cycle)) x $CSSF_{intra}$
DRX cycle>320ms	ceil(5 x K_p) x DRX cycle x $CSSF_{intra}$
NOTE 1: If different SMTC periodicities are configured for different cells, the SMTC period in the requirement is the one used by the cell being identified	

Table 9.2.5.2-2: Measurement period for intrafrequency measurements without gaps(Frequency FR2)

DRX cycle	$T_{SSB\_measurement\_period\_intra}$
No DRX	max(400ms, ceil($M_{meas\_period\_w/o\_gaps}$ x K_p x $K_{layer1\_measurement}$) x SMTC period)$^{Note\ 1}$ x $CSSF_{intra}$
DRX cycle≤ 320ms	max(400ms, ceil(1.5x $M_{meas\_period\_w/o\_gaps}$ x K_p x $K_{layer1\_measurement}$) x max(SMTC period,DRX cycle)) x $CSSF_{intra}$
DRX cycle>320ms	ceil($M_{meas\_period\_w/o\_gaps}$ xK_p x $K_{layer1\_measurement}$) x DRX cycle x $CSSF_{intra}$
NOTE 1: If different SMTC periodicities are configured for different cells, the SMTC period in the requirement is the one used by the cell being identified	

Table 9.2.5.2-3: Measurement period for intrafrequency measurements without gaps (deactivated SCell) (Frequency range FR1)

DRX cycle	$T_{SSB\_measurement\_period\_intra}$
No DRX	5 x measCycleSCell x $CSSF_{intra}$
DRX cycle≤ 320ms	5 x max(measCycleSCell, 1.5xDRX cycle) x $CSSF_{intra}$
DRX cycle> 320ms	5 x max(measCycleSCell, DRX cycle) x $CSSF_{intra}$

Table 9.2.5.2-4: Measurement period for intrafrequency measurements without gaps (deactivated SCell) (Frequency range FR2)

DRX cycle	$T_{SSB\_measurement\_period\_intra}$
No DRX	$M_{meas\_period\ with\_gaps}$ x measCycleSCell x $CSSF_{intra}$
DRX cycle≤ 320ms	$M_{meas\_period\ with\_gaps}$ x max(measCycleSCell, 1.5xDRX cycle) x $CSSF_{intra}$
DRX cycle> 320ms	$M_{meas\_period\ with\_gaps}$ x max(measCycleSCell, DRX cycle) x $CSSF_{intra}$

9.2.5.3 Scheduling availability of UE during intra-frequency measurements

UE are required to be capable of measuring without measurement gaps when the SSB is completely contained in the active bandwidth part of the UE. When the measurement signal has different subcarrier spacing than PDSCH/PDCCH or on frequency range FR2, there are restrictions on the scheduling availability as described in the following clauses. Note that the SSB symbols to be measured in the following clauses are the SSB symbols indicated by *SSB-ToMeasure* [2], if it is configured; otherwise, all *L* SSB symbols within SMTC window duration defined in Section 4.1 of [3] are included.

9.2.5.3.1 Scheduling availability of UE performing measurements with a same subcarrier spacing as PDSCH/PDCCH on FR1

There are no scheduling restrictions due to measurements performed with a same subcarrier spacing as PDSCH/PDCCH on FR1.

9.2.5.3.2 Scheduling availability of UE performing measurements with a different subcarrier spacing than PDSCH/PDCCH on FR1

For UE which support *simultaneousRxDataSSB-DiffNumerology* [14] there are no restrictions on scheduling availability due to measurements. For UE which do not support *simultaneousRxDataSSB-DiffNumerology* [14] the following restrictions apply due to SS-RSRP/RSRQ/SINR measurement

- If *deriveSSB_IndexFromCell* is enabled the UE is not expected to transmit PUCCH/PUSCH/SRS or receive PDCCH/PDSCH/TRS/CSI-RS for CQI on SSB symbols to be measured, and on 1 data symbol before each consecutive SSB symbols to be measured and 1 data symbol after each consecutive SSB symbols to be measured within SMTC window duration. If the high layer in TS 38.331 [2] signaling of *smtc2* is configured, the SMTC periodicity follows *smtc2*; Otherwise SMTC periodicity follows *smtc1*.

- If *deriveSSB_IndexFromCell* is not enabled the UE is not expected to transmit PUCCH/PUSCH/SRS or receive PDCCH/PDSCH/TRS/CSI-RS for CQI on all symbols within SMTC window duration. If the high layer in TS 38.331 [2] signaling of *smtc2* is configured, the SMTC periodicity follows *smtc2*; Otherwise SMTC periodicity follows *smtc1*.

When intra-band carrier aggregation is performed, the scheduling restrictions due to one serving cell should also apply to all other serving cells in the same band on the symbols that fully or partially overlap with aforementioned restricted symbols. When inter-band carrier aggregation within FR1 is performed, there are no scheduling restrictions on FR1 serving cell(s) in the bands due to measurements performed on FR1 serving cell frequency layer in different bands.

9.2.5.3.3 Scheduling availability of UE performing measurements on FR2

The following scheduling restriction applies due to SS-RSRP or SS-SINR measurement on an FR2 intra-frequency cell

The UE is not expected to transmit PUCCH/PUSCH/SRS or receive PDCCH/PDSCH/TRS/CSI-RS for CQI on SSB symbols to be measured, and on 1 data symbol before each consecutive SSB symbols to be measured and 1 data symbol after each consecutive SSB symbols to be measured within SMTC window duration (The signaling *deriveSSB_IndexFromCell* is always enabled for FR2) . If the high layer in TS 38.331 [2] signaling of *smtc2* is configured, the SMTC periodicity follows *smtc2*; Otherwise SMTC periodicity follows *smtc1*.

The following scheduling restriction applies to SS-RSRQ measurement on an FR2 intra-frequency cell

- UE is not expected to transmit PUCCH/PUSCH/SRS or receive PDCCH/PDSCH/TRS/CSI-RS for CQI on SSB symbols to be measured, RSSI measurement symbols, and on 1 data symbol before each consecutive SSB to be measured/RSSI symbols and 1 data symbol after each consecutive SSB to be measured/RSSI symbols within SMTC window duration (The signaling *deriveSSB_IndexFromCellc* is always enabled for FR2). If the high layer in TS 38.331 [2] signaling of *smtc2* is configured, the SMTC periodicity follows *smtc2*; Otherwise SMTC periodicity follows *smtc1*.

When intra-band carrier aggregation is performed, the scheduling restrictions due to one serving cell should also apply to all other serving cells in the same band on the symbols that fully or partially overlap with aforementioned restricted symbols. When inter-band carrier aggregation within FR2 is performed, the scheduling restrictions apply to all the other serving cells.

Editor's Note: FFS scheduling restrictions for inter-band carrier aggregation will be defined depending on band combination in future.

9.2.5.3.4 Scheduling availability of UE performing measurements on FR1 or FR2 in case of FR1-FR2 inter-band CA

There are no scheduling restrictions on FR1 serving cell(s) due to measurements performed on FR2 serving cell frequency layer.

There are no scheduling restrictions on FR2 serving cell(s) due to measurements performed on FR1 serving cell frequency layer.

9.2.6 Intrafrequency measurements with measurement gaps

9.2.6.1 Void

9.2.6.2 Intrafrequency cell identification

The UE shall be able to identify a new detectable intra frequency cell within $T_{identify\_intra\_without\_index}$ if UE is not indicated to report SSB based RRM measurement result with the associated SSB index (*reportQuantityRsIndexes* or *maxNrofRSIndexesToReport* is not configured), or the UE has been indicated that the neighbour cell is synchronous with the serving cell (*deriveSSB-IndexFromCell* is enabled). Otherwise UE shall be able to identify a new detectable intra frequency cell within $T_{identify\_intra\_with\_index}$. The UE shall be able to identify a new detectable intra frequency SS block of an already detected cell within $T_{identify\_intra\_without\_index}$. It is assumed that *deriveSSB-IndexFromCell* is always enabled for FR1 TDD and FR2.

$$T_{identify\_intra\_without\_index} = T_{PSS/SSS\_sync\_intra} + T_{SSB\_measurement\_period\_intra} \text{ ms}$$

$$T_{identify\_intra\_with\_index} = T_{PSS/SSS\_sync\_ntra} + T_{SSB\_measurement\_period\_intra} + T_{SSB\_time\_index\_intra}$$

Where:

T_{PSS/SSS_sync_intra}: it is the time period used in PSS/SSS detection given in table 9.2.6.2-1 or 9.2.6.2-2.

$T_{SSB\_time\_index\_intra}$: it is the time period used to acquire the index of the SSB being measured given in table 9.2.6.2-3.

$T_{SSB\_measurement\_period\_intra}$: equal to a measurement period of SSB based measurement given in table 9.2.6.2-1 or 9.2.6.2-2.

$CSSF_{intra}$: it is a carrier specific scaling factor and is determined according to $CSSF_{within\_gap,i}$ in section 9.1.5.2 for measurement conducted within measurement gaps.

$M_{pss/sss\_sync\_with\_gaps}$: For a UE supporting FR2 power class 1, $M_{pss/sss\_sync with\_gaps}$=40. For a UE supporting FR2 power class 2, $M_{pss/sss\_sync with\_gaps}$ =24. For a UE supporting FR2 power class 3, $M_{pss/sss\_sync with\_gaps}$ =24. For a UE supporting power class 4, $M_{pss/sss\_sync with\_gaps}$ =24

$M_{meas\_period\_ with\_gaps}$: For a UE supporting power class 1, $M_{meas\_period\_ with\_gaps}$ =40. For a UE supporting power class 2, $M_{meas\_period\_ with\_gaps}$ =24. For a UE supporting power class 3, $M_{meas\_period\_ with\_gaps}$ =24. For a UE supporting power class 4, $M_{meas\_period with\_gaps}$ =24.

If the higher layer signaling in TS 38.331 [2] signaling of *smtc2* is present and smtc1 is fully overlapping with measurement gaps and smtc2 is partially overlapping with measurement gaps, requirements are not specified for $T_{identify\_intra\_without\_index}$ or $T_{identify\_intra\_with\_index}$.

If SCG DRX is in use, intrafrequency cell identification requirements specified in Table 9.2.6.1-1, Table 9.2.6.1-2, and Table 9.2.5.1-3 shall depend on the SCG DRX cycle. Otherwise, the requirements for when DRX is not in use shall apply.

Table 9.2.6.2-1: Time period for PSS/SSS detection (Frequency range FR1)

DRX cycle	T_{PSS/SSS_sync_intra}
No DRX	max(600ms, 5 x max(MGRP, SMTC period)) x $CSSF_{intra}$
DRX cycle≤ 320ms	max(600ms, ceil(1.5x 5) x max(MGRP, SMTC period,DRX cycle)) x $CSSF_{intra}$
DRX cycle>320ms	5 x max(MGRP, DRX cycle) x $CSSF_{intra}$

Table 9.2.6.2-2: Time period for PSS/SSS detection (Frequency range FR2)

DRX cycle	T_{PSS/SSS_sync_intra}
No DRX	max(600ms, $M_{pss/sss\_sync\_with\_gaps}$ x max(MGRP, SMTC period)) x $CSSF_{intra}$
DRX cycle≤ 320ms	max(600ms, ceil(1.5x $M_{pss/sss\_sync\_with\_gaps}$) x max(MGRP, SMTC period, DRX cycle)) x $CSSF_{intra}$
DRX cycle>320ms	$M_{pss/sss\_sync\_with\_gaps}$ x max(MGRP, DRX cycle) x $CSSF_{intra}$

Table 9.2.6.2-3: Time period for time index detection (Frequency range FR1)

DRX cycle	$T_{SSB\_time\_index\_intra}$
No DRX	max(120ms, 3 x max(MGRP, SMTC period)) x $CSSF_{intra}$
DRX cycle≤ 320ms	max(120ms, ceil(1.5x 3) x max(MGRP, SMTC period,DRX cycle) x $CSSF_{intra}$)
DRX cycle>320ms	3 x max(MGRP, DRX cycle) x $CSSF_{intra}$

Table 9.2.6.2-7: Void

Table 9.2.6.2-8: Void

9.2.6.3 Intrafrequency Measurement Period

The measurement period for FR1 intrafrequency measurements with gaps is as shown in table 9.2.6.3-1.

The measurement period for FR2 intrafrequency measurements with gaps is as shown in table 9.2.6.3-2 .

If SCG DRX is in use, intrafrequency measurement period requirements specified in Table 9.2.6.3-1and Table 9.2.6.3-2, shall depend on the SCG DRX cycle. Otherwise, the requirements for when DRX is not in use shall apply.

Table 9.2.6.3-1: Measurement period for intrafrequency measurements with gaps(Frequency Range FR1)

DRX cycle	$T_{SSB\_measurement\_period\_intra}$
No DRX	max(200ms, 5 x max(MGRP, SMTC period)) x $CSSF_{intra}$
DRX cycle≤ 320ms	max(200ms, ceil(1.5x 5) x max(MGRP, SMTC period,DRX cycle)) x $CSSF_{intra}$
DRX cycle>320ms	5 x max(MGRP, DRX cycle) x $CSSF_{intra}$

Table 9.2.6.3-2: Measurement period for intrafrequency measurements with gaps(Frequency Range FR2)

DRX cycle	$T_{SSB\_measurement\_period\_intra}$
No DRX	max(400ms, $M_{meas\_period\ with\_gaps}$ x max(MGRP, SMTC period)) x $CSSF_{intra}$
DRX cycle≤ 320ms	max(400ms, ceil(1.5 x $M_{meas\_period\ with\_gaps}$) x max(MGRP, SMTC period, DRX cycle)) Note 1 x $CSSF_{intra}$
DRX cycle>320ms	$M_{meas\_period\ with\_gaps}$ x max(MGRP, DRX cycle) x $CSSF_{intra}$

9.3 NR inter-frequency measurements

9.3.1 Introduction

A measurement is defined as a SSB based inter-frequency measurement provided it is not defined as in intra-frequency measurement according to section 9.2.

The UE shall be able to identify new inter-frequency cells and perform SS-RSRP, SS-RSRQ, and SS-SINR measurements of identified inter-frequency cells if carrier frequency information is provided by PCell or the PSCell, even if no explicit neighbour list with physical layer cell identities is provided.

SSB based measurements are configured along with a measurement timing configuration (SMTC) per carrier, which provides periodicity, duration and offset information on a window of up to 5ms where the measurements on the configured inter-frequency carrier are to be performed. For inter-frequency connected mode measurements, one measurement window periodicity may be configured per inter-frequency measurement object.

When measurement gaps are needed, the UE is not expected to detect SSB on an inter-frequency measurement object which start earlier than the gap starting time + switching time, nor detect SSB which end later than the gap end – switching time. When the inter-frequency cells are in FR2 and the per-FR gap is configured to the UE in EN-DC, SA NR, NE-DC and NR-DC, or the serving cells are in FR2, the inter-frequency cells are in FR2 and the per-UE gap is configured to the UE in SA NR and NR-DC, the switching time is 0.25ms. Otherwise the switching time is 0.5ms.

9.3.2 Requirements applicability

The requirements in Section 9.3 apply, provided:

- The cell being identified or measured is detectable.

An inter-frequency cell shall be considered detectable when for each relevant SSB:

- SS-RSRP related side conditions given in Sections 10.1.4 and 10.1.5 for FR1 and FR2, respectively, for a corresponding Band,
- SS-RSRQ related side conditions given in Sections 10.1.9 and 10.1.10 for FR1 and FR2, respectively, for a corresponding Band,
- SS-SINR related side conditions given in Sections 10.1.14 and 10.1.15 for FR1 and FR2, respectively, for a corresponding Band,
- SSB_RP and SSB Ês/Iot according to Annex B.2.3 for a corresponding Band.

9.3.2.1 Void

9.3.2.2 Void

9.3.3 Number of cells and number of SSB

9.3.3.1 Requirements for FR1

For each inter-frequency layer, during each layer 1 measurement period, the UE shall be capable of performing SS-RSRP, SS-RSRQ, and SS-SINR measurements for at least:

- 4 identified cells, and
- 7 SSBs with different SSB index and/or PCI on the inter-frequency layer.

9.3.3.2 Requirements for FR2

For each inter-frequency layer, during each layer 1 measurement period, the UE shall be capable of performing SS-RSRP, SS-RSRQ, and SS-SINR measurements for at least:

- 4 identified cells, and
- 10 SSBs with different SSB index and/or PCI on the inter-frequency layer, and
- one SSB per identified cell.

9.3.4 Inter frequency cell identification

When measurement gaps are provided, or the UE supports capability of conducting such measurements without gaps, the UE shall be able to identify a new detectable inter frequency cell within $T_{identify\_inter\_without\_index}$ if UE is not indicated to report SSB based RRM measurement result with the associated SSB index (*reportQuantityRsIndexes* or *maxNrofRSIndexesToReport* is not configured). Otherwise UE shall be able to identify a new detectable inter frequency cell within $T_{identify\_inter\_with\_index}$. The UE shall be able to identify a new detectable inter frequency SS block of an already detected cell within $T_{identify\_inter\_without\_index}$.

$$T_{identify\_inter\_without\_index} = (T_{PSS/SSS\_sync\_inter} + T_{SSB\_measurement\_period\_inter})\ ms$$

$$T_{identify\_inter\_with\_index} = (T_{PSS/SSS\_sync\_inter} + T_{SSB\_measurement\_period\_inter} + T_{SSB\_time\_index\_inter})\ ms$$

Where:

T_{PSS/SSS_sync_inter}: it is the time period used in PSS/SSS detection given in table 9.3.4-1 and table 9.3.4-2.

$T_{SSB\_time\_index\_inter}$: it is the time period used to acquire the index of the SSB being measured given in table 9.3.4-3 and table 9.3.4-4.

$T_{SSB\_measurement\_period\_inter}$: equal to a measurement period of SSB based measurement given in table 9.3.5-1 and table 9.3.5-2.

M_{pss/sss_sync_inter}: For a UE supporting FR2 power class 1, M_{pss/sss_sync_inter} = 64 samples. For a UE supporting FR2 power class 2, M_{pss/sss_sync_inter} = 40 samples. For a UE supporting FR2 power class 3, M_{pss/sss_sync_inter} = 40 samples. For a UE supporting FR2 power class 4, M_{pss/sss_sync} = 40 samples.

$M_{SSB\_index\_inter}$: For a UE supporting power class 1, $M_{SSB\_index\_inter}$ = 40 samples. For a vehicle mounted UE supporting power class 2, M_{pss/sss_sync_inter} = 24 samples. For a UE supporting power class 3, $M_{SSB\_index\_inter}$ = 24 samples. For a UE supporting power class 4, $M_{meas\_period\_inter}$ = 24 samples.

$M_{meas\_period\_inter}$: For a UE supporting FR2 power class 1, $M_{meas\_period\_inter}$ =64 samples. For a vehicle mounted UE supporting FR2 power class 2, M_{pss/sss_sync_inter}=40 samples. For a UE supporting FR2 power class 3, $M_{meas\_period\_inter}$ =40 samples. For a UE supporting FR2 power class 4, $M_{meas\_period\_inter}$ = 40 samples.

$CSSF_{inter}$: it is a carrier specific scaling factor and is determined according to $CSSF_{within\_gap,i}$ in section 9.1.5.2 for measurement conducted within measurement gaps.

Table 9.3.4-1: Time period for PSS/SSS detection, (Frequency range FR1)

Condition NOTE1,2	T_{PSS/SSS_sync_inter}
No DRX	max[600ms, [8] x max(MGRP, SMTC period)] x $CSSF_{inter}$
DRX cycle ≤ 320ms	max[600ms, ceil(8x1.5) x max(MGRP, SMTC period, DRX cycle)] x $CSSF_{inter}$
DRX cycle > 320ms	[8] x DRX cycle x $CSSF_{inter}$
NOTE 1: DRX or non DRX requirements apply according to the conditions described in section 3.6.1 NOTE 2: In EN-DC operation, the parameters, timers and scheduling requests referred to in section 3.6.1 are for the secondary cell group. The DRX cycle is the DRX cycle of the secondary cell group.	

Table 9.3.4-2: Time period for PSS/SSS detection, (Frequency range FR2)

Condition NOTE1,2	T_{PSS/SSS_sync_inter}
No DRX	max[600ms, M_{pss/sss_sync_inter} x max(MGRP, SMTC period)] x $CSSF_{inter}$
DRX cycle ≤ 320ms	max[600ms, (1.5 x M_{pss/sss_sync_inter}) x max(MGRP, SMTC period, DRX cycle)] x $CSSF_{inter}$
DRX cycle > 320ms	M_{pss/sss_sync_inter} x DRX cycle x $CSSF_{inter}$
NOTE 1: DRX or non DRX requirements apply according to the conditions described in section 3.6.1 NOTE 2: In EN-DC operation, the parameters, timers and scheduling requests referred to in section 3.6.1 are for the secondary cell group. The DRX cycle is the DRX cycle of the secondary cell group.	

Table 9.3.4-3: Time period for time index detection (Frequency range FR1)

Condition NOTE1,2	$T_{SSB\_time\_index\_inter}$
No DRX	max[120ms, [3] x max(MGRP, SMTC period)] x $CSSF_{inter}$
DRX cycle ≤ 320ms	max[120ms, ceil(3 x 1.5) x max(MGRP, SMTC period, DRX cycle)] x $CSSF_{inter}$
DRX cycle > 320ms	[3] x DRX cycle x $CSSF_{inter}$
NOTE 1: DRX or non DRX requirements apply according to the conditions described in section 3.6.1 NOTE 2: In EN-DC operation, the parameters, timers and scheduling requests referred to in section 3.6.1 are for the secondary cell group. The DRX cycle is the DRX cycle of the secondary cell group.	

Table 9.3.4-4: Time period for time index detection (Frequency range FR2)

Condition NOTE1,2	$T_{SSB\_time\_index\_inter}$
No DRX	max[200ms, $M_{SSB\_index\_inter}$ x max(MGRP, SMTC period)] x $CSSF_{inter}$
DRX cycle ≤ 320ms	max[200ms, (1.5 x $M_{SSB\_index\_inter}$) x max(MGRP, SMTC period, DRX cycle)] x $CSSF_{inter}$
DRX cycle > 320ms	$M_{SSB\_index\_inter}$ x DRX cycle x $CSSF_{inter}$
NOTE 1: DRX or non DRX requirements apply according to the conditions described in section 3.6.1 NOTE 2: In EN-DC operation, the parameters, timers and scheduling requests referred to in section 3.6.1 are for the secondary cell group. The DRX cycle is the DRX cycle of the secondary cell group.	

9.3.4.1 Void

9.3.4.2 Void

9.3.5 Inter frequency measurements

When measurement gaps are provided for inter frequency measurements, or the UE supports capability of conducting such measurements without gaps, the UE physical layer shall be capable of reporting SS-RSRP, SS-RSRQ and SS-SINR measurements to higher layers with measurement accuracy as specified in sub-clauses 10.1.4, 10.1.5, 10.1.9, 10.1.10, 10.1.14 and 10.1.15, respectively, as shown in table 9.3.5-1 and 9.3.5-2:

Table 9.3.5-1: Measurement period for inter-frequency measurements with gaps (Frequency FR1)

Condition NOTE1,2	$T_{SSB\_measurement\_period\_inter}$
No DRX	max[200ms, [8] x max(MGRP, SMTC period)] x $CSSF_{inter}$
DRX cycle ≤ 320ms	max[200ms, ceil(8 x 1.5) x max(MGRP, SMTC period, DRX cycle)] x $CSSF_{inter}$
DRX cycle > 320ms	[8] x DRX cycle x $CSSF_{inter}$
NOTE 1: DRX or non DRX requirements apply according to the conditions described in section 3.6.1 NOTE 2: In EN-DC operation, the parameters, timers and scheduling requests referred to in section 3.6.1 are for the secondary cell group. The DRX cycle is the DRX cycle of the secondary cell group.	

Table 9.3.5-2: Measurement period for inter-frequency measurements with gaps (Frequency FR2)

Condition NOTE1,2	$T_{SSB\_measurement\_period\_inter}$
No DRX	max[400ms, $M_{meas\_period\_inter}$ x max(MGRP, SMTC period)] x $CSSF_{inter}$
DRX cycle ≤ 320ms	max[400ms, (1.5 x $M_{meas\_period\_inter}$) x max(MGRP, SMTC period, DRX cycle)] x $CSSF_{inter}$
DRX cycle > 320ms	$M_{meas\_period\_inter}$ x DRX cycle x $CSSF_{inter}$
NOTE 1: DRX or non DRX requirements apply according to the conditions described in section 3.6.1 NOTE 2: In EN-DC operation, the parameters, timers and scheduling requests referred to in section 3.6.1 are for the secondary cell group. The DRX cycle is the DRX cycle of the secondary cell group.	

9.3.5.1 Void

9.3.5.2 Void

9.3.5.3 Void

9.3.6 NR Inter frequency measurements reporting requirements

9.3.6.1 Periodic Reporting

Reported SS-RSRP, SS-RSRQ, and SS-SINR measurements contained in periodically triggered measurement reports shall meet the requirements in sections 10.1.4.1, 10.1.5.1, 10.1.9.1, 10.1.10.1, 10.1.14.1 and 10.1.15.1, respectively.

9.3.6.2 Event-triggered Periodic Reporting

Reported SS-RSRP, SS-RSRQ, and SS-SINR measurements contained in event triggered periodic measurement reports shall meet the requirements in sections 10.1.4.1, 10.1.5.1, 10.1.9.1, 10.1.10.1, 10.1.14.1 and 10.1.15.1, respectively.

The first report in event triggered periodic measurement reporting shall meet the requirements specified in clause 9.3.6.3.

9.3.6.3 Event-triggered Reporting

Reported SS-RSRP, SS-RSRQ, and SS-SINR measurements contained in event triggered measurement reports shall meet the requirements in sections 10.1.4.1, 10.1.5.1, 10.1.9.1, 10.1.10.1, 10.1.14.1 and 10.1.15.1, respectively.

The UE shall not send any event triggered measurement reports, as long as no reporting criteria are fulfilled.

The measurement reporting delay is defined as the time between an event that will trigger a measurement report and the point when the UE starts to transmit the measurement report over the air interface. This requirement assumes that the measurement report is not delayed by other RRC signalling on the DCCH. This measurement reporting delay excludes a delay uncertainty resulted when inserting the measurement report to the TTI of the uplink DCCH. The delay uncertainty is: 2 x TTI_{DCCH}. This measurement reporting delay excludes a delay which caused by no UL resources for UE to send the measurement report.

The event triggered measurement reporting delay, measured without L3 filtering shall be within $T_{identify\_inter\_without\_index}$ if UE is not indicated to report SSB based RRM measurement result with the associated SSB index. Otherwise UE shall be able to identify a new detectable inter frequency cell within $T_{identify\_inter\_with\_index}$. Both $T_{identify\_inter\_without\_index}$ and $T_{identify\_inter\_with\_index}$ are defined in clause 9.3.4. When L3 filtering is used an additional delay can be expected.

If a cell which has been detectable at least for the time period $T_{identify\_inter\_without\_index}$ or $T_{identify\_inter\_with\_index}$ defined in clause 9.3.4 and then triggers the measurement report as per TS 38.331 [2], the event triggered measurement reporting delay shall be less than $T_{SSB\_measurement\_period\_inter}$ defined in clause 9.3.5 provided the timing to that cell has not changed more than ± 3200 Tc while measurement gap has not been available and the L3 filter has not been used. When L3 filtering is used an additional delay can be expected.

9.3.7 Void

9.4 Inter-RAT measurements

9.4.1 Introduction

The requirements in this section are specified for NR−E-UTRAN FDD and NR−E-UTRAN TDD measurements and are applicable without an explicit E-UTRAN neighbour cell list containing physical layer cell identities, for a UE:

- in RRC_CONNECTED state, and
- configured with at least PCell, and
- configured with an appropriate measurement gap pattern according to Table 9.1.2-3.

Parameter T_{Inter1} used in inter-RAT requirements in Section 9.4 is specified in Table 9.4.1-1.

Table 9.4.1-1: Minimum available time for inter-RAT measurements

Gap Pattern Id	MeasurementGap Length (MGL, ms)	Measurement Gap Repetition Period (MGRP, ms)	Minimum available time for inter-frequency and inter-RAT measurements during 480ms period (Tinter1, ms)
0	6	40	60
1	6	80	30
2	3	40	24 Note 1
3	3	80	12 Note 1
4	6	20	120 Note 1
6	4	20	72 Note 1,3,6
7	4	40	36 Note 1,4,6
8	4	80	18 Note 1,5,6
10	3	20	48 Note 1
NOTE 1: When determing UE requirements using Tinter1 for GP2 , 3, 4, 6, 7, 8, 10, Tinter1 = 60 for GP2, GP4, GP6, GP7, GP10 and Tinter1 = 30 for GP3 and GP8 shall be used. NOTE 2: Measurement gaps pattern configurations applicability is as specified in Table 9.1.2-1. NOTE 3: When this gap pattern is used, the T_{inter} for E-UTRA inter-frequency measurements is 48 ms corresponding to the first 3 ms of the 4 ms gap NOTE 4: When this gap pattern is used, the T_{inter} for E-UTRA inter-frequency measurements is 24 ms corresponding to the first 3 ms of the 4 ms gap NOTE 5: When this gap pattern is used, the T_{inter} for E-UTRA inter-frequency measurements is 12 ms corresponding to the first 3 ms of the 4 ms gap NOTE 6: This gap pattern is applicable for E-UTRA inter-frequency measurements only if gap based NR measurements are also configured.			

Editor's note: a note to be added in Table 9.4.1-1 on that measurement gap patterns #2 #3, #6, #7, #8, #10 are supported only by the UEs which have a corresponding capability once RAN2 specifies the capability.

A UE configured with gap pattern Id 2, 3 or 10, shall be able to detect a target cell if the E-UTRA subframe #0 or #5 of the target E-UTRAN cell begins no earlier than 500 μs from the start of the measurement gap and if the E-UTRA subframe #0 or #5 of the target E-UTRAN cell ends no later than 500 μs before the end of the measurement gap in case of FDD, and no later than 750 μs before the end of measurement gap in case of TDD.

A UE configured with gap pattern Id 6, 7 or 8 shall be able to detect a target cell if the E-UTRA subframe #0 or #5 of the target E-UTRAN cell begins no earlier than 500 μs from the start of the measurement gap and if the E-UTRA subframe #0 or #5 of the target E-UTRAN cell ends no later than 1500 μs before the end of the measurement gap in case of FDD, and no later than 1750 μs before the end of measurement gap in case of TDD.

9.4.2 SA: NR − E-UTRAN FDD measurements

9.4.2.1 Introduction

The requirements are applicable for NR−E-UTRAN FDD RSRP, RSRQ, and RS-SINR measurements.

In the requirements, an E-UTRAN FDD cell is considered to be detectable when:

- RSRP related conditions in the accuracy requirements in Section 10.2.2 are fulfilled for a corresponding Band, together with the corresponding side conditions in Annex B.2.3 and Annex B.3.3 of TS 36.133 [15],
- RSRQ related conditions in the accuracy requirements in Section 10.2.3 are fulfilled for a corresponding Band, together with the corresponding side conditions in Annex B.2.3 and Annex B.3.3 of TS 36.133 [15],
- RS-SINR related conditions in the accuracy requirements in Section 10.2.5 are fulfilled for a corresponding Band, together with the corresponding side conditions in Annex B.2.3 and Annex B.3.19 of TS 36.133 [15].

9.4.2.2 Requirements when no DRX is used

When the UE requires measurement gaps to idenitify and measure inter-RAT cells and an appropriate measurement gap pattern is scheduled, the UE shall be able to identify a new detectable FDD cell within $T_{\text{Identify, E-UTRAN FDD}}$ according to the following expression:

$$T_{Identify,E-UTRAN\ FDD} = T_{BasicIdentify} * \frac{480}{T_{Inter1}} * K \quad ms,$$

where:

$T_{\text{BasicIdentify}}$ = 480 ms,

T_{Inter1} is defined in Section 9.4.1,

$CSSF_{\text{interRAT}} = CSSF_{\text{within\_gap\_i\_}}$ is the scaling factor for the measured inter-RAT E-UTRA carrier i which is calculated as specified in Section 9.1.5.2.

Identification of a cell shall include detection of the cell and additionally performing a single measurement with measurement period of $T_{\text{Measure, E-UTRAN FDD}}$ defined in Table 9.4.2.2-1.

Table 9.4.2.2-1: Measurement period and measurement bandwidth

Configuration	Physical Layer Measurement period: $T_{\text{Measure, E-UTRAN FDD}}$ [ms]	Measurement bandwidth [RB]
0	480 x $CSSF_{\text{interRAT}}$	6
1 (Note 1)	240 x $CSSF_{\text{interRAT}}$	50
NOTE 1: This configuration is optional.		

The UE shall be capable of identifying and performing NR – E-UTRAN FDD RSRP, RSRQ, and RS-SINR measurements of at least 4 identified E-UTRAN FDD cells per E-UTRA FDD carrier frequency layer during each layer 1 measurement period, for up to 7 E-UTRA FDD carrier frequency layers.

If higher layer filtering is used, an additional cell identification delay can be expected.

The NR – E-UTRAN FDD RSRP measurement accuracy for all measured cells shall be as specified in Section 10.2.2. The NR – E-UTRAN FDD RSRQ measurement accuracy for all measured cells shall be as specified in Section 10.2.3. The NR – E-UTRAN FDD RS-SINR measurement accuracy for all measured cells shall be as specified in Section 10.2.5.

9.4.2.3 Requirements when DRX is used

When DRX is in use and measurement gaps are configured, the UE shall be able to identify a new detectable E-UTRAN FDD cell within $T_{\text{Identify, E-UTRAN FDD}}$ specified in Table 9.4.2.3-1.

Table 9.4.2.3-1: Requirement to identify a newly detectable E-UTRAN FDD cell

DRX cycle length (s)	$T_{Identify, E\text{-}UTRAN FDD}$ (s) (DRX cycles)	
	Gap period = 40 ms, 20 ms	Gap period = 80 ms
≤0.16	Non-DRX requirements in Section 9.4.2.2 apply	Non-DRX requirements in Section 9.4.2.2 apply
0.256	5.12*K (20*$CSSF_{interRAT}$)	7.68*K (30*$CSSF_{interRAT}$)
0.32	6.4*K (20*$CSSF_{interRAT}$)	7.68*K (24*$CSSF_{interRAT}$)
0.32< DRX-cycle ≤ 10.24	Note1 (20*$CSSF_{interRAT}$)	Note1 (20*$CSSF_{interRAT}$)
NOTE 1: The time depends on the DRX cycle length. NOTE 2: $CSSF_{interRAT}$ is as defined in Section 9.4.2.2.		

When DRX is in use, the UE shall be capable of performing NR – E-UTRAN FDD RSRP, RSRQ, and RS-SINR measurements of at least 4 identified E-UTRAN FDD cells per E-UTRA FDD frequency layer during each layer 1 measurement period, for up to 7 E-UTRA FDD carrier frequency layers, and the UE physical layer shall be capable of reporting NR – E-UTRAN FDD RSRP, RSRQ, and RS-SINR measurements to higher layers with the measurement period $T_{measure, E\text{-}UTRAN FDD}$ specified in Table 9.4.2.3-2.

Table 9.4.2.3-2: Requirement to measure E-UTRAN FDD cells

DRX cycle length (s)	$T_{measure, E\text{-}UTRAN FDD}$ (s) (DRX cycles)
≤0.08	Non-DRX requirements in Section 9.4.2.2 apply
0< DRX-cycle ≤ 10.24	Note1 (5* $CSSF_{interRAT}$)
NOTE 1: The time depends on the DRX cycle length. NOTE 2: $CSSF_{interRAT}$ is as defined in Section 9.4.2.2.	

If higher layer filtering is used, an additional cell identification delay can be expected.

The NR – E-UTRAN FDD RSRP measurement accuracy for all measured cells shall be as specified in Section 10.2.2. The NR – E-UTRAN FDD RSRQ measurement accuracy for all measured cells shall be as specified in Section 10.2.3. The NR – E-UTRAN FDD RS-SINR measurement accuracy for all measured cells shall be as specified in Section 10.2.5.

9.4.2.4 Measurement reporting requirements

9.4.2.4.1 Periodic Reporting

The reported NR – E-UTRAN FDD RSRP, RSRQ, and RS-SINR measurements contained in periodically triggered measurement reports shall meet the requirements in Sections 10.2.2, 10.2.3, and 10.2.5, respectively.

9.4.2.4.2 Event-Triggered Periodic Reporting

The reported NR – E-UTRAN FDD RSRP, RSRQ, and RS-SINR measurements contained in event-triggered periodic measurement reports shall meet the requirements in Sections 10.2.2, 10.2.3, and 10.2.5, respectively.

The first report in event-triggered periodic measurement reporting shall meet the requirements specified in Section 9.4.2.4.3.

9.4.2.4.3 Event-Triggered Reporting

The reported NR – E-UTRAN FDD RSRP, RSRQ, and RS-SINR measurements contained in event-triggered measurement reports shall meet the requirements in Sections 10.2.2, 10.2.3, and 10.2.5, respectively.

The UE shall not send any event-triggered measurement reports, as long as no reporting criteria are fulfilled.

The measurement reporting delay is defined as the time between an event that will trigger a measurement report and the point when the UE starts to transmit the measurement report over the air interface. This requirement assumes that that the measurement report is not delayed by other RRC signalling on the DCCH. This measurement reporting delay excludes a delay uncertainty resulted when inserting the measurement report to the TTI of the uplink DCCH. The delay uncertainty is: 2 x TTI_{DCCH} where TTI_{DCCH} is the duration of subframe or slot or subslot when the measurement report is transmitted on the PUSCH with subframe or slot or subslot duration. This measurement reporting delay excludes a delay which caused by no UL resources for UE to send the measurement report.

The event triggered measurement reporting delay, measured without L3 filtering shall be less than $T_{\text{Identify, E-UTRAN FDD}}$ defined in Sections 9.4.2.2 and 9.4.2.3 without DRX and with DRX, respectively. When L3 filtering is used, an additional delay can be expected.

If a cell which has been detectable at least for the time period $T_{\text{Identify, E-UTRAN FDD}}$ becomes undetectable for a period ≤ [5] seconds and then the cell becomes detectable again and triggers an event as per TS 38.331 [2], the event triggered measurement reporting delay shall be less than $T_{\text{Measure, E-UTRAN FDD}}$ provided the timing to that cell has not changed more than ± 50 Ts while measurement gap has not been available and the L3 filter has not been used.

9.4.3 SA: NR − E-UTRAN TDD measurements

9.4.3.1 Introduction

The requirements are applicable for NR−E-UTRAN TDD RSRP, RSRQ, and RS-SINR measurements.

In the requirements, an E-UTRAN TDD cell is considered to be detectable when:

- RSRP related conditions in the accuracy requirements in Section 10.2.2 are fulfilled for a corresponding Band, together with the corresponding side conditions in Annex B.2.3 and Annex B.3.3 of TS 36.133 [15],
- RSRQ related conditions in the accuracy requirements in Section 10.2.3 are fulfilled for a corresponding Band, together with the corresponding side conditions in Annex B.2.3 and Annex B.3.3 of TS 36.133 [15],

  RS-SINR related conditions in the accuracy requirements in Section 10.2.5 are fulfilled for a corresponding Band, together with the corresponding side conditions in Annex B.2.3 and Annex B.3.19 of TS 36.133 [15].-.

9.4.3.2 Requirements when no DRX is used

When the UE requires measurement gaps to idenitify and measure inter-RAT cells and an appropriate measurement gap pattern is scheduled, the UE shall be able to identify a new detectable TDD cell within $T_{\text{Identify, E-UTRAN TDD}}$ according to the following expression:

- When configuration 0 or configuration 1 in Table 9.4.3.2-1 is applied,

,

- When configuration 2 or configuration 3 in Table 9.4.3.2-1 is applied,

,

where:

$T_{BasicIdentify}$ = 480 ms,

T_{Inter1} is defined in Section 9.4.1,

$CSSF_{interRAT} = CSSF_{within\_gap\_i\_}$ is the scaling factor for the measured inter-RAT E-UTRA carrier i which is calculated as specified in Section 9.1.5.2.

Identification of a cell shall include detection of the cell and additionally performing a single measurement with measurement period of $T_{\text{Measure, E-UTRAN TDD}}$ defined in Table 9.4.3.2-1.

Table 9.4.3.2-1: $T_{Measure, E\text{-}UTRAN TDD}$ for different configurations

Configuration	Measurement bandwidth [RB]	Number of UL/DL sub-frames per half frame (5 ms)		DwPTS		$T_{Measure, E\text{-}UTRAN TDD}$ [ms]
		DL	UL	Normal CP	Extended CP	
0	6	2	2	$19760 \cdot T_s$	$20480 \cdot T_s$	480 x $CSSF_{interRAT}$
1 (Note 1)	50	2	2	$19760 \cdot T_s$	$20480 \cdot T_s$	240 x $CSSF_{interRAT}$
NOTE 1: This configuration is optional.NOTE 2: Void						

The UE shall be capable of identifying and performing NR – E-UTRAN TDD RSRP, RSRQ, and RS-SINR measurements of at least 4 identified E-UTRAN TDD cells per E-UTRA TDD carrier frequency layer during each layer 1 measurement period, for up to 7 E-UTRA TDD carrier frequency layers.

If higher layer filtering is used, an additional cell identification delay can be expected.

The NR – E-UTRAN TDD RSRP measurement accuracy for all measured cells shall be as specified in Section 10.2.2. The NR – E-UTRAN TDD RSRQ measurement accuracy for all measured cells shall be as specified in Section 10.2.3. The NR – E-UTRAN TDD RS-SINR measurement accuracy for all measured cells shall be as specified in Section 10.2.5.

9.4.3.3 Requirements when DRX is used

When DRX is in use and measurement gaps are configured, the UE shall be able to identify a new detectable E-UTRAN TDD cell within $T_{Identify, E\text{-}UTRAN TDD}$ specified in Table 9.4.3.3-1.

Table 9.4.3.3-1: Requirement to identify a newly detectable E-UTRAN TDD cell

DRX cycle length (s)	$T_{Identify, E\text{-}UTRAN TDD}$ (s) (DRX cycles)	
	Gap period = 40 ms, 20 ms	Gap period = 80 ms
≤0.16	Non-DRX requirements in Section 9.4.3.2 apply	Non-DRX requirements in Section 9.4.3.2 apply
0.256	5.12*K (20*$CSSF_{interRAT}$)	7.68*K (30*$CSSF_{interRAT}$)
0.32	6.4*K (20*$CSSF_{interRAT}$)	7.68*K (24*$CSSF_{interRAT}$)
0.32< DRX-cycle ≤10.24	Note1 (20*$CSSF_{interRAT}$)	Note1 (20*$CSSF_{interRAT}$)
NOTE 1: The time depends on the DRX cycle length. NOTE 2: $CSSF_{interRAT}$ is as defined in Section 9.4.3.2.		

When DRX is in use, the UE shall be capable of performing NR – E-UTRAN TDD RSRP, RSRQ, and RS-SINR measurements of at least 4 identified E-UTRAN TDD cells per E-UTRA TDD frequency layer during each layer 1 measurement period, for up to 7 E-UTRA TDD carrier frequency layers, and the UE physical layer shall be capable of reporting NR – E-UTRAN TDD RSRP, RSRQ, and RS-SINR measurements to higher layers with the measurement period $T_{measure, E\text{-}UTRAN TDD}$ specified in Table 9.4.3.3-2.

Table 9.4.3.3-2: Requirement to measure E-UTRAN TDD cells

DRX cycle length (s)	$T_{measure, E\text{-}UTRAN TDD}$ (s) (DRX cycles)
≤0.08	Non-DRX Requirements in Section 9.4.3.2 apply
0.128	For configuration 2, non-DRX requirements in section 9.4.3.2 apply, Otherwise: Note1 (5*$CSSF_{interRAT}$)
0.128<DRX-cycle≤ 10.24	Note1 (5*$CSSF_{interRAT}$)
NOTE 1: The time depends on the DRX cycle length. NOTE 2: $CSSF_{interRAT}$ is as defined in Section 9.4.3.2.	

If higher layer filtering is used, an additional cell identification delay can be expected.

The NR – E-UTRAN TDD RSRP measurement accuracy for all measured cells shall be as specified in Section 10.2.2.
The NR – E-UTRAN TDD RSRQ measurement accuracy for all measured cells shall be as specified in Section 10.2.3.
The NR – E-UTRAN TDD RS-SINR measurement accuracy for all measured cells shall be as specified in Section 10.2.5.

9.4.3.4 Measurement reporting requirements

9.4.3.4.1 Periodic Reporting

The reported NR – E-UTRAN TDD RSRP, RSRQ, and RS-SINR measurements contained in periodically triggered measurement reports shall meet the requirements in Sections 10.2.2, 10.2.3, and 10.2.5, respectively.

9.4.3.4.2 Event-Triggered Periodic Reporting

The reported NR – E-UTRAN TDD RSRP, RSRQ, and RS-SINR measurements contained in event-triggered periodic measurement reports shall meet the requirements in Sections 10.2.2, 10.2.3, and 10.2.5, respectively.

The first report in event-triggered periodic measurement reporting shall meet the requirements specified in Section 9.4.3.4.3.

9.4.3.4.3 Event-Triggered Reporting

The reported NR – E-UTRAN TDD RSRP, RSRQ, and RS-SINR measurements contained in event-triggered measurement reports shall meet the requirements in Sections 10.2.2, 10.2.3, and 10.2.5, respectively.

The UE shall not send any event-triggered measurement reports, as long as no reporting criteria are fulfilled.

The measurement reporting delay is defined as the time between an event that will trigger a measurement report and the point when the UE starts to transmit the measurement report over the air interface. This requirement assumes that that the measurement report is not delayed by other RRC signalling on the DCCH. This measurement reporting delay excludes a delay uncertainty resulted when inserting the measurement report to the TTI of the uplink DCCH. The delay uncertainty is: 2 x TTI_{DCCH} where TTI_{DCCH} is the duration of subframe or slot or subslot when the measurement report is transmitted on the PUSCH with subframe or slot or subslot duration. This measurement reporting delay excludes a delay which caused by no UL resources for UE to send the measurement report.

The event triggered measurement reporting delay, measured without L3 filtering shall be less than $T_{\text{Identify, E-UTRAN TDD}}$ defined in Sections 9.4.3.2 and 9.4.3.3 without DRX and with DRX, respectively. When L3 filtering is used, an additional delay can be expected.

If a cell which has been detectable at least for the time period $T_{\text{Identify, E-UTRAN TDD}}$ becomes undetectable for a period ≤ [5] seconds and then the cell becomes detectable again and triggers an event as per TS 38.331 [2], the event triggered measurement reporting delay shall be less than $T_{\text{Measure, E-UTRAN TDD}}$ provided the timing to that cell has not changed more than ± 50 Ts while measurement gap has not been available and the L3 filter has not been used.

9.4.4 SA: Inter-RAT RSTD measurements

9.4.4.1 SA: NR − E-UTRAN FDD RSTD measurements

9.4.4.1.1 Introduction

The requirements are applicable for NR−E-UTRAN FDD RSTD measurements requested via LPP [22, 24].

The requirements in section 9.4.4.1 apply when:

- the UE is provided with the LTE timing information via LPP [24], including both *nr-LTE-SFN-Offset* and *nr-LTE-fineTiming-Offset*, or
- the UE is not provided with *nr-LTE-SFN-Offset* or *nr-LTE-fineTiming-Offset*, or
- the UE is provided with *nr-LTE-SFN-Offset* but not with *nr-LTE-fineTiming-Offset*.

When the UE is not aware of the SFN of at least one LTE cell in the OTDOA assistance data, the UE may be using autonomous gaps in FR1 to acquire SFN of the OTDOA assistance data reference cell prior to requesting measurement gaps for performing the requested E-UTRA RSTD measurements before the $\mathrm{T}_{\mathrm{RSTD\ InterRAT,E\text{-}UTRAN\ FDD}}$ time period starts while meeting all the requirements in Section 9.4.4.1.2, provided that the OTDOA assistance data is provided to allow sufficient time for the UE to acquire the SFN before the $\mathrm{T}_{\mathrm{RSTD\ InterRAT,E\text{-}UTRAN\ FDD}}$ starts.

When the UE is not aware of and cannot derive the subframe timing difference between the NR serving cell and the OTDOA assistance data reference cell, the UE may need to request measurement gaps in FR1 to perform cell detection for the OTDOA assistance data reference cell prior to requesting measurement gaps for performing the requested E-UTRA RSTD measurements before the $\mathrm{T}_{\mathrm{RSTD\ InterRAT,E\text{-}UTRAN\ FDD}}$ time period starts while meeting all the requirements in Section 9.4.4.1.2, provided that the OTDOA assistance data is provided to allow sufficient time for the UE to detect the cell before the $\mathrm{T}_{\mathrm{RSTD\ InterRAT,E\text{-}UTRAN\ FDD}}$ starts.

9.4.4.1.2 Requirements

When the physical layer cell identities of neighbour cells together with the OTDOA assistance data are provided, the UE shall be able to detect and measure inter-RAT E-UTRAN FDD RSTD, specified in TS 38.215 [4], for at least *n*=16 cells, including the reference cell, within $\mathrm{T}_{\mathrm{RSTD\ InterRAT,E\text{-}UTRAN\ FDD}}$ ms as given below:

$$\mathrm{T}_{\mathrm{RSTD\ InterRAT,E\text{-}UTRAN\ FDD}} = T_{\mathrm{PRS}} \cdot (M - 1) + \Delta \qquad ms\ ,$$

where

$\mathrm{T}_{\mathrm{RSTD\ InterRAT,E\text{-}UTRAN\ FDD}}$ is the total time for detecting and measuring at least *n* cells,

T_{PRS} is the largest value of the cell-specific positioning subframe configuration period, defined in TS 36.211 [23], among the measured *n* cells including the reference cell,

M is the number of PRS positioning occasions as defined in Table 9.4.4.1.2-1, where each PRS positioning occasion comprises of N_{PRS} ($1 \leq N_{PRS} \leq 6$) consecutive downlink positioning subframes defined in TS 36.211 [23],

$\mathrm{CSSF}_{\mathrm{interRAT}}=\mathrm{CSSF}_{\mathrm{within\_gap\_i}}$ is the scaling factor determined by the gap sharing scheme for the RSTD measurements on the carrier frequency i as defined in Section 9.1.5.2,

$\Delta = 160 \cdot \left\lceil \frac{n}{M} \right\rceil$ ms is the measurement time for a single PRS positioning occasion which includes the sampling time and the processing time, and

the *n* cells are distributed on up to two E-UTRAN FDD carrier frequencies.

Table 9.4.4.1.2-1: Number of PRS positioning occasions within $\mathrm{T}_{\mathrm{RSTD\ InterRAT,E\text{-}UTRAN\ FDD}}$

Positioning subframe configuration period T_{PRS}	Number of PRS positioning occasions M	
	f2 Note1	f1 and f2 Note2
160 ms	16 × $\mathrm{CSSF}_{\mathrm{interRAT}}$	32 × $\mathrm{CSSF}_{\mathrm{interRAT}}$
>160 ms	8 × $\mathrm{CSSF}_{\mathrm{interRAT}}$	16 × $\mathrm{CSSF}_{\mathrm{interRAT}}$
NOTE 1: When inter-RAT E-UTRAN FDD RSTD measurements are performed over the reference cell and neighbour cells, which belong to the E-UTRAN FDD carrier frequency f2. NOTE 2: When inter-RAT E-UTRAN FDD RSTD measurements are performed over the reference cell and the neighbour cells, which belong to the E-UTRAN FDD carrier frequency f1 and the E-UTRAN FDD carrier frequency f2 respectively.		

The UE physical layer shall be capable of reporting RSTD for the reference cell and all the neighbor cells *i* out of at least (*n*-1) neighbor cells within $\mathrm{T}_{\mathrm{RSTD\ InterRAT,E\text{-}UTRAN\ FDD}}$ provided:

$\left(\mathrm{PRS}\ \hat{\mathrm{E}}_{\mathrm{s}} / \mathrm{Iot}\right)_{ref}$ ≥-6 dB for all Frequency Bands for the reference cell,

$\left(\text{PRS}\ \hat{\text{E}}_\text{s}/\text{Iot}\right)_i$ ≥-13 dB for all Frequency Bands for neighbour cell *i*,

$\left(\text{PRS}\ \hat{\text{E}}_\text{s}/\text{Iot}\right)_{ref}$ and $\left(\text{PRS}\ \hat{\text{E}}_\text{s}/\text{Iot}\right)_i$ conditions apply for all subframes of at least $L = \frac{M}{2}$ PRS positioning occasions,

PRP 1,2$|_{\text{dBm}}$ according to TS 36.133 [15, Annex B.2.6] for a corresponding Band

$\text{PRS}\ \hat{\text{E}}_\text{s}/\text{Iot}$ is defined as the ratio of the average received energy per PRS RE during the useful part of the symbol to the average received power spectral density of the total noise and interference for this RE, where the ratio is measured over all REs which carry PRS.

The time $T_{\text{RSTD InterRAT, E-UTRAN FDD}}$ starts from the first subframe of the PRS positioning occasion closest in time after both the *OTDOA-RequestLocationInformation* message and the OTDOA assistance data in the *OTDOA-ProvideAssistanceData* message via LPP as specified in TS 38.305 [22], are delivered to the physical layer of the UE.

The RSTD measurement accuracy for all measured neighbor cells *i* shall be fulfilled according to the accuracy as specified in Section 10.2.4.

9.4.4.1.2.1 RSTD Measurement Reporting Delay

This requirement assumes that the measurement report is not delayed by other LPP signalling on the DCCH. This measurement reporting delay excludes a delay uncertainty resulted when inserting the measurement report to the TTI of the uplink DCCH. The delay uncertainty is: 2 x TTI_{DCCH} where TTI_{DCCH} is the duration of subframe or slot or subslot when the measurement report is transmitted on the PUSCH with subframe or slot or subslot duration. This measurement reporting delay excludes any delay caused by no UL resources for UE to send the measurement report.

9.4.4.1.2.2 Requirements for acquiring the timing of the E-UTRA OTDOA reference cell

When the UE is not aware of the SFN of at least one LTE cell in the OTDOA assistance data, the UE supporting per-FR gaps may make autonomous gaps in downlink reception and uplink transmission of the PCell and each of the SCells in FR1 for acquiring SFN of the reference cell in the E-UTRA OTDOA assistance data. No autonomous gaps in downlink reception or uplink transmission are allowed in any of the UE serving cells in FR2. The UE, which are only supporting per-UE gaps, may make autonomous gaps in downlink reception and uplink transmission of the PCell and each of the SCells for acquiring the SFN of the reference cell in the E-UTRA OTDOA assistance data.

When the UE is not aware of and cannot derive the subframe timing difference between the NR serving cell and the OTDOA assistance data reference cell, the UE may need to request measurement gaps while indicating *eutra-FineTimingDetection* according to TS 38.331 [2] for detecting the reference cell in the E-UTRA OTDOA assistance data.

When the UE is performning one or both of SFN acquisition or cell detection as specified above, the UE shall be able to determine the timing of the E-UTRA OTDOA assistance data reference cell during the time period

$$T_{\text{RefCell,E-UTRAN}} = T_{\text{Detect, E-UTRAN FDD}} + T_{\text{MIB}} + T_{\text{ECGI}}\ ,$$

where

$T_{\text{Detect, E-UTRAN FDD}} = T_{\text{Identify, E-UTRAN FDD}} - T_{\text{measure, E-UTRAN FDD}}$ is according to Section 9.4.2 assuming $CSSF_{\text{interRAT}}$=1 and it is the time needed to detect the E-UTRA OTDOA assistance data reference cell when the UE needs to acquire the subframe and slot timing of the cell, provided the UE is configured with measurement gaps ($T_{\text{Detect, E-UTRAN FDD}}$=0 when both *nr-LTE-SFN-Offset* and *nr-LTE-fineTiming-Offset* are provided in the E-UTRA OTDOA assistance data or the E-UTRA OTDOA assistance data reference cell is known to the UE), and

T_{MIB} = 50 ms is the time required to acquire SFN of the E-UTRA OTDOA assistance data reference cell provided the OTDOA assistance data reference cell is decodable and at least all E-UTRA subframes #0 during T_{MIB} are available at the UE receiver (T_{MIB}=0 when *nr-LTE-SFN-Offset* is provided in the E-UTRA OTDOA assistance data), and

T_{ECGI} = 100 ms is the time required to acquire ECGI of the E-UTRA OTDOA assistance data reference cell when *cellGlobalId* is included in *OTDOA-ReferenceCellInfo* and the UE is not aware of the ECGI of this cell (T_{ECGI} = 0 when *cellGlobalId* is not included in *OTDOA-ReferenceCellInfo* or the UE is aware of the ECGI of the E-UTRA OTDOA assistance data reference cell).

When detecting the E-UTRAN OTDOA reference cell, the requirements in this section shall be met, provided the conditions for the detectable cell are fulfilled according to Section 9.4.2.1. In addition, the MIB of the E-UTRA OTDOA reference cell whose SFN is acquired shall be considered decodable by the UE provided the PBCH demodulation requirements are met according to TS 36.101 [25].

The requirement for acquiring the timing of the E-UTRA OTDOA reference cell within $T_{RefCell,E-UTRAN}$ is applicable when no DRX is used as well as when any of the DRX cycles specified in TS 38.331 [2] is used.

When T_{MIB}>0 and UE is using autonomous gaps during T_{MIB}, the UE shall transmit at least $N_{ACK/NACK, MIB, FDD, FR1}$ ACK/NACKs on PCell in FR1 or each of activated SCell(s) in the same frequency range, specified in Table 9.4.4.1.2.2-1. When T_{ECGI}>0 and UE is using autonomous gaps during T_{ECGI}, the UE shall transmit at least $N_{ACK/NACK, ECGI, FDD, FR1}$ ACK/NACKs on PCell in FR1 or each of activated SCell(s) in the same frequency range, specified in Table 9.4.4.1.2.2-2. The requirements in Tables 9.4.4.1.2.2-1 and 9.4.4.1.2.2-2 apply, provided that:

- there is continuous DL data allocation,
- no DRX cycle is used,
- no measurement gaps are configured,
- only one code word is transmitted in each slot,
- 2 slot ACK/NACK feedback is configured,
- 20 ms SMTC period is configured.

Table 9.4.4.1.2.2-1: Number of ACK/NACKs transmitted by the UE during T_{MIB}

$N_{ACK/NACK, MIB, FDD, FR1}$	Configuration of the serving cell in which the transmitted ACK/NACKs are counted	
	Duplex mode configuration	SCS
[15]	FDD	15 kHz
[39]	FDD	30 kHz
[85]	FDD	60 kHz
[2]	TDD Note 1	15 kHz
[4]	TDD Note 1	30 kHz
[44]	TDD Note 1	60 kHz
NOTE 1: TDD UL-DL configuration is as specified in Table A.3.3.1-1 of TS 38.101-1 [18].		

Table 9.4.4.1.2.2-2: Number of ACK/NACKs transmitted by the UE during T_{ECGI}

$N_{ACK/NACK, ECGI, FDD, FR1}$	Configuration of the serving cell in which the transmitted ACK/NACKs are counted	
	Duplex mode configuration	SCS
TBD	FDD	15 kHz
TBD	FDD	30 kHz
TBD	FDD	60 kHz
TBD	TDD Note 1	15 kHz
TBD	TDD Note 1	30 kHz
TBD	TDD Note 1	60 kHz
NOTE 1: TDD UL-DL configuration is as specified in Table A.3.3.1-1 of TS 38.101-1 [18].		

9.4.4.2 SA: NR − E-UTRAN TDD RSTD measurements

9.4.4.2.1 Introduction

The requirements are applicable for NR−E-UTRAN TDD RSTD measurements requested via LPP [22, 24].

The requirements in section 9.4.4.1 apply when:

- the UE is provided with the LTE timing information via LPP [24], including both *nr-LTE-SFN-Offset* and *nr-LTE-fineTiming-Offset*, or
- the UE is not provided with *nr-LTE-SFN-Offset* or *nr-LTE-fineTiming-Offset*, or
- the UE is provided with *nr-LTE-SFN-Offset* but not with *nr-LTE-fineTiming-Offset*.

When the UE is not aware of the SFN of at least one LTE cell in the OTDOA assistance data, the UE may be using autonomous gaps in FR1 to acquire SFN of the OTDOA assistance data reference cell prior to requesting measurement gaps for performing the requested E-UTRA RSTD measurements before the $\mathrm{T}_{\text{RSTD InterRAT, E-UTRAN TDD}}$ time period starts while meeting all the requirements in Section 9.4.4.2.2, provided that the OTDOA assistance data is provided to allow sufficient time for the UE to acquire the SFN before the $\mathrm{T}_{\text{RSTD InterRAT, E-UTRAN TDD}}$ starts.When the UE is not aware of and cannot derive the subframe timing difference between the NR serving cell and the OTDOA assistance data reference cell, the UE may need to request measurement gaps in FR1 to perform cell detection for the OTDOA assistance data reference cell prior to requesting measurement gaps for performing the requested E-UTRA RSTD measurements before the $\mathrm{T}_{\text{RSTD InterRAT, E-UTRAN TDD}}$ time period starts while meeting all the requirements in Section 9.4.4.2.2, provided that the OTDOA assistance data is provided to allow sufficient time for the UE to detect the cell before the $\mathrm{T}_{\text{RSTD InterRAT, E-UTRAN TDD}}$ starts.

9.4.4.2.2 Requirements

When the physical layer cell identities of neighbour cells together with the OTDOA assistance data are provided, the UE shall be able to detect and measure inter-RAT -UTRAN TDD RSTD, specified in TS 38.215 [4], for at least *n*=16 cells, including the reference cell, within $\mathrm{T}_{\text{RSTD InterRAT, E-UTRAN TDD}}$ ms as given below:

$$\mathrm{T}_{\text{RSTD InterRAT, E-UTRAN TDD}} = T_{\text{PRS}} \cdot (M - 1) + \Delta \qquad ms \qquad ,$$

where

$\mathrm{T}_{\text{RSTD InterRAT, E-UTRAN TDD}}$ is the total time for detecting and measuring at least *n* cells,

T_{PRS} is the largest value of the cell-specific positioning subframe configuration period, defined in TS 36.211 [23], among the measured *n* cells including the reference cell,
M is the number of PRS positioning occasions as defined in Table 9.4.4.2.2-1, where a PRS positioning occasion is as defined in clause 9.4.4.1.2,
$CSSF_{interRAT}=CSSF_{within\_gap\_i}$ is the scaling factor determined by the gap sharing scheme for the RSTD measurements on the carrier frequency i as defined in Section 9.1.5.2,
$\Delta = 160 \cdot \left\lceil \frac{n}{M} \right\rceil$ ms is the measurement time for a single PRS positioning occasion which includes the sampling time and the processing time, and

the *n* cells are distributed on up to two E-UTRAN TDD carrier frequencies.

Table 9.4.4.2.2-1: Number of PRS positioning occasions within $\mathrm{T}_{\text{RSTD InterRAT, E-UTRAN TDD}}$

Positioning subframe configuration period T_{PRS}	Number of PRS positioning occasions M	
	f2 Note1	**f1 and f2 Note2**
160 ms	16 × $CSSF_{interRAT}$	32 × $CSSF_{interRAT}$
>160 ms	8 × $CSSF_{interRAT}$	16 × $CSSF_{interRAT}$
NOTE 1: When inter-RAT E-UTRAN TDD RSTD measurements are performed over the reference cell and neighbour cells, which belong to the E-UTRAN TDD carrier frequency f2. NOTE 2: When inter-RAT E-UTRAN TDD RSTD measurements are performed over the reference cell and the neighbour cells, which belong to the E-UTRAN TDD carrier frequency f1 and the E-UTRAN TDD carrier frequency f2 respectively.		

The requirements in this section shall apply for all TDD special subframe configurations specified in TS 36.211 [23] and for the TDD uplink-downlink configurations as specified in Table 9.4.4.2.2-2 for UE requiring measurement gaps for these measurements. For UEs capable of performing inter-RAT RSTD measurements without measurement gaps, TDD uplink-downlink subframe configurations as specified in Table 9.4.4.2.2-3 shall apply.

Table 9.4.4.2.2-2: TDD uplink-downlink subframe configurations applicable for inter-RAT RSTD requirements

PRS Transmission Bandwidth [RB]	Applicable TDD uplink-downlink configurations
6, 15	3, 4 and 5
25	1, 2, 3, 4, 5 and 6
50, 75, 100	0, 1, 2, 3, 4, 5 and 6
NOTE 1: Uplink-downlink configurations are specified in Table 4.2-2 in TS 36.211 [23].	

Table 9.4.4.2.2-3: TDD uplink-downlink subframe configurations applicable for inter-RAT RSTD requirements without gaps

PRS Transmission Bandwidth [RB]	Applicable TDD uplink-downlink configurations
6, 15	1, 2, 3, 4 and 5
25, 50, 75, 100	0, 1, 2, 3, 4, 5 and 6
NOTE: Uplink-downlink configurations are specified in Table 4.2-2 in TS 36.211 [23].	

The UE physical layer shall be capable of reporting RSTD for the reference cell and all the neighbor cells *i* out of at least (*n*-1) neighbor cells within $\mathrm{T}_{\text{RSTD InterRAT, E-UTRAN TDD}}$ provided:

$\left(\mathrm{PRS}\ \hat{\mathrm{E}}_{\mathrm{s}}/\mathrm{Iot}\right)_{ref}$ ≥-6 dB for all Frequency Bands for the reference cell,

$\left(\mathrm{PRS}\ \hat{\mathrm{E}}_{\mathrm{s}}/\mathrm{Iot}\right)_{i}$ ≥-13 dB for all Frequency Bands for neighbour cell *i*,

$\left(\mathrm{PRS}\ \hat{\mathrm{E}}_{\mathrm{s}}/\mathrm{Iot}\right)_{ref}$ and $\left(\mathrm{PRS}\ \hat{\mathrm{E}}_{\mathrm{s}}/\mathrm{Iot}\right)_{i}$ conditions apply for all subframes of at least $L=\frac{M}{2}$ PRS positioning occasions,

PRP 1,2$|_{\mathrm{dBm}}$ according to TS 36.133 [15, Annex B.2.6] for a corresponding Band

$\mathrm{PRS}\ \hat{\mathrm{E}}_{\mathrm{s}}/\mathrm{Iot}$ is as defined in Section 9.4.4.1.2.

The time $\mathrm{T}_{\text{RSTD InterRAT, E-UTRAN TDD}}$ starts from the first subframe of the PRS positioning occasion closest in time after both the OTDOA-RequestLocationInformation message and the OTDOA assistance data in the OTDOA-ProvideAssistanceData message via LPP as specified in TS 38.305 [22], are delivered to the physical layer of the UE.

The RSTD measurement accuracy for all measured neighbor cells *i* shall be fulfilled according to the accuracy as specified in Section 10.2.4.

9.4.4.2.2.1 RSTD Measurement Reporting Delay

This requirement assumes that that the measurement report is not delayed by other LPP signalling on the DCCH. This measurement reporting delay excludes a delay uncertainty resulted when inserting the measurement report to the TTI of the uplink DCCH. The delay uncertainty is: 2 x $\mathrm{TTI}_{\mathrm{DCCH}}$ where $\mathrm{TTI}_{\mathrm{DCCH}}$ is the duration of subframe or slot or subslot when the measurement report is transmitted on the PUSCH with subframe or slot or subslot duration. This measurement reporting delay excludes any delay caused by no UL resources for UE to send the measurement report.

9.4.4.2.2.2 Requirements for acquiring the timing of the E-UTRA OTDOA reference cell

When the UE is not aware of the SFN of at least one LTE cell in the OTDOA assistance data, the UE supporting per-FR gaps may make autonomous gaps in downlink reception and uplink transmission of the PCell and each of the SCells in FR1 for acquiring SFN of the reference cell in the E-UTRA OTDOA assistance data. No autonomous gaps in downlink reception or uplink transmission are allowed in any of the UE serving cells in FR2. The UE, which are only supporting per-UE gaps, may make autonomous gaps in downlink reception and uplink transmission of the PCell and each of the SCells for acquiring the SFN of the reference cell in the E-UTRA OTDOA assistance data.

When the UE is not aware of and cannot derive the subframe timing difference between the NR serving cell and the OTDOA assistance data reference cell, the UE may need to request measurement gaps while indicating *eutra-FineTimingDetection* according to TS 38.331 [2] for detecting the reference cell in the E-UTRA OTDOA assistance data.

When the UE is performning one or both of SFN acquisition or cell detection as specified above, the UE shall be able to determine the timing of the E-UTRA OTDOA assistance data reference cell during the time period

$$T_{RefCell,E\text{-}UTRAN} = T_{Detect,\ E\text{-}UTRAN\ TDD} + T_{MIB} + T_{ECGI}\ ,$$

where

$T_{Detect,\ E\text{-}UTRAN\ TDD} = T_{Identify,\ E\text{-}UTRAN\ TDD} - T_{measure,\ E\text{-}UTRAN\ TDD}$ is according to Section 9.4.3 assuming $CSSF_{interRAT}$=1 and it is the time needed to detect the E-UTRA OTDOA assistance data reference cell when the UE needs to acquire the subframe and slot timing of the cell, provided the UE is configured with measurement gaps ($T_{Detect,\ E\text{-}UTRAN\ TDD}$=0 when both *nr-LTE-SFN-Offset* and *nr-LTE-fineTiming-Offset* are provided in the E-UTRA OTDOA assistance data or the E-UTRA OTDOA assistance data reference cell is known to the UE), and

T_{MIB} = 50 ms is the time required to acquire SFN of the E-UTRA OTDOA assistance data reference cell provided the OTDOA assistance data reference cell is decodable and at least all E-UTRA subframes #0 during T_{MIB} are available at the UE receiver (T_{MIB}=0 when *nr-LTE-SFN-Offset* is provided in the E-UTRA OTDOA assistance data) , and

T_{ECGI} = 100 ms is the time required to acquire ECGI of the E-UTRA OTDOA assistance data reference cell when *cellGlobalId* is included in *OTDOA-ReferenceCellInfo* and the UE is not aware of the ECGI of this cell (T_{ECGI} = 0 when *cellGlobalId* is not included in *OTDOA-ReferenceCellInfo* or the UE is aware of the ECGI of the E-UTRA OTDOA assistance data reference cell).

When detecting the E-UTRAN OTDOA reference cell, the requirements in this section shall be met, provided the conditions for the detectable cell are fulfilled according to Section 9.4.3.1. In addition, the MIB of an the E-UTRA OTDOA reference cell whose SFN is acquired shall be considered decodable by the UE provided the PBCH demodulation requirements are met according to TS 36.101 [25].

The requirement for acquiring the timing of the E-UTRA OTDOA reference cell within $T_{RefCell,E\text{-}UTRAN}$ is applicable when no DRX is used as well as when any of the DRX cycles specified in TS 38.331 [2] is used.

When T_{MIB}>0 and UE is using autonomous gaps during T_{MIB}, the UE shall transmit at least $N_{ACK/NACK,\ MIB,\ TDD,\ FR1}$ ACK/NACKs on PCell in FR1 or each of activated SCell(s) in the same frequency range, specified in Table 9.4.4.2.2.2-1. When T_{ECGI}>0 and UE is using autonomous gaps during T_{ECGI}, the UE shall transmit at least $N_{ACK/NACK,\ ECGI,\ TDD,\ FR1}$ ACK/NACKs on PCell in FR1 or each of activated SCell(s) in the same frequency range, specified in Table 9.4.4.2.2.2-2. The requirements in Tables 9.4.4.2.2.2-1 and 9.4.4.2.2.2-2 apply, provided that:

- there is continuous DL data allocation,
- no DRX cycle is used,
- no measurement gaps are configured,
- only one code word is transmitted in each slot,
- 2 slot ACK/NACK feedback is configured,
- 20 ms SMTC period is configured.

Table 9.4.4.2.2.2-1: Minimum number of ACK/NACKs transmitted by the UE during T_{MIB}

$N_{ACK/NACK,\ MIB,\ TDD,\ FR1}$	Configuration of the serving cell in which the transmitted ACK/NACKs are counted	
	Duplex mode configuration	**SCS**
[15]	FDD	15 kHz
[39]	FDD	30 kHz
[85]	FDD	60 kHz
[2]	TDD Note 1	15 kHz
[4]	TDD Note 1	30 kHz
[44]	TDD Note 1	60 kHz
NOTE 1: TDD UL-DL configuration is as specified in Table A.3.3.1-1 of TS 38.101-1 [18].		

Table 9.4.4.2.2.2-2: Number of ACK/NACKs transmitted by the UE during T_{ECGI}

$N_{ACK/NACK,\ ECGI,\ TDD,\ FR1}$	Configuration of the serving cell in which the transmitted ACK/NACKs are counted	
	Duplex mode configuration	**SCS**
TBD	FDD	15 kHz
TBD	FDD	30 kHz
TBD	FDD	60 kHz
TBD	TDD Note 1	15 kHz
TBD	TDD Note 1	30 kHz
TBD	TDD Note 1	60 kHz
NOTE 1: TDD UL-DL configuration is as specified in Table A.3.3.1-1 of TS 38.101-1 [18].		

9.4.5 SA: Inter-RAT E-CID measurements

9.4.5.1 NR−E-UTRAN FDD E-CID RSRP and RSRQ measurements

9.4.5.1.1 Introduction

The requirements in Section 9.4.5.1. shall apply provided the UE has received *ECID-RequestLocationInformation* message from LMF via LPP requesting the UE to report inter-RAT E-UTRAN FDD E-CID RSRP and RSRQ measurements [22].

9.4.5.1.2 Requirements

The requirements in Section 9.4.2 also apply for this section except the measurement reporting requirements. The measurement reporting requirements for E-CID RSRP and RSRQ are defined in Section 9.4.5.1.3.

9.4.5.1.3 Measurement Reporting Delay

This requirement assumes that that the measurement report is not delayed by other LPP signalling on the DCCH. This measurement reporting delay excludes a delay uncertainty resulted when inserting the measurement report to the TTI of the uplink DCCH. The delay uncertainty is: 2 x TTI_{DCCH} where TTI_{DCCH} is the duration of subframe or slot or subslot when the measurement report is transmitted on the PUSCH with subframe or slot or subslot duration. This measurement reporting delay excludes any delay caused by no UL resources for UE to send the measurement report.

Reported RSRP and RSRQ measurements contained in periodically triggered measurement reports shall meet the requirements in Sections 10.2.2 and 10.2.3, respectively.

9.4.5.2 NR−E-UTRAN TDD E-CID RSRP and RSRQ measurements

9.4.5.2.1 Introduction

The requirements in Section 9.4.5.2. shall apply provided the UE has received *ECID-RequestLocationInformation* message from LMF via LPP requesting the UE to report inter-RAT E-UTRAN TDD E-CID RSRP and RSRQ measurements [22].

9.4.5.2.2 Requirements

The requirements in Section 9.4.3 also apply for this section except the measurement reporting requirements. The measurement reporting requirements for E-CID RSRP and RSRQ are defined in Section 9.4.5.2.3.

9.4.5.2.3 Measurement Reporting Delay

This requirement assumes that the measurement report is not delayed by other LPP signalling on the DCCH. This measurement reporting delay excludes a delay uncertainty resulted when inserting the measurement report to the TTI of the uplink DCCH. The delay uncertainty is: 2 x TTI_{DCCH} where TTI_{DCCH} is the duration of subframe or slot or subslot when the measurement report is transmitted on the PUSCH with subframe or slot or subslot duration. This measurement reporting delay excludes any delay caused by no UL resources for UE to send the measurement report.

Reported RSRP and RSRQ measurements contained in periodically triggered measurement reports shall meet the requirements in Sections 10.2.2 and 10.2.3, respectively.

9.5 L1-RSRP measurements for Reporting

9.5.1 Introduction

When configured by the network, the UE shall be able to perform L1-RSRP measurements of configured CSI-RS, SSB or CSI-RS and SSB resources for L1-RSRP. The measurements shall be performed for a serving cell, including PCell, PSCell, or SCell, on the resources configured for L1-RSRP measurements within the active BWP.

The UE shall be able to measure all CSI-RS resources and/or SSB resources of the CSI Resource set(s) within the CSI Resource settings configured for L1-RSRP for the active BWP, provided that the number of resources does not exceed the UE capability indicated by *beamManagementSSB-CSI-RS*.

Unless the reporting quantity is set to ‘none’, the UE shall report the quantity for the CSI reporting configuration associated by the reporting quantity.

9.5.2 Requirements applicability

The requirements in Section 9.5 apply, provided:

- The CSI-RS or SSB or CSI-RS and SSB resources configured for L1-RSRP measurements are measurable.

An SSB resource configured for L1-RSRP shall be considered measurable when for each relevant SSB the following conditions are met:

- L1-RSRP related side conditions given in Sections 10.1.19.1. and 10.1.20.1 for FR1 and FR2, respectively, for a corresponding band,
- SSB_RP and SSB Ês/Iot according to Annex B.2.4.1 for a corresponding band.

A CSI-RS resource configured for L1-RSRP shall be considered measurable when for each relevant CSI-RS the following conditions are met:

- L1-RSRP related side conditions given in Sections 10.1.19.2 and 10.1.20.2 for FR1 and FR2, repectively, for a corresponding band,
- CSI-RS_RP and CSI-RS Ês/Iot according to Annex B.2.4.2 for a corresponding band.

A CSI-RS and SSB resource configured for L1-RSRP shall be considered measurable when the measurable resource conditions are met for both CSI-RS resource and SSB resource.

Requirements are defined for periodic, semi-persistent and aperiodic resources.

9.5.3 Measurement Reporting Requirements

The UE shall only send L1-RSRP reports for report configurations configured for the active BWP.

The UE shall report the L1-RSRP value as a 7-bit value in the range [-140, -44] dBm with 1dB step size according to section 10.1.x if *nrofReportedRS* is configured to one. Otherwise, and additionally if *groupBasedBeamReporting* is enabled the UE shall use differential L1-RSRP based reporting as defined in section 10.1.x.

9.5.3.1 Periodic Reporting

Reported L1-RSRP measurements contained in periodic L1-RSRP reports shall meet the requirements in sections 10.x, 10.y and 10.z, respectively.

The UE shall not send any periodic L1-RSRP reports for a non-active BWP.

The L1-RSRP reporting delay is FFS.

The periodic L1-RSRP reporting delay shall be less than [TBD].

9.5.3.2 Semi-Persistent Reporting

Reported L1-RSRP measurements contained in Semi-Persistent L1-RSRP reports shall meet the requirements in sections 10.x, 10.y and 10.z, respectively. This requirement applies for semi-persistent L1-RSRP reports send on PUSCH or PUCCH.

The UE shall not send any semi-persistent L1-RSRP reports on PUSCH, as long as no DCI request have been received.

The UE shall not send any semi-persistent L1-RSRP reports on PUCCH, as long as no activation command [38.321] have been received.

The L1-RSRP reporting delay is defined as the time between a request or command that will trigger an L1-RSRP report is received by the UE and the point when the UE starts to transmit the L1-RSRP report over the air interface.

The Semi-persistent L1-RSRP reporting delay shall be less than [TBD] for a DCI requsted semi-persistent L1-RSRP report and less than [TBD] for an L1-RSRP requested by activation command [36.321].

9.5.3.3 Aperiodic Reporting

Reported L1-RSRP measurements contained in Aperiodic triggered, Aperiodic triggered periodic and Aperiodic triggered semi-persistent L1-RSRP reports shall meet the requirements in sections 10.x, 10.y and 10.z, respectively.

The UE shall not send any aperiodic L1-RSRP reports, as long as no DCI trigger have been received.

The L1-RSRP reporting delay is defined as the time between a DCI request that will trigger an L1-RSRP report and the point when the UE starts to transmit the L1-RSRP report over the air interface.

The aperiodic L1-RSRP reporting delay shall be less than [TBD].

9.5.4 L1-RSRP measurement requirements

9.5.4.1 SSB based L1-RSRP Reporting

The UE shall be capable of performing L1-RSRP measurements based on the configured SSB resource for L1-RSRP computation, and the UE physical layer shall be capable of reporting L1-RSRP measured over the measurement period of $T_{BM\_Measurement\_Period\_SSB}$.

The value of $T_{BM\_Measurement\_Period\_SSB}$ is defined in Table 9.5.4.1-1 for FR1 and Table 9.5.4.1-2 for FR2, where

- M=1 if higher layer parameter *timeRestrictionForChannelMeasurement* is configured, and M=3 otherwise

- N= 8.

For FR1,

  - P=1/(1 – T_{SSB}/MGRP), when in the monitored cell there are measurement gaps configured for intra-frequency, inter-frequency or inter-RAT measurements, which are overlapping with some but not all occasions of the SSB; and

  - P=1 when in the monitored cell there are no measurement gaps overlapping with any occasion of the SSB.

For FR2,

  - P=1/(1 – $T_{SSB}/T_{SMTCperiod}$), when BM-RS is not overlapped with measurement gap and BM-RS is partially overlapped with SMTC occasion ($T_{SSB} < T_{SMTCperiod}$).

  - P is $P_{sharing\ factor}$, when BM-RS is not overlapped with measurement gap and BM-RS is fully overlapped with SMTC period ($T_{SSB} = T_{SMTCperiod}$).

  - P is 1/(1- T_{SSB}/MGRP - $T_{SSB}/T_{SMTCperiod}$), when BM-RS is partially overlapped with measurement gap and BM-RS is partially overlapped with SMTC occasion ($T_{SSB} < T_{SMTCperiod}$) and SMTC occasion is not overlapped with measurement gap and

    - $T_{SMTCperiod} \neq$ MGRP or

    - $T_{SMTCperiod}$ = MGRP and $T_{SSB} < 0.5*T_{SMTCperiod}$

  - P is 1/(1- T_{SSB} /MGRP)* $P_{sharing\ factor}$, when BM-RS is partially overlapped with measurement gap and BM-RS is partially overlapped with SMTC occasion ($T_{SSB} < T_{SMTCperiod}$) and SMTC occasion is not overlapped with measurement gap and $T_{SMTCperiod}$ = MGRP and $T_{SSB} = 0.5*T_{SMTCperiod}$

  - P is 1/{1- T_{SSB} /min ($T_{SMTCperiod}$,MGRP)}, when BM-RS is partially overlapped with measurement gap (T_{SSB} <MGRP) and BM-RS is partially overlapped with SMTC occasion ($T_{SSB} < T_{SMTCperiod}$) and SMTC occasion is partially or fully overlapped with measurement gap.

  - P is 1/(1- T_{SSB} /MGRP)* $P_{sharing\ factor}$, when BM-RS is partially overlapped with measurement gap and BM-RS is fully overlapped with SMTC occasion ($T_{SSB} = T_{SMTCperiod}$) and SMTC occasion is partially overlapped with measurement gap ($T_{SMTCperiod}$ < MGRP)

  - $P_{sharing\ factor}$ = 3.

If the high layer in TS 38.331 [2] signaling of *smtc2* is configured, $T_{SMTCperiod}$ corresponds to the value of higher layer parameter *smtc2*; Otherwise $T_{SMTCperiod}$ corresponds to the value of higher layer parameter *smtc1*.

Longer evaluation period would be expected if the combination of BM-RS, SMTC occasion and measurement gap configurations does not meet pervious conditions.

Editor’s Note: FFS what evaluation period would be expected if BM-RS are in the same OFDM symbols with RLM/BFD/CBD-RS, or other BM-RS.

Table 9.5.4.1-1: Measurement period $T_{BM\_Measurement\_Period\_SSB}$ for FR1

Configuration	$T_{BM\_Measurement\_Period\_SSB}$ (ms)
non-DRX	max(T_{Report}, ceil(M*P)*T_{SSB})
DRX cycle ≤ 320ms	max(T_{Report}, ceil(1.5*M*P)*max(T_{DRX},T_{SSB}))
DRX cycle > 320ms	ceil(M*P)*T_{DRX}
Note: T_{SSB} is the periodicity of SSB configured for L1-RSRP measurement. T_{DRX} is the DRX cycle length. T_{Report} is configured periodicity for reporting.	

Table 9.5.4.1-2: Measurement period $T_{BM\_Measurement\_Period\_SSB}$ for FR2

Configuration	$T_{BM\_Measurement\_Period\_SSB}$ (ms)
non-DRX	max(T_{Report}, ceil(M*P*N)*T_{SSB})
DRX cycle ≤ 320ms	max(T_{Report}, ceil(1.5*M*P*N)*max(T_{DRX},T_{SSB}))
DRX cycle > 320ms	ceil(1.5*M*P*N)*T_{DRX}
Note: T_{SSB} is the periodicity of SSB configured for L1-RSRP measurement. T_{DRX} is the DRX cycle length. T_{Report} is configured periodicity for reporting.	

9.5.4.2 CSI-RS based L1-RSRP Reporting

The UE shall be capable of performing L1-RSRP measurements based on the configured CSI-RS resource for L1-RSRP computation, and the UE physical layer shall be capable of reporting L1-RSRP measured over the measurement period of $T_{BM\_Measurement\_Period\_CSI-RS}$.

The value of $T_{BM\_Measurement\_Period\_CSI-RS}$ is defined in Table 9.5.4.2-1 for FR1 and in Table 9.5.4.2-2 for FR2, where

- For periodic and semi-persistent CSI-RS resources, M=1 if higher layer parameter *timeRestrictionForChannelMeasurement* is configured, and M=3 otherwise

- For aperiodic CSI-RS resources M=1

- N=TBD

For FR1,

- P=1/(1 – T_{CSI-RS}/MGRP), when in the monitored cell there are measurement gaps configured for intra-frequency, inter-frequency or inter-RAT measurements, which are overlapping with some but not all occasions of the CSI-RS; and

- P=1 when in the monitored cell there are no measurement gaps overlapping with any occasion of the CSI-RS.

For FR2,

- P=1, when BM-RS is not overlapped with measurement gap and also not overlapped with SMTC occasion.

- P=1/(1 – T_{CSI-RS}/MGRP) , when BM-RS is partially overlapped with measurement gap and BM-RS is not overlapped with SMTC occasion (T_{CSI-RS} < MGRP)

- P=1/(1 – T_{CSI-RS} /$T_{SMTCperiod}$), when BM-RS is not overlapped with measurement gap and BM-RS is partially overlapped with SMTC occasion (T_{CSI-RS} < $T_{SMTCperiod}$).

- P is $P_{sharing\ factor}$, when BM-RS is not overlapped with measurement gap and BM-RS is fully overlapped with SMTC occasion (T_{CSI-RS} = $T_{SMTCperiod}$).

- P is 1/(1- T_{CSI-RS} /MGRP - T_{CSI-RS} /$T_{SMTCperiod}$), when BM-RS is partially overlapped with measurement gap and BM-RS is partially overlapped with SMTC occasion (TCSI-RS < $T_{SMTCperiod}$) and SMTC occasion is not overlapped with measurement gap and

    - $T_{SMTCperiod}$ ≠ MGRP or

    - $T_{SMTCperiod}$ = MGRP and T_{CSI-RS} < 0.5*$T_{SMTCperiod}$

- P is 1/(1- T_{CSI-RS} /MGRP)* $P_{sharing\ factor}$, when BM-RS is partially overlapped with measurement gap and BM-RS is partially overlapped with SMTC occasion (T_{CSI-RS} < $T_{SMTCperiod}$) and SMTC occasion is not overlapped with measurement gap and $T_{SMTCperiod}$ = MGRP and T_{CSI-RS} = 0.5*$T_{SMTCperiod}$

- P is 1/{1- T_{CSI-RS} /min ($T_{SMTCperiod}$,MGRP)}, when BM-RS is partially overlapped with measurement gap (T_{CSI-RS} < MGRP) and BM-RS is partially overlapped with SMTC occasion (T_{CSI-RS} < $T_{SMTCperiod}$) and SMTC occasion is partially or fully overlapped with measurement gap.

- P is 1/(1- T_{CSI-RS} /MGRP)* $P_{sharing\ factor}$, when BM-RS is partially overlapped with measurement gap and BM-RS is fully overlapped with SMTC occasion (T_{CSI-RS} = $T_{SMTCperiod}$) and SMTC occasion is partially overlapped with measurement gap ($T_{SMTCperiod}$ < MGRP)

- $P_{\text{sharing factor}}$ is 3.

If the high layer in TS 38.331 [2] signaling of *smtc2* is configured, $T_{SMTCperiod}$ corresponds to the value of higher layer parameter *smtc2*; Otherwise $T_{SMTCperiod}$ corresponds to the value of higher layer parameter *smtc1*.

Note: The overlap between CSI-RS for L1-RSRP measurement and SMTC means that CSI-RS for L1-RSRP measurement is within the SMTC window duration.

Longer evaluation period would be expected if the combination of BM-RS, SMTC occasion and measurement gap configurations does not meet pervious conditions.

Editor's Note: FFS what evaluation period would be expected if BM-RS are in the same OFDM symbols with RLM/BFD/CBD-RS, or other BM-RS.

Table 9.5.4.2-1: Measurement period $T_{BM\_Measurement\_Period\_CSI-RS}$ for FR1

Configuration	$T_{BM\_Measurement\_Period\_CSI-RS}$ (ms)
non-DRX	$\max(T_{Report}, \text{ceil}(M*P)*T_{CSI-RS})$
DRX cycle ≤ 320ms	$\max(T_{Report}, \text{ceil}(1.5*M*P)*\max(T_{DRX},T_{CSI-RS}))$
DRX cycle > 320ms	$\text{ceil}(M*P)*T_{DRX}$
Note 1: T_{CSI-RS} is the periodicity of CSI-RS configured for L1-RSRP measurement. T_{DRX} is the DRX cycle length. T_{Report} is configured periodicity for reporting. Note 2: the requirements are applicable provided that the CSI-RS resource configured for L1-RSRP measurement is transmitted with Density = 3.	

Table 9.5.4.2-2: Measurement period $T_{BM\_Measurement\_Period\_CSI-RS}$ for FR2

Configuration	$T_{BM\_Measurement\_Period\_CSI-RS}$ (ms)
non-DRX	$\max(T_{Report}, \text{ceil}(M*P*N)*T_{CSI-RS})$
DRX cycle ≤ 320ms	$\max(T_{Report}, \text{ceil}(1.5*M*P*N)*\max(T_{DRX},T_{CSI-RS}))$
DRX cycle > 320ms	$\text{ceil}(M*P*N)*T_{DRX}$
Note 1: T_{CSI-RS} is the periodicity of CSI-RS configured for L1-RSRP measurement. T_{DRX} is the DRX cycle length. T_{Report} is configured periodicity for reporting. Note 2: the requirements are applicable provided that the CSI-RS resource configured for L1-RSRP measurement is transmitted with Density = 3.	

9.5.5 Measurement restriction for CSI-RS and SSB for L1-RSRP measurement

The UE is required to be capable of measuring CSI-RS for L1-RSRP without measurement gaps. The UE is required to perform the CSI-RS measurements as described in the following clauses.

9.5.5.1 UE performing CSI-RS measurements with a same subcarrier spacing as SSB on FR1

When the SSB is within the active BWP and has same SCS than CSI-RS, the UE shall be able to perform CSI-RS measurement without restrictions when CSI-RS measurement are performed with same subcarrier spacing as the SSB on FR1.

9.5.5.2 CSI-RS measurement restrictions of UE performing CSI-RS measurements with a different subcarrier spacing than SSB on FR1

When the SSB is within the active BWP and has different SCS than CSI-RS, the UE shall be able to perform CSI-RS measurement with restrictions according to its capabilities:

- If CSI-RS and SSB are FDM'ed, the UE measurement capability depends on the whether the UE supports *simultaneousRxDataSSB-DiffNumerology*.
  - If the UE supports *simultaneousRxDataSSB-DiffNumerology* the UE shall be able to perform CSI-RS measurement without restrictions.
  - If the UE does not support *simultaneousRxDataSSB-DiffNumerology* the UE is not expected to perform simultaneous FDM'ed SSB and CSI-RS measurements,
- If CSI-RS and SSB are TDM'ed, the UE shall be able to perform CSI-RS measurement with restrictions: the UE is not expected to measure CSI-RS on symbols on 1 data symbol before each consecutive SSB symbols and 1 data symbol after each consecutive SSB symbols within the SMTC window duration.

9.5.6 Scheduling availability of UE during L1-RSRP measurement

Scheduling availability restrictions when the UE is performing L1-RSRP measurement are described in the following clauses.

9.5.6.1 Scheduling availability of UE performing L1-RSRP measurement with a same subcarrier spacing as PDSCH/PDCCH on FR1

There are no scheduling restrictions due to L1-RSRP measurement performed on SSB and CSI-RS configured as RS for L1-RSRP measurement with the same SCS as PDSCH/PDCCH in FR1.

9.5.6.2 Scheduling availability of UE performing L1-RSRP measurement with a different subcarrier spacing than PDSCH/PDCCH on FR1

For UEs which support *simultaneousRxDataSSB-DiffNumerology* [14] there are no restrictions on scheduling availability due to L1-RSRP measurement based on SSB as RS for L1-RSRP measurement. For UEs which do not support *simultaneousRxDataSSB-DiffNumerology* [14] the following restrictions apply due to L1-RSRP measurement based on SSB configured as RS for L1-RSRP measurement.

- The UE is not expected to transmit PUCCH/PUSCH/SRS or receive PDCCH/PDSCH/TRS/CSI-RS for CQI on SSB symbols to be measured for L1-RSRP measurement.

When intra-band carrier aggregation in FR1 is configured, the scheduling restrictions apply to all SCells that are aggregated in the same band as the PCell or PSCell. When inter-band carrier aggregation within FR1 is configured, there are no scheduling restrictions on FR1 serving cell(s) configured in other bands than the bands in which PCell or PSCell is configured.

9.5.6.3 Scheduling availability of UE performing L1-RSRP measurement on FR2

The following scheduling restriction applies due to L1-RSRP measurement.

- For the case where RS for L1-RSRP measurement is QCLed with active TCI state for PDCCH/PDSCH, and N=1 applies for the RS for L1-RSRP measurement as specified in section 9.4.5.1 if the reference signal is SSB and in section 9.4.5.2 if the reference signal is CSI-RS
  - There are no scheduling restrictions due to L1-RSRP measurement performed based on SSB or CSI-RS with a same SCS as PDSCH/PDCCH.
  - When performing L1-RSRP measurement based on SSB with a different SCS than PDSCH/PDCCH, for UEs which support *simultaneousRxDataSSB-DiffNumerology* [14] there are no restrictions on scheduling availability due to L1-RSRP measurement. For UEs which do not support *simultaneousRxDataSSB-DiffNumerology* [14] the UE is not expected to transmit PUCCH/PUSCH/SRS or receive PDCCH/PDSCH/TRS/CSI-RS for CQI on SSB symbols to be measured for L1-RSRP measurement.
- Otherwise
  - The UE is not expected to transmit PUCCH/PUSCH/SRS or receive PDCCH/PDSCH/TRS/CSI-RS for CQI on RS for L1-RSRP measurement symbols to be measured for L1-RSRP measurement.

When intra-band carrier aggregation is performed, the scheduling restrictions apply to all serving cells on the band due to L1-RSRP measurement performed on any serving cell in the same band.

Editor's Note: FFS scheduling restrictions for inter-band carrier aggregation will be defined depending on band combination in future.

9.5.6.4 Scheduling availability of UE performing L1-RSRP measurement on FR1 or FR2 in case of FR1-FR2 inter-band CA

There are no scheduling restrictions on FR1 serving cell(s) due to L1-RSRP measurement performed on FR2 serving PCell and/or PSCell.

There are no scheduling restrictions on FR2 serving cell(s) due to L1-RSRP measurement performed on FR1 serving PCell and/or PSCell.

10 Measurement Performance requirements

Editor's note: Accuracy requirement might be an individual top-level chapter to maintain since it is the performance part.

10.1 NR measurements

10.1.1 Introduction

Editor's note: new measurement metrics may be added according to the RAN4 discussion. Absolute/relative accuracy requirement, mapping table of RSRP/RSRQ may be specified in this section. The numerology and BW combinations might be reflected in the accuracy requirement table.

The requirements in Section 10.1 apply as follows:

- intra-frequency requirements apply for PCell measurements in SA, NR-DC, or NE-DC operaion mode,
- intra-frequency requirements apply for PSCell measurements in NR-DC or EN-DC operaion mode,
- intra-frequency requirements apply for SCell measurements in SA operation mode with NR CA or any MR-DC operaion mode with NR CA,
- inter-frequency requirements apply for non-serving cell measurements on NR carrier frequencies.

In the requirements of Section 10.1, the exceptions for side conditions apply as follows:

- for the UE capable of CA but not configured with any SCell, the applicable exceptions for side conditions are specified in Annex B, Section B.3.2.1 for UE supporting CA in FR1, and Section B.3.2.3 for UE supporting CA in FR2, respectively;
- for the UE capable of CA and configured with at least one SCell, the applicable exceptions for side conditions are specified in Annex B, Section B.3.2.2 for UE configured with CA in FR1, and Section B.3.2.4 for UE supporting CA in FR2 respectively;
- for the UE capable of SUL but not configured with SUL, the applicable exceptions for side conditions are specified in Annex B, Section B.3.4.1 for UE supporting SUL in FR1;
- for the UE capable of SUL and configured with at least one SUL, the applicable exceptions for side conditions are specified in Annex B, Section B.3.4.2 for UE configured with SUL in FR1.

10.1.2 Intra-frequency RSRP accuracy requirements for FR1

10.1.2.1 Intra-frequency SS-RSRP accuracy requirements

10.1.2.1.1 Absolute SS-RSRP Accuracy

Unless otherwise specified, the requirements for absolute accuracy of SS-RSRP in this clause apply to a cell on the same frequency as that of the serving cell in FR1.

The accuracy requirements in Table 10.1.2.1.1-1 are valid under the following conditions:

- Conditions defined in 38.101-1 [18] Clause 7.3 for reference sensitivity are fulfilled.
- Conditions for intra-frequency measurements are fulfilled according to Annex B.2.2 for a corresponding Band for each relevant SSB.

Table 10.1.2.1.1-1: SS-RSRP Intra frequency absolute accuracy in FR1

Accuracy		Conditions					
Normal condition	Extreme condition	SSB Ês/Iot	Io Note 1 range				
			NR operating band groups Note 2	Minimum Io			Maximum Io
dB	dB	dB		dBm / SCS_{SSB}		$dBm/BW_{Channel}$	$dBm/BW_{Channel}$
				SCS_{SSB} = 15 kHz	SCS_{SSB} = 30 kHz		
±4.5	±9	≥-6 dB	NR_FDD_FR1_A, NR_TDD_FR1_A	-121	-118	N/A	-70
			NR_FDD_FR1_B	-120.5	-117.5	N/A	-70
			NR_TDD_FR1_C	-120	-117	N/A	-70
			NR_FDD_FR1_D, NR_TDD_FR1_D	-119.5	-116.5	N/A	-70
			NR_FDD_FR1_E, NR_TDD_FR1_E	-119	-116	N/A	-70
			NR_FDD_FR1_G	-118	-115	N/A	-70
			NR_FDD_FR1_H	-117.5	-114.5	N/A	-70
±8	±11	≥-6 dB	ANR_FDD_FR1_A, NR_TDD_FR1_A, NR_FDD_FR1_B, NR_TDD_FR1_C, NR_FDD_FR1_D, NR_TDD_FR1_D, NR_FDD_FR1_E, NR_TDD_FR1_E, NR_FDD_FR1_G, NR_FDD_FR1_H,	N/A	N/A	-70	-50
NOTE 1: Io is assumed to have constant EPRE across the bandwidth. NOTE 2: NR operating band groups in FR1 are as defined in Section 3.5.2.							

10.1.2.1.2 Relative SS-RSRP Accuracy

The relative accuracy of SS-RSRP is defined as the SS-RSRP measured from one cell compared to the SS-RSRP measured from another cell on the same frequency, or between any two SS RSRP levels measured on the same cell in FR1.

The accuracy requirements in Table 10.1.2.1.2-1 are valid under the following conditions:

- Conditions defined in 38.101-1 [18] Clause 7.3 for reference sensitivity are fulfilled.
- Conditions for intra-frequency measurements are fulfilled according to Annex B.2.2 for a corresponding Band for each relevant SSB.

Table 10.1.2.1.2-1: SS-RSRP Intra frequency relative accuracy in FR1

<table>
<tr><th colspan="2">Accuracy</th><th colspan="6">Conditions</th></tr>
<tr><th rowspan="2">Normal condition</th><th rowspan="2">Extreme condition</th><th rowspan="2">SSB Ês/Iot Note 2</th><th colspan="5">Io Note 1 range</th></tr>
<tr><th>NR operating band groups Note 4</th><th colspan="3">Minimum Io</th><th>Maximum Io</th></tr>
<tr><th rowspan="2">dB</th><th rowspan="2">dB</th><th rowspan="2">dB</th><th rowspan="2"></th><th colspan="2">dBm / SCS_{SSB}</th><th rowspan="2">dBm/BW_{Channel}</th><th rowspan="2">dBm/BW_{Channel}</th></tr>
<tr><th>SCS_{SSB} = 15 kHz</th><th>SCS_{SSB} = 30 kHz</th></tr>
<tr><td rowspan="7">±2</td><td rowspan="7">±3</td><td rowspan="7">≥-3 dB</td><td>NR_FDD_FR1_A, NR_TDD_FR1_A</td><td>-121</td><td>-118</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_FDD_FR1_B</td><td>-120.5</td><td>-117.5</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_TDD_FR1_C</td><td>-120</td><td>-117</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_FDD_FR1_D, NR_TDD_FR1_D</td><td>-119.5</td><td>-116.5</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_FDD_FR1_E, NR_TDD_FR1_E</td><td>-119</td><td>-116</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_FDD_FR1_G</td><td>-118</td><td>-115</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_FDD_FR1_H</td><td>-117.5</td><td>-114.5</td><td>N/A</td><td>-50</td></tr>
<tr><td>±3</td><td>±3</td><td>≥-6 dB</td><td>Note 3</td><td>Note 3</td><td>Note 3</td><td>N/A</td><td>Note 3</td></tr>
<tr><td colspan="8">NOTE 1: Io is assumed to have constant EPRE across the bandwidth.
NOTE 2: The parameter SSB Ês/Iot is the minimum SSB Ês/Iot of the pair of cells to which the requirement applies.
NOTE 3: The same bands and the same Io conditions for each band apply for this requirement as for the corresponding highest accuracy requirement.
NOTE 4: NR operating band groups in FR1 are as defined in Section 3.5.2.</td></tr>
</table>

10.1.2.2 Intra-frequency [CSI-RS RSRP] accuracy requirements

10.1.3 Intra-frequency RSRP accuracy requirements for FR2

10.1.3.1 Intra-frequency SS-RSRP accuracy requirements

10.1.3.1.1 Absolute SS-RSRP Accuracy

Unless otherwise specified, the requirements for absolute accuracy of SS-RSRP in this clause apply to a cell on the same frequency as that of the serving cell in FR2.

The accuracy requirements in Table 10.1.3.1.1-1 are valid under the following conditions:

- Conditions defined in 38.101-2 [19] Clause 7.3 for reference sensitivity are fulfilled.
- Conditions for intra-frequency measurements are fulfilled according to Annex B.2.2 for a corresponding Band for each relevant SSB.

Table 10.1.3.1.1-1: SS-RSRP Intra frequency absolute accuracy in FR2

Accuracy		Conditions					
Normal condition	Extreme condition	SSB Ês/Iot	Io Note 1 range				
			NR operating band groups Note 2	Minimum Io			Maximum Io
				dBm / SCS_{SSB}		dBm/$BW_{Channel}$	dBm/$BW_{Channel}$
dB	dB	dB		SCS_{SSB} = 120kHz	SCS_{SSB} = 240kHz		
±[6]	±[9]	TBD	NR_TDD_FR2_A	TBD	TBD	N/A	-70
			NR_TDD_FR2_B	TBD	TBD	N/A	-70
			NR_TDD_FR2_F	TBD	TBD	N/A	-70
			NR_TDD_FR2_G	TBD	TBD	N/A	-70
			NR_TDD_FR2_T	TBD	TBD	N/A	-70
			NR_TDD_FR2_Y	TBD	TBD	N/A	-70
±[8]	±[11]	TBD	TNR_TDD_FR2_A, NR_TDD_FR2_B, NR_TDD_FR2_F, NR_TDD_FR2_G, NR_TDD_FR2_T, NR_TDD_FR2_Y	N/A	N/A	-70	-50
NOTE 1: Io is assumed to have constant EPRE across the bandwidth. NOTE 2: NR operating band groups in FR2 are as defined in Section 3.5.3.							

10.1.3.1.2 Relative SS-RSRP Accuracy

The relative accuracy of SS-RSRP is defined as the SS-RSRP measured from one cell compared to the SS-RSRP measured from another cell on the same frequency, or between any two SS RSRP levels measured on the same cell in FR2.

The accuracy requirements in Table 10.1.3.1.2-1 are valid under the following conditions:

- Conditions defined in 38.101-2 [19] Clause 7.3 for reference sensitivity are fulfilled.
- Conditions for intra-frequency measurements are fulfilled according to Annex B.2.2 for a corresponding Band for each relevant SSB.

Table 10.1.3.1.2-1: SS-RSRP Intra frequency relative accuracy in FR2

Accuracy		Conditions					
Normal condition	Extreme condition	SSB Ês/Iot Note 2	Io Note 1 range				
			NR operating band groups Note 3	Minimum Io			Maximum Io
				dBm / SCS_{SSB}		dBm/$BW_{Channel}$	dBm/$BW_{Channel}$
dB	dB	dB		SCS_{SSB} = 120kHz	SCS_{SSB} = 240kHz		
±[6]	±[9]	TBD	NR_TDD_FR2_A	TBD	TBD	N/A	TBD
			NR_TDD_FR2_B	TBD	TBD	N/A	TBD
			NR_TDD_FR2_F	TBD	TBD	N/A	TBD
			NR_TDD_FR2_G	TBD	TBD	N/A	TBD
			NR_TDD_FR2_T	TBD	TBD	N/A	TBD
			NR_TDD_FR2_Y	TBD	TBD	N/A	TBD
NOTE 1: Io is assumed to have constant EPRE across the bandwidth. NOTE 2: The parameter SSB Ês/Iot is the minimum SSB Ês/Iot of the pair of cells to which the requirement applies. NOTE 3: NR operating band groups in FR2 are as defined in Section 3.5.3.							

10.1.3.2 Intra-frequency [CSI-RS RSRP] accuracy requirements

10.1.4 Inter-frequency RSRP accuracy requirements for FR1

10.1.4.1 Inter-frequency SS-RSRP accuracy requirements

10.1.4.1.1 Absolute Accuracy of SS-RSRP in FR1

The requirements for absolute accuracy of SS-RSRP in this clause apply to a cell on a frequency in FR1 that has different carrier frequency from the serving cell.

The accuracy requirements in Table 10.1.4.1.1-1 are valid under the following conditions:

- Conditions defined in 38.101-1 [18] Clause 7.3 for reference sensitivity are fulfilled.
- Conditions for inter-frequency measurements are fulfilled according to Annex B.2.3 for a corresponding Band for each relevant SSB.

Table 10.1.4.1.1-1: SS-RSRP Inter frequency Absolute accuracy in FR1

<table>
<tr><th colspan="2">Accuracy</th><th colspan="6">Conditions</th></tr>
<tr><th rowspan="2">Normal condition</th><th rowspan="2">Extreme condition</th><th rowspan="2">SSB Ês/Iot Note 2</th><th colspan="5">Io Note 1 range</th></tr>
<tr><th>NR operating band groups Note 3</th><th colspan="3">Minimum Io</th><th>Maximum Io</th></tr>
<tr><th rowspan="2">dB</th><th rowspan="2">dB</th><th rowspan="2">dB</th><th rowspan="2"></th><th colspan="2">dBm / SCS_{SSB}</th><th rowspan="2">dBm/BW_{Channel}</th><th rowspan="2">dBm/BW_{Channel}</th></tr>
<tr><th>SCS_{SSB} = 15 kHz</th><th>SCS_{SSB} = 30 kHz</th></tr>
<tr><td rowspan="7">±4.5</td><td rowspan="7">±6</td><td rowspan="7">≥-6 dB</td><td>NR_FDD_FR1_A, NR_TDD_FR1_A</td><td>-121</td><td>-118</td><td>N/A</td><td>-70</td></tr>
<tr><td>NR_FDD_FR1_B</td><td>-120.5</td><td>-117.5</td><td>N/A</td><td>-70</td></tr>
<tr><td>NR_TDD_FR1_C</td><td>-120</td><td>-117</td><td>N/A</td><td>-70</td></tr>
<tr><td>NR_FDD_FR1_D, NR_TDD_FR1_D</td><td>-119.5</td><td>-116.5</td><td>N/A</td><td>-70</td></tr>
<tr><td>NR_FDD_FR1_E, NR_TDD_FR1_E</td><td>-119</td><td>-116</td><td>N/A</td><td>-70</td></tr>
<tr><td>NR_FDD_FR1_G</td><td>-118</td><td>-115</td><td>N/A</td><td>-70</td></tr>
<tr><td>NR_FDD_FR1_H</td><td>-117.5</td><td>-114.5</td><td>N/A</td><td>-70</td></tr>
<tr><td>±8</td><td>±11</td><td>≥-6 dB</td><td>NR_FDD_FR1_A,
NR_TDD_FR1_A,
NR_FDD_FR1_B,
NR_TDD_FR1_C,
NR_FDD_FR1_D,
NR_TDD_FR1_D,
NR_FDD_FR1_E,
NR_TDD_FR1_E,
NR_FDD_FR1_G,
NR_FDD_FR1_H,</td><td>N/A</td><td>N/A</td><td>-70</td><td>-50</td></tr>
<tr><td colspan="8">NOTE 1: Io is assumed to have constant EPRE across the bandwidth.
NOTE 2: The parameter SSB Ês/Iot is the minimum SSB Ês/Iot of the pair of cells to which the requirement applies.
NOTE 3: NR operating band groups in FR1 are as defined in Section 3.5.2.</td></tr>
</table>

10.1.4.1.2 Relative Accuracy of SS-RSRP in FR1

The relative accuracy of SS-RSRP in inter frequency case is defined as the RSRP measured from one cell on a frequency in FR1compared to the RSRP measured from another cell on a different frequency in FR1.

The accuracy requirements in Table 10.1.4.1.2-1 are valid under the following conditions:

- Conditions defined in 38.101-1 [18] Clause 7.3 for reference sensitivity are fulfilled.
- Conditions for inter-frequency measurements are fulfilled according to Annex B.2.3 for a corresponding Band for each relevant SSB.

- $\left| RSRP1|_{dBm} - RSRP2|_{dBm} \right| \leq 27 dB$

- | Channel 1_Io -Channel 2_Io | ≤ 20 dB

Table 10.1.4.1.2-1: SS-RSRP Inter frequency relative accuracy in FR1

<table>
<tr><th colspan="2">Accuracy</th><th colspan="6">Conditions</th></tr>
<tr><th rowspan="2">Normal condition</th><th rowspan="2">Extreme condition</th><th rowspan="2">SSB Ês/Iot Note 2</th><th colspan="5">Io Note 1 range</th></tr>
<tr><th>NR operating band groups Note 3</th><th colspan="3">Minimum Io</th><th>Maximum Io</th></tr>
<tr><th rowspan="2">dB</th><th rowspan="2">dB</th><th rowspan="2">dB</th><th rowspan="2"></th><th colspan="2">dBm / SCS_{SSB}</th><th rowspan="2">dBm/BW_{Channel}</th><th rowspan="2">dBm/BW_{Channel}</th></tr>
<tr><th>SCS_{SSB} = 15 kHz</th><th>SCS_{SSB} = 30 kHz</th></tr>
<tr><td rowspan="7">±4.5</td><td rowspan="7">±6</td><td rowspan="7">≥-6 dB</td><td>NR_FDD_FR1_A, NR_TDD_FR1_A</td><td>-121</td><td>-118</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_FDD_FR1_B</td><td>-120.5</td><td>-117.5</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_TDD_FR1_C</td><td>-120</td><td>-117</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_FDD_FR1_D, NR_TDD_FR1_D</td><td>-119.5</td><td>-116.5</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_FDD_FR1_E, NR_TDD_FR1_E</td><td>-119</td><td>-116</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_FDD_FR1_G</td><td>-118</td><td>-115</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_FDD_FR1_H</td><td>-117.5</td><td>-114.5</td><td>N/A</td><td>-50</td></tr>
<tr><td colspan="8">NOTE 1: Io is assumed to have constant EPRE across the bandwidth.
NOTE 2: The parameter SSB Ês/Iot is the minimum SSB Ês/Iot of the pair of cells to which the requirement applies.
NOTE 3: NR operating band groups in FR1 are as defined in Section 3.5.2.</td></tr>
</table>

10.1.4.2 Inter-frequency [CSI-RS RSRP] accuracy requirements

10.1.5 Inter-frequency RSRP accuracy requirementsfor FR2

10.1.5.1 Inter-frequency SS-RSRP accuracy requirements

10.1.5.1.1 Absolute SS-RSRP Accuracy

Unless otherwise specified, the requirements for absolute accuracy of SS-RSRP in this clause apply to a cell on a frequency in FR2 that is on a different frequency than the serving cell.

The accuracy requirements in Table 10.1.5.1.1-1 are valid under the following conditions:

- Conditions defined in 38.101-2 [19] Clause 7.3 for reference sensitivity are fulfilled.

- Conditions for inter-frequency measurements are fulfilled according to Annex B.2.3 for a corresponding Band for each relevant SSB.

Table 10.1.5.1.1-1: SS-RSRP Inter frequency absolute accuracy in FR2

Accuracy		Conditions					
Normal condition	Extreme condition	SSB Ês/Iot	Io Note 1 range				
			NR operating band groups Note 2	Minimum Io			Maximum Io
dB	dB	dB		dBm / SCS_{SSB}		dBm/$BW_{Channel}$	dBm/$BW_{Channel}$
				SCS_{SSB} = 120kHz	SCS_{SSB} = 240kHz		
±[6]	±[9]	TBD	NR_TDD_FR2_A	TBD	TBD	N/A	-70
			NR_TDD_FR2_B	TBD	TBD	N/A	-70
			NR_TDD_FR2_F	TBD	TBD	N/A	-70
			NR_TDD_FR2_G	TBD	TBD	N/A	-70
			NR_TDD_FR2_T	TBD	TBD	N/A	-70
			NR_TDD_FR2_Y	TBD	TBD	N/A	-70
±[8]	±[11]	TBD	TNR_TDD_FR2_A, NR_TDD_FR2_B, NR_TDD_FR2_F, NR_TDD_FR2_G, NR_TDD_FR2_T, NR_TDD_FR2_Y	N/A	N/A	-70	-50
NOTE 1: Io is assumed to have constant EPRE across the bandwidth. NOTE 2: NR operating band groups in FR2 are as defined in Section 3.5.3.							

10.1.5.1.2 Relative SS-RSRP Accuracy

The relative accuracy of SS-RSRP is defined as the SS-RSRP measured from one cell on a frequency in FR2 compared to the SS-RSRP measured from another cell on another frequency in FR2.

The accuracy requirements in Table 10.1.5.1.2-1 are valid under the following conditions:

- Conditions defined in 38.101-2 [19] Clause 7.3 for reference sensitivity are fulfilled.
- Conditions for inter-frequency measurements are fulfilled according to Annex B.2.3 for a corresponding Band for each relevant SSB.
- $\left| RSRP1|_{dBm} - RSRP2|_{dBm} \right| \leq 27\,dB$
- | Channel 1_Io -Channel 2_Io | ≤ 20 dB

Table 10.1.5.1.2-1: SS-RSRP Inter frequency relative accuracy in FR2

Accuracy		Conditions					
Normal condition	Extreme condition	SSB Ês/Iot Note 2	Io Note 1 range				
			NR operating band groups Note 3	Minimum Io			Maximum Io
dB	dB	dB		dBm / SCS_{SSB}		dBm/$BW_{Channel}$	dBm/$BW_{Channel}$
				SCS_{SSB} = 120kHz	SCS_{SSB} = 240kHz		
±[6]	±[9]	TBD	NR_TDD_FR2_A	TBD	TBD	N/A	TBD
			NR_TDD_FR2_B	TBD	TBD	N/A	TBD
			NR_TDD_FR2_F	TBD	TBD	N/A	TBD
			NR_TDD_FR2_G	TBD	TBD	N/A	TBD
			NR_TDD_FR2_T	TBD	TBD	N/A	TBD
			NR_TDD_FR2_Y	TBD	TBD	N/A	TBD
NOTE 1: Io is assumed to have constant EPRE across the bandwidth. NOTE 2: The parameter SSB Ês/Iot is the minimum SSB Ês/Iot of the pair of cells to which the requirement applies. NOTE 3: NR operating band groups in FR2 are as defined in Section 3.5.3.							

10.1.5.2 Inter-frequency [CSI-RS RSRP] accuracy requirements

10.1.6 RSRP Measurement Report Mapping

The reporting range of SS-RSRP for L3 reporting is defined from -156 dBm to -31 dBm with 1 dB resolution. The reporting range of SS-RSRP and CSI-RSRP for L1 reporting is defined from -140 to -40dBm with 1dB resolution.

The mapping of measured quantity is defined in Table 10.1.6.1-1. The range in the signalling may be larger than the guaranteed accuracy range.

The reporting range of differential SS-RSRP and CSI-RSRP for L1 reporting is defined from 0 dBm to -30 dB with 2 dB resolution.

The mapping of measured quantity is defined in Table 10.1.6.1-2. The range in the signalling may be larger than the guaranteed accuracy range.

Table 10.1.6.1-1: SS-RSRP and CSI-RSRP measurement report mapping

Reported value	Measured quantity value(L3 SS-RSRP)	Measured quantity value(L1 SS-RSRP and CSI-RSRP)	Unit
RSRP_0	SS-RSRP<-156	Not valid	dBm
RSRP_1	-156≤ SS-RSRP<-155	Not valid	dBm
RSRP_2	-155≤ SS-RSRP<-154	Not valid	dBm
RSRP_3	-154≤ SS-RSRP<-153	Not valid	dBm
RSRP_4	-153≤ SS-RSRP<-152	Not valid	dBm
RSRP_5	-152≤ SS-RSRP<-151	Not valid	dBm
RSRP_6	-151≤ SS-RSRP<-150	Not valid	dBm
RSRP_7	-150≤ SS-RSRP<-149	Not valid	dBm
RSRP_8	-149≤ SS-RSRP<-148	Not valid	dBm
RSRP_9	-148≤ SS-RSRP<-147	Not valid	dBm
RSRP_10	-147≤ SS-RSRP<-146	Not valid	dBm
RSRP_11	-146≤ SS-RSRP<-145	Not valid	dBm
RSRP_12	-145≤ SS-RSRP<-144	Not valid	dBm
RSRP_13	-144≤ SS-RSRP<-143	Not valid	dBm
RSRP_14	-143≤ SS-RSRP<-142	Not valid	dBm
RSRP_15	-142≤ SS-RSRP<-141	Not valid	dBm
RSRP_16	-141≤ SS-RSRP<-140	RSRP<-140	dBm
RSRP_17	-140≤ SS-RSRP<-139	-140≤RSRP<-139	dBm
RSRP_18	-139≤ SS-RSRP<-138	-139≤ RSRP<-138	dBm
…	…		…
RSRP_111	-46≤ SS-RSRP<-45	-46≤ RSRP<-45	dBm
RSRP_112	-45≤ SS-RSRP<-44	-45≤ RSRP<-44	dBm
RSRP_113	-44≤ SS-RSRP<-43	-44≤ RSRP	dBm
RSRP_114	-43≤ SS-RSRP<-42	Not valid	dBm
RSRP_115	-42≤ SS-RSRP<-41	Not valid	dBm
RSRP_116	-41≤ SS-RSRP<-40	Not valid	dBm
RSRP_117	-40≤ SS-RSRP<-39	Not valid	dBm
RSRP_118	-39≤ SS-RSRP<-38	Not valid	dBm
RSRP_119	-38≤ SS-RSRP<-37	Not valid	dBm
RSRP_120	-37≤ SS-RSRP<-36	Not valid	dBm
RSRP_121	-36≤ SS-RSRP<-35	Not valid	dBm
RSRP_122	-35≤ SS-RSRP<-34	Not valid	dBm
RSRP_123	-34≤ SS-RSRP<-33	Not valid	dBm
RSRP_124	-33≤ SS-RSRP<-32	Not valid	dBm
RSRP_125	-32≤ SS-RSRP<-31	Not valid	dBm
RSRP_126	-31≤ SS-RSRP	Not valid	dBm
RSRP_127 (Note)	Infinity	Infinity	dBm
Note: The value of RSRP_127 is applicable for RSRP threshold configured by the network as defined in TS 38.331 [2], but not for the purpose of measurement reporting.			

Table 10.1.6.1-2:Differential SS-RSRP and CSI-RSRP measurement report mapping

Reported value	Measured quantity value(difference in measured RSRP from strongest RSRP)	Unit
DIFFRSRP_0	0⩾ΔRSRP>-2	dB
DIFFRSRP_1	-2⩾ΔRSRP>-4	dB
DIFFRSRP_2	-4⩾ΔRSRP>-6	dB
DIFFRSRP_3	-6⩾ΔRSRP>-8	dB
DIFFRSRP_4	-8⩾ΔRSRP>-10	dB
DIFFRSRP_5	-10⩾ΔRSRP>-12	dB
DIFFRSRP_6	-12⩾ΔRSRP>-14	dB
DIFFRSRP_7	-14⩾ΔRSRP>-16	dB
DIFFRSRP_8	-16⩾ΔRSRP>-18	dB
DIFFRSRP_9	-18⩾ΔRSRP>-20	dB
DIFFRSRP_10	-20⩾ΔRSRP>-22	dB
DIFFRSRP_11	-22⩾ΔRSRP>-24	dB
DIFFRSRP_12	-24⩾ΔRSRP>-26	dB
DIFFRSRP_13	-26⩾ΔRSRP>-28	dB
DIFFRSRP_14	-28⩾ΔRSRP>-30	dB
DIFFRSRP_15	-30⩾ΔRSRP	dB

10.1.7 Intra-frequency RSRQ accuracy requirements for FR1

10.1.7.1 Intra-frequency SS-RSRQ accuracy requirements in FR1

10.1.7.1.1 Absolute SS-RSRQ Accuracy in FR1

Unless otherwise specified, the requirements for absolute accuracy of SS-RSRQ in this clause apply to a cell on the same frequency as that of the serving cell in FR1.

The accuracy requirements in Table 10.1.7.1.1-1 are valid under the following conditions:

- Conditions defined in 38.101-1 [18] Clause 7.3 for reference sensitivity are fulfilled.
- Conditions for intra-frequency measurements are fulfilled according to Annex B.2.2 for a corresponding Band for each relevant SSB.

Table 10.1.7.1.1-1: SS-RSRQ Intra frequency absolute accuracy in FR1

<table>
<tr><th colspan="2">Accuracy</th><th colspan="6">Conditions</th></tr>
<tr><th rowspan="2">Normal condition</th><th rowspan="2">Extreme condition</th><th rowspan="2">SSB Ês/Iot</th><th colspan="5">Io Note 1 range</th></tr>
<tr><th>NR operating band groups Note 3</th><th colspan="3">Minimum Io</th><th>Maximum Io</th></tr>
<tr><th rowspan="2">dB</th><th rowspan="2">dB</th><th rowspan="2">dB</th><th rowspan="2"></th><th colspan="2">dBm / SCS_{SSB}</th><th rowspan="2">$dBm/BW_{Channel}$</th><th rowspan="2">$dBm/BW_{Channel}$</th></tr>
<tr><th>SCS_{SSB} = 15 kHz</th><th>SCS_{SSB} = 30 kHz</th></tr>
<tr><td rowspan="7">±2.5</td><td rowspan="7">±4</td><td rowspan="7">≥-3 dB</td><td>NR_FDD_FR1_A, NR_TDD_FR1_A</td><td>-121</td><td>-118</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_FDD_FR1_B</td><td>-120.5</td><td>-117.5</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_TDD_FR1_C</td><td>-120</td><td>-117</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_FDD_FR1_D, NR_TDD_FR1_D</td><td>-119.5</td><td>-116.5</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_FDD_FR1_E, NR_TDD_FR1_E</td><td>-119</td><td>-116</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_FDD_FR1_G</td><td>-118</td><td>-115</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_FDD_FR1_H</td><td>-117.5</td><td>-114.5</td><td>N/A</td><td>-50</td></tr>
<tr><td>±3.5</td><td>±4</td><td>≥-6 dB</td><td>Note 2</td><td>Note 2</td><td>Note 2</td><td>Note 2</td><td>Note 2</td></tr>
<tr><td colspan="8">NOTE 1: Io is assumed to have constant EPRE across the bandwidth.
NOTE 2: The same bands and the same Io conditions for each band apply for this requirement as for the corresponding highest accuracy requirement.
NOTE 3: NR operating band groups in FR1 are as defined in Section 3.5.2.</td></tr>
</table>

10.1.8 Intra-frequency RSRQ accuracy requirements for FR2

10.1.8.1 Intra-frequency SS-RSRQ accuracy requirements in FR2

10.1.8.1.1 Absolute SS-RSRQ Accuracy in FR2

Unless otherwise specified, the requirements for absolute accuracy of SS-RSRQ in this clause apply to a cell on the same frequency as that of the serving cell in FR2.

The accuracy requirements in Table 10.1.8.1.1-1 are valid under the following conditions:

- Conditions defined in 38.101-2 [19] Clause 7.3 for reference sensitivity are fulfilled.

- Conditions for intra-frequency measurements are fulfilled according to Annex B.2.2 for a corresponding Band for each relevant SSB.

Table 10.1.8.1.1-1: SS-RSRQ Intra frequency absolute accuracy in FR2

<table>
<tr><th colspan="2">Accuracy</th><th colspan="6">Conditions</th></tr>
<tr><th rowspan="2">Normal condition</th><th rowspan="2">Extreme condition</th><th rowspan="2">SSB Ês/Iot</th><th colspan="5">Io Note 1 range</th></tr>
<tr><th>NR operating band groups Note 3</th><th colspan="3">Minimum Io</th><th>Maximum Io</th></tr>
<tr><th rowspan="2">dB</th><th rowspan="2">dB</th><th rowspan="2">dB</th><th rowspan="2"></th><th colspan="2">dBm / SCS_{SSB}</th><th rowspan="2">dBm/BW_{Channel}</th><th rowspan="2">dBm/BW_{Channel}</th></tr>
<tr><th>SCS_{SSB} = 120 kHz</th><th>SCS_{SSB} = 240 kHz</th></tr>
<tr><td rowspan="6">±[2.5]</td><td rowspan="6">±[4]</td><td rowspan="6">≥[TBD] dB</td><td>NR_TDD_FR2_A</td><td>TBD</td><td>TBD</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_TDD_FR2_B</td><td>TBD</td><td>TBD</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_TDD_FR2_F</td><td>TBD</td><td>TBD</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_TDD_FR2_G</td><td>TBD</td><td>TBD</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_TDD_FR2_T</td><td>TBD</td><td>TBD</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_TDD_FR2_Y</td><td>TBD</td><td>TBD</td><td>N/A</td><td>-50</td></tr>
<tr><td>±[3.5]</td><td>±[4]</td><td>≥[TBD] dB</td><td>Note 2</td><td>Note 2</td><td>Note 2</td><td>Note 2</td><td>Note 2</td></tr>
<tr><td colspan="8">NOTE 1: Io is assumed to have constant EPRE across the bandwidth.
NOTE 2: The same bands and the same Io conditions for each band apply for this requirement as for the corresponding highest accuracy requirement.
NOTE 3: NR operating band groups in FR2 are as defined in Section 3.5.3.</td></tr>
</table>

10.1.9 Inter-frequency RSRQ accuracy requirements for FR1

10.1.9.1 Inter-frequency SS-RSRQ accuracy requirements in FR1

10.1.9.1.1 Aboslute Accuracy of SS-RSRQ in FR1

The requirements for absolute accuracy of SS-RSRQ in this clause apply to a cell on a frequency in FR1 that has different carrier frequency from the serving cell.

The accuracy requirements in Table 10.1.9.1.1-1 are valid under the following conditions:

- Conditions defined in 38.101-1 [18] Clause 7.3 for reference sensitivity are fulfilled.

- Conditions for inter-frequency measurements are fulfilled according to Annex B.2.3 for a corresponding Band for each relevant SSB.

Table 10.1.9.1.1-1: SS-RSRQ Inter frequency absolute accuracy in FR1

Accuracy		Conditions					
			Io Note 1 range				
Normal condition	Extreme condition	SSB Ês/Iot	NR operating band groups Note 3	Minimum Io			Maximum Io
				dBm / SCS_{SSB}			
dB	dB	dB		SCS_{SSB} = 15 kHz	SCS_{SSB} = 30 kHz	dBm/$BW_{Channel}$	dBm/$BW_{Channel}$
±2.5	±4	≥-3 dB	NR_FDD_FR1_A, NR_TDD_FR1_A	-121	-118	N/A	-50
			NR_FDD_FR1_B	-120.5	-117.5	N/A	-50
			NR_TDD_FR1_C	-120	-117	N/A	-50
			NR_FDD_FR1_D, NR_TDD_FR1_D	-119.5	-116.5	N/A	-50
			NR_FDD_FR1_E, NR_TDD_FR1_E	-119	-116	N/A	-50
			NR_FDD_FR1_G	-118	-115	N/A	-50
			NR_FDD_FR1_H	-117.5	-114.5	N/A	-50
±3.5	±4	≥-6 dB	Note 2	Note 2	Note 2	Note 2	Note 2

NOTE 1: Io is assumed to have constant EPRE across the bandwidth.
NOTE 2: The same bands and the same Io conditions for each band apply for this requirement as for the corresponding highest accuracy requirement.
NOTE 3: NR operating band groups in FR1 are as defined in Section 3.5.2.

10.1.9.1.2 Relative Accuracy of SS-RSRQ in FR1

The relative accuracy of SS-RSRQ in inter frequency case is defined as the RSRQ measured from one cell on a frequency in FR1 compared to the RSRP measured from another cell on a different frequency in FR1.

The accuracy requirements in Table 10.1.9.1.2-1 are valid under the following conditions:

- Conditions defined in 38.101-1 [18] Clause 7.3 for reference sensitivity are fulfilled.
- Conditions for inter-frequency measurements are fulfilled according to Annex B.2.3 for a corresponding Band for each relevant SSB.
- $\left| RSRP1|_{dBm} - RSRP2|_{dBm} \right| \le 27\,dB$
- | Channel 1_Io -Channel 2_Io | ≤ 20 dB

Table 10.1.9.1.2-1: SS-RSRQ Inter frequency relative accuracy in FR1

Accuracy		Conditions					
Normal condition	Extreme condition	SSB Ês/Iot Note 2	Io Note 1 range				
			NR operating band groups Note 4	Minimum Io			Maximum Io
dB	dB	dB		dBm / SCS_{SSB}		dBm/$BW_{Channel}$	dBm/$BW_{Channel}$
				SCS_{SSB} = 15 kHz	SCS_{SSB} = 30 kHz		
±3	±4	≥-3 dB	NRFDD_FR1_A, NRTDD_FR1_A	TBD	TBD	N/A	-50
			NRFDD_FR1_B	TBD	TBD	N/A	-50
			NRTDD_FR1_C	TBD	TBD	N/A	-50
			NRFDD_FR1_E, NRTDD_FR1_E	TBD	TBD	N/A	-50
			NRFDD_FR1_G	TBD	TBD	N/A	-50
			NRFDD_FR1_H	TBD	TBD	N/A	-50
±4	±4	≥-6 dB	Note 3	Note 3	Note 3	Note 3	Note 3

NOTE 1: Io is assumed to have constant EPRE across the bandwidth.
NOTE 2: The parameter SSB Ês/Iot is the minimum SSB Ês/Iot of the pair of cells to which the requirement applies.
NOTE 3: The same bands and the same Io conditions for each band apply for this requirement as for the corresponding highest accuracy requirement.
NOTE 4: NR operating band groups in FR1 are as defined in Section 3.5.2.

10.1.10 Inter-frequency RSRQ accuracy requirements for FR2

10.1.10.1 Inter-frequency SS-RSRQ accuracy requirements in FR2

10.1.10.1.1 Aboslute Accuracy of SS-RSRQ in FR2

The requirements for absolute accuracy of SS-RSRQ in this clause apply to a cell on a frequency in FR2 that has different carrier frequency from the serving cell.

The accuracy requirements in Table 10.1.10.1.1-1 are valid under the following conditions:

- Conditions defined in 38.101-2 [19] Clause 7.3 for reference sensitivity are fulfilled.
- Conditions for inter-frequency measurements are fulfilled according to Annex B.2.3 for a corresponding Band for each relevant SSB.

Table 10.1.10.1.1-1: SS-RSRQ Inter frequency absolute accuracy in FR2

Accuracy		Conditions					
Normal condition	Extreme condition	SSB Ês/Iot	Io Note 1 range				
			NR operating band groups Note 3	Minimum Io			Maximum Io
dB	dB	dB		dBm / SCS_{SSB}		dBm/$BW_{Channel}$	dBm/$BW_{Channel}$
				SCS_{SSB} = 120 kHz	SCS_{SSB} = 240 kHz		
±[2.5]	±[4]	≥[TBD] dB	NR_TDD_FR2_A	TBD	TBD	N/A	-50
			NR_TDD_FR2_B	TBD	TBD	N/A	-50
			NR_TDD_FR2_F	TBD	TBD	N/A	-50
			NR_TDD_FR2_G	TBD	TBD	N/A	-50
			NR_TDD_FR2_T	TBD	TBD	N/A	-50
			NR_TDD_FR2_Y	TBD	TBD	N/A	-50
±[3.5]	±[4]	≥[TBD] dB	Note 2	Note 2	Note 2	Note 2	Note 2

NOTE 1: Io is assumed to have constant EPRE across the bandwidth.
NOTE 2: The same bands and the same Io conditions for each band apply for this requirement as for the corresponding highest accuracy requirement.
NOTE 3: NR operating band groups in FR2 are as defined in Section 3.5.3.

10.1.10.1.2 Relative Accuracy of SS-RSRQ in FR2

The relative accuracy of SS-RSRQ in inter frequency case is defined as the RSRQ measured from one cell on a frequency in FR2 compared to the RSRP measured from another cell on a different frequency in FR2.

The accuracy requirements in Table 10.1.10.1.2-1 are valid under the following conditions:

- Conditions defined in 38.101-2 [19] Clause 7.3 for reference sensitivity are fulfilled.
- Conditions for inter-frequency measurements are fulfilled according to Annex B.2.3 for a corresponding Band for each relevant SSB.
- $\left| RSRP1|_{dBm} - RSRP2|_{dBm} \right| \le 27\,dB$
- | Channel 1_Io -Channel 2_Io | ≤ 20 dB-

Table 10.1.10.1.2-1: SS-RSRQ Inter frequency relative accuracy in FR2

<table>
<tr><th colspan="2">Accuracy</th><th colspan="6">Conditions</th></tr>
<tr><th rowspan="2">Normal condition</th><th rowspan="2">Extreme condition</th><th rowspan="2">SSB Ês/Iot Note 2</th><th colspan="5">Io Note 1 range</th></tr>
<tr><th>NR operating band groups Note 4</th><th colspan="3">Minimum Io</th><th>Maximum Io</th></tr>
<tr><th rowspan="2">dB</th><th rowspan="2">dB</th><th rowspan="2">dB</th><th rowspan="2"></th><th colspan="2">dBm / SCS_{SSB}</th><th rowspan="2">dBm/BW_{Channel}</th><th rowspan="2">dBm/BW_{Channel}</th></tr>
<tr><th>SCS_{SSB} = 120 kHz</th><th>SCS_{SSB} = 240 kHz</th></tr>
<tr><td rowspan="6">±[3]</td><td rowspan="6">±[4]</td><td rowspan="6">≥[TBD] dB</td><td>NR_TDD_FR2_A</td><td>TBD</td><td>TBD</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_TDD_FR2_B</td><td>TBD</td><td>TBD</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_TDD_FR2_F</td><td>TBD</td><td>TBD</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_TDD_FR2_G</td><td>TBD</td><td>TBD</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_TDD_FR2_T</td><td>TBD</td><td>TBD</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_TDD_FR2_Y</td><td>TBD</td><td>TBD</td><td>N/A</td><td>-50</td></tr>
<tr><td>±[4]</td><td>±[4]</td><td>≥[TBD] dB</td><td>Note 3</td><td>Note 3</td><td>Note 3</td><td>Note 3</td><td>Note 3</td></tr>
<tr><td colspan="8">NOTE 1: Io is assumed to have constant EPRE across the bandwidth.
NOTE 2: The parameter SSB Ês/Iot is the minimum SSB Ês/Iot of the pair of cells to which the requirement applies.
NOTE 3: The same bands and the same Io conditions for each band apply for this requirement as for the corresponding highest accuracy requirement.
NOTE 4: NR operating band groups in FR2 are as defined in Section 3.5.3.</td></tr>
</table>

10.1.11 RSRQ report mapping

10.1.11.1 SS-RSRQ measurement report mapping

The reporting range of SS-RSRQ is defined from -43 dB to 20 dB with 0.5 dB resolution. The mapping of measured quantity is defined in Table 10.1.11.1-1. The range in the signalling may be larger than the guaranteed accuracy range.

Table 10.1.11.1-1: SS-RSRQ measurement report mapping

Reported value	Measured quantity value	Unit
SS-RSRQ_0	SS-RSRQ<-43	dB
SS-RSRQ_1	-43⩽ SS-RSRQ<-42.5	dB
SS-RSRQ_2	-42.5⩽ SS-RSRQ<-42	dB
SS-RSRQ_3	-42⩽ SS-RSRQ<-41.5	dB
SS-RSRQ_4	-41.5⩽ SS-RSRQ<-41	dB
..	..	…
SS-RSRQ_122	17.5⩽ SS-RSRQ<18	dB
SS-RSRQ_123	18⩽ SS-RSRQ<18.5	dB
SS-RSRQ_124	18.5⩽ SS-RSRQ<19	dB
SS-RSRQ_125	19⩽ SS-RSRQ<19.5	dB
SS-RSRQ_126	19.5⩽ SS-RSRQ<20	dB
SS-RSRQ_127	20 ⩽ SS-RSRQ	dB

10.1.12 Intra-frequency SINR accuracy requirements for FR1

10.1.12.1 Intra-frequency SS-SINR accuracy requirements in FR1

10.1.12.1.1 Absolute SS-SINR Accuracy in FR1

Unless otherwise specified, the requirements for absolute accuracy of SS-SINR in this clause apply to a cell on the same frequency as that of the serving cell in FR1.

The accuracy requirements in Table 10.1.12.1.1-1 are valid under the following conditions:

- Conditions defined in 38.101-1 [18] Clause 7.3 for reference sensitivity are fulfilled.
- Conditions for intra-frequency measurements are fulfilled according to Annex B.2.2 for a corresponding Band.

Table 10.1.12.1.1-1: SS-SINR Intra frequency absolute accuracy in FR1

<table>
<tr><th colspan="2">Accuracy</th><th colspan="6">Conditions</th></tr>
<tr><th rowspan="2">Normal condition</th><th rowspan="2">Extreme condition</th><th rowspan="2">SSB Ês/Iot Note 3</th><th colspan="5">Io Note 1 range</th></tr>
<tr><th>NR operating band groups Note 4</th><th colspan="3">Minimum Io</th><th>Maximum Io</th></tr>
<tr><th rowspan="2">dB</th><th rowspan="2">dB</th><th rowspan="2">dB</th><th rowspan="2"></th><th colspan="2">dBm / SCS_{SSB}</th><th rowspan="2">dBm/BW_{Channel}</th><th rowspan="2">dBm/BW_{Channel}</th></tr>
<tr><th>SCS_{SSB} = 15 kHz</th><th>SCS_{SSB} = 30 kHz</th></tr>
<tr><td rowspan="7">±3.0</td><td rowspan="7">±4</td><td rowspan="7">≥-3 dB</td><td>NR_FDD_FR1_A, NR_TDD_FR1_A</td><td>-121</td><td>-118</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_FDD_FR1_B</td><td>-120.5</td><td>-117.5</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_TDD_FR1_C</td><td>-120</td><td>-117</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_FDD_FR1_D, NR_TDD_FR1_D</td><td>-119.5</td><td>-116.5</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_FDD_FR1_E, NR_TDD_FR1_E</td><td>-119</td><td>-116</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_FDD_FR1_G</td><td>-118</td><td>-115</td><td>N/A</td><td>-50</td></tr>
<tr><td>NR_FDD_FR1_H</td><td>-117.5</td><td>-114.5</td><td>N/A</td><td>-50</td></tr>
<tr><td>±3.5</td><td>±4</td><td>≥-6 dB</td><td>Note 2</td><td>Note 2</td><td>Note 2</td><td>Note 2</td><td>Note 2</td></tr>
<tr><td colspan="8">NOTE 1: Io is assumed to have constant EPRE across the bandwidth.
NOTE 2: The same bands and the same Io conditions for each band apply for this requirement as for the corresponding highest accuracy requirement.
NOTE 3: The requirements apply for SSB Ês/Iot ⩽ 25 dB.
NOTE 4: NR operating band groups in FR1 are as defined in Section 3.5.2.</td></tr>
</table>

10.1.13 Intra-frequency SINR accuracy requirements for FR2

10.1.13.1 Intra-frequency SS-SINR accuracy requirements in FR2

10.1.13.1.1 Absolute SS-SINR Accuracy in FR2

Unless otherwise specified, the requirements for absolute accuracy of SS-SINR in this clause apply to a cell on the same frequency as that of the serving cell in FR2.

The accuracy requirements in Table 10.1.13.1.1-1 are valid under the following conditions:

- Conditions defined in 38.101-2 [19] Clause 7.3 for reference sensitivity are fulfilled.
- Conditions for intra-frequency measurements are fulfilled according to Annex B.2.2 for a corresponding Band.

Table 10.1.13.1.1-1: SS-SINR Intra frequency absolute accuracy in FR2

Accuracy		Conditions					
Normal condition	Extreme condition	SSB Ês/Iot Note 3	Io Note 1 range				
			NR operating band groups Note 4	Minimum Io			Maximum Io
dB	dB	dB		dBm / SCS_{SSB}		$dBm/BW_{Channel}$	$dBm/BW_{Channel}$
				SCS_{SSB} = 120 kHz	SCS_{SSB} = 240 kHz		
±[3.0]	±[4]	≥[TBD] dB	NR_TDD_FR2_A	TBD	TBD	N/A	-50
			NR_TDD_FR2_B	TBD	TBD	N/A	-50
			NR_TDD_FR2_F	TBD	TBD	N/A	-50
			NR_TDD_FR2_G	TBD	TBD	N/A	-50
			NR_TDD_FR2_T	TBD	TBD	N/A	-50
			NR_TDD_FR2_Y	TBD	TBD	N/A	-50
±[3.5]	±[4]	≥[TBD] dB	Note 2	Note 2	Note 2	Note 2	Note 2

NOTE 1: Io is assumed to have constant EPRE across the bandwidth.
NOTE 2: The same bands and the same Io conditions for each band apply for this requirement as for the corresponding highest accuracy requirement.
NOTE 3: The requirements apply for SSB Ês/Iot ≤ [25] dB.
NOTE 4: NR operating band groups in FR2 are as defined in Section 3.5.3.

10.1.14 Inter-frequency SINR accuracy requirements for FR1

10.1.14.1 Inter-frequency SS-SINR accuracy requirements in FR1

10.1.14.1.1 Aboslute Accuracy of SS-SINR in FR1

The requirements for absolute accuracy of SS-SINR in this clause apply to a cell on a frequency in FR1 that has different carrier frequency from the serving cell.

The accuracy requirements in Table 10.1.14.1.1-1 are valid under the following conditions:

- Conditions defined in 38.101-1 [18] Clause 7.3 for reference sensitivity are fulfilled.

- Conditions for inter-frequency measurements are fulfilled according to Annex B.2.3 for a corresponding Band.

Table 10.1.14.1.1-1: SS-SINR Inter frequency absolute accuracy in FR1

Accuracy		Conditions					
Normal condition	Extreme condition	SSB Ês/Iot Note 3	Io Note 1 range				
			NR operating band groups Note 4	Minimum Io			Maximum Io
dB	dB	dB		dBm / SCS_{SSB}		$dBm/BW_{Channel}$	$dBm/BW_{Channel}$
				SCS_{SSB} = 15 kHz	SCS_{SSB} = 30 kHz		
±3.0	±4	≥-3 dB	NR_FDD_FR1_A, NR_TDD_FR1_A	-121	-118	N/A	-50
			NR_FDD_FR1_B	-120.5	-117.5	N/A	-50
			NR_TDD_FR1_C	-120	-117	N/A	-50
			NR_FDD_FR1_D, NR_TDD_FR1_D	-119.5	-116.5	N/A	-50
			NR_FDD_FR1_E, NR_TDD_FR1_E	-119	-116	N/A	-50
			NR_FDD_FR1_G	-118	-115	N/A	-50
			NR_FDD_FR1_H	-117.5	-114.5	N/A	-50
±3.5	±4	≥-6 dB	Note 2	Note 2	Note 2	Note 2	Note 2
NOTE 1: Io is assumed to have constant EPRE across the bandwidth. NOTE 2: The same bands and the same Io conditions for each band apply for this requirement as for the corresponding highest accuracy requirement. NOTE 3: The requirements apply for SSB Ês/Iot ⩽ 25 dB. NOTE 4: NR operating band groups in FR1 are as defined in Section 3.5.2.							

10.1.14.1.2 Relative Accuracy of SS-SINR in FR1

The relative accuracy of SS-SINR in inter frequency case is defined as the SS-SINR measured from one cell on a frequency in FR1 compared to the SS-SINR measured from another cell on a different frequency in FR1.

The accuracy requirements in Table 10.1.14.1.2-1 are valid under the following conditions:

- Conditions defined in 38.101-1 [18] Clause 7.3 for reference sensitivity are fulfilled.
- Conditions for inter-frequency measurements are fulfilled according to Annex B.2.3 for a corresponding Band.
- $\left| RSRP1|_{dBm} - RSRP2|_{dBm} \right| \le 27\,dB$
- | Channel 1_Io -Channel 2_Io | ≤ 20 dB

Table 10.1.14.1.2-1: SS-SINR Inter frequency relative accuracy in FR1

Accuracy		**Conditions**					
Normal condition	**Extreme condition**	**SSB Ês/Iot** Note 2,4	**Io** Note 1 **range**				
			NR operating band groups Note 5	**Minimum Io**			**Maximum Io**
dB	**dB**	**dB**		**dBm / SCS_{SSB}**		**dBm/$BW_{Channel}$**	**dBm/$BW_{Channel}$**
				SCS_{SSB} = 120 kHz	**SCS_{SSB} = 240 kHz**		
±3.5	±4	≥-3 dB	NR_FDD_FR1_A, NR_TDD_FR1_A	-121	-118	N/A	-50
			NR_FDD_FR1_B	-120.5	-117.5	N/A	-50
			NR_TDD_FR1_C	-120	-117	N/A	-50
			NR_FDD_FR1_D, NR_TDD_FR1_D	-119.5	-116.5	N/A	-50
			NR_FDD_FR1_E, NR_TDD_FR1_E	-119	-116	N/A	-50
			NR_FDD_FR1_G	-118	-115	N/A	-50
			NR_FDD_FR1_H	-117.5	-114.5	N/A	-50
±4	±4	≥-6 dB	Note 3	Note 3	Note 3	Note 3	Note 3

NOTE 1: Io is assumed to have constant EPRE across the bandwidth.
NOTE 2: The parameter SSB Ês/Iot is the minimum SSB Ês/Iot of the pair of cells to which the requirement applies.
NOTE 3: The same bands and the same Io conditions for each band apply for this requirement as for the corresponding highest accuracy requirement.
NOTE 4: The requirements apply for SSB Ês/Iot ⩽ [25] dB.
NOTE 5: NR operating band groups in FR1 are as defined in Section 3.5.2.

10.1.15 Inter-frequency SINR accuracy requirements for FR2

10.1.15.1 Inter-frequency SS-SINR accuracy requirements in FR2

10.1.15.1.1 Aboslute Accuracy of SS-SINR in FR2

The requirements for absolute accuracy of SS-SINR in this clause apply to a cell on a frequency in FR2 that has different carrier frequency from the serving cell.

The accuracy requirements in Table 10.1.15.1.1-1 are valid under the following conditions:

- Conditions defined in 38.101-2 [19] Clause 7.3 for reference sensitivity are fulfilled.
- Conditions for inter-frequency measurements are fulfilled according to Annex B.2.3 for a corresponding Band.

Table 10.1.15.1.1-1: SS-SINR Inter frequency absolute accuracy in FR2

Accuracy		Conditions					
Normal condition	Extreme condition	SSB Ês/Iot Note 3	Io Note 1 range				
			NR operating band groups Note 4	Minimum Io			Maximum Io
dB	dB	dB		dBm / SCS_{SSB}		$dBm/BW_{Channel}$	$dBm/BW_{Channel}$
				SCS_{SSB} = 120 kHz	SCS_{SSB} = 240 kHz		
±[3.0]	±[4]	≥[TBD] dB	NR_TDD_FR2_A	TBD	TBD	N/A	-50
			NR_TDD_FR2_B	TBD	TBD	N/A	-50
			NR_TDD_FR2_F	TBD	TBD	N/A	-50
			NR_TDD_FR2_G	TBD	TBD	N/A	-50
			NR_TDD_FR2_T	TBD	TBD	N/A	-50
			NR_TDD_FR2_Y	TBD	TBD	N/A	-50
±[3.5]	±[4]	≥[TBD] dB	Note 2	Note 2	Note 2	Note 2	Note 2

NOTE 1: Io is assumed to have constant EPRE across the bandwidth.
NOTE 2: The same bands and the same Io conditions for each band apply for this requirement as for the corresponding highest accuracy requirement.
NOTE 3: The requirements apply for SSB Ês/Iot ⩽ [25] dB.
NOTE 4: NR operating band groups in FR2 are as defined in Section 3.5.3.

10.1.15.1.2 Relative Accuracy of SS-SINR in FR2

The relative accuracy of SS-SINR in inter frequency case is defined as the SS-SINR measured from one cell on a frequency in FR2 compared to the SS-SINR measured from another cell on a different frequency in FR2.

The accuracy requirements in Table 10.1.15.1.2-1 are valid under the following conditions:

- Conditions defined in 38.101-2 [19] Clause 7.3 for reference sensitivity are fulfilled.
- Conditions for inter-frequency measurements are fulfilled according to Annex B.2.3 for a corresponding Band.
- $\left| RSRP1|_{dBm} - RSRP2|_{dBm} \right| \leq 27\,dB$
- | Channel 1_Io -Channel 2_Io | ≤ 20 dB

Table 10.1.15.1.2-1: SS-SINR Inter frequency relative accuracy in FR2

Accuracy		Conditions					
Normal condition	Extreme condition	SSB Ês/Iot Note 2, Note 4	Io Note 1 range				
			NR operating band groups Note 5	Minimum Io			Maximum Io
dB	dB	dB		dBm / SCS_{SSB}		$dBm/BW_{Channel}$	$dBm/BW_{Channel}$
				SCS_{SSB} = 120 kHz	SCS_{SSB} = 240 kHz		
±[3.5]	±[4]	≥[TBD] dB	NR_TDD_FR2_A	TBD	TBD	N/A	-50
			NR_TDD_FR2_B	TBD	TBD	N/A	-50
			NR_TDD_FR2_F	TBD	TBD	N/A	-50
			NR_TDD_FR2_G	TBD	TBD	N/A	-50
			NR_TDD_FR2_T	TBD	TBD	N/A	-50
			NR_TDD_FR2_Y	TBD	TBD	N/A	-50
±[4]	±[4]	≥[TBD] dB	Note 3	Note 3	Note 3	Note 3	Note 3

NOTE 1: Io is assumed to have constant EPRE across the bandwidth.
NOTE 2: The parameter SSB Ês/Iot is the minimum SSB Ês/Iot of the pair of cells to which the requirement applies.
NOTE 3: The same bands and the same Io conditions for each band apply for this requirement as for the corresponding highest accuracy requirement.
NOTE 4: The requirements apply for SSB Ês/Iot ≤ [25] dB.
NOTE 5: NR operating band groups in FR2 are as defined in Section 3.5.3.

10.1.16 SINR report mapping

10.1.16.1 SS-SINR measurement report mapping

The reporting range of SS-SINR is defined from -23 dB to 40 dB with 0.5 dB resolution. The mapping of measured quantity is defined in Table 10.1.16.1-1. The range in the signalling may be larger than the guaranteed accuracy range.

Table 10.1.16.1-1: SS-SINR measurement report mapping

Reported value	Measured quantity value	Unit
SS-SINR_0	SS-SINR<-23	dB
SS-SINR_1	-23≤ SS-SINR<-22.5	dB
SS-SINR_2	-22.5≤ SS-SINR<-22	dB
SS-SINR_3	-22≤ SS-SINR<-21.5	dB
SS-SINR_4	-21.5≤ SS-SINR<-21	dB
..	..	…
SS-SINR_123	38≤ SS-SINR<38.5	dB
SS-SINR_124	38.5≤ SS-SINR<39	dB
SS-SINR_125	39≤ SS-SINR<39.5	dB
SS-SINR_126	39.5≤ SS-SINR<40	dB
SS-SINR_127	40≤ SS-SINR	dB

10.1.17 Power Headroom

10.1.17.1 Power Headroom Report

10.1.17.1.1 Power Headroom Report Mapping

The power headroom reporting range is from -32 ...+38 dB. Table 10.1.17.1-1 defines the report mapping.

Table 10.1.17.1-1: Power headroom report mapping

Reported value	Measured quantity value (dB)
POWER_HEADROOM_0	PH < -32
POWER_HEADROOM_1	-32 ≤ PH < -31
POWER_HEADROOM_2	-31 ≤ PH < -30
POWER_HEADROOM_3	-30 ≤ PH < -29
…	…
POWER_HEADROOM_53	20 ≤ PH < 21
POWER_HEADROOM_54	21 ≤ PH < 22
POWER_HEADROOM_55	22 ≤ PH < 24
POWER_HEADROOM_56	24 ≤ PH < 26
POWER_HEADROOM_57	26 ≤ PH < 28
POWER_HEADROOM_58	28 ≤ PH < 30
POWER_HEADROOM_59	30 ≤ PH < 32
POWER_HEADROOM_60	32 ≤ PH < 34
POWER_HEADROOM_61	34 ≤ PH < 36
POWER_HEADROOM_62	36 ≤ PH < 38
POWER_HEADROOM_63	PH ⩾ 38

10.1.18 $P_{CMAX,c,f}$

The UE is required to report the UE configured maximum output power ($P_{CMAX,c,f}$) together with the power headroom. This clause defines the requirements for the $P_{CMAX,c,f}$ reporting.

10.1.18.1 Report Mapping

The $P_{CMAX,c,f}$ reporting range is defined from -29dBm to 33 dBm with 1 dB resolution. Table 10.1.18.1-1 defines the reporting mapping.

Table 10.1.18.1-1 Mapping of $P_{CMAX,c.f}$

Reported value	Measured quantity value	Unit
PCMAX_C_00	$P_{CMAX,c,f}$ < -29	dBm
PCMAX_C_01	-29 ≤ $P_{CMAX,c,f}$ < -28	dBm
PCMAX_C_02	-28 ≤ $P_{CMAX,c,f}$ < -27	dBm
…	…	…
PCMAX_C_61	31 ≤ $P_{CMAX,c,f}$ < 32	dBm
PCMAX_C_62	32 ≤ $P_{CMAX,c,f}$ < 33	dBm
PCMAX_C_63	33 ≤ $P_{CMAX,c,f}$	dBm

10.1.19 L1-RSRP accuracy requirements for FR1

10.1.19.1 SSB based L1-RSRP accuracy requirements

10.1.19.1.1 Absolute Accuracy

Unless otherwise specified, the requirements for absolute accuracy of SSB based L1-RSRP in this clause apply to all SSBs of the serving cell configured for L1-RSRP measurement.

The accuracy requirements in Table 10.1.19.1.1-1 are valid under the following conditions:

Conditions for L1-RSRP measurements are fulfilled according to Annex B.2.4.1 for a corresponding Band for each relevant SSB-.

Table 10.1.19.1.1-1: SSB based L1-RSRP absolute accuracy in FR1

<table>
<tr><th colspan="2">Accuracy</th><th colspan="6">Conditions</th></tr>
<tr><th rowspan="2">Normal condition</th><th rowspan="2">Extreme condition</th><th rowspan="2">SSB Ês/Iot</th><th colspan="5">Io Note 1 range</th></tr>
<tr><th>NR operating band groups Note 2</th><th colspan="3">Minimum Io</th><th>Maximum Io</th></tr>
<tr><th rowspan="2">dB</th><th rowspan="2">dB</th><th rowspan="2">dB</th><th rowspan="2"></th><th colspan="2">dBm / SCS_{SSB}</th><th rowspan="2">$dBm/BW_{Channel}$</th><th rowspan="2">$dBm/BW_{Channel}$</th></tr>
<tr><th>SCS_{SSB} = 15 kHz</th><th>SCS_{SSB} = 30 kHz</th></tr>
<tr><td rowspan="7">TBD</td><td rowspan="7">TBD</td><td rowspan="7">≥-3dB</td><td>NR_FDD_FR1_A, NR_TDD_FR1_A</td><td>-121</td><td>-118</td><td>N/A</td><td>-70</td></tr>
<tr><td>NR_FDD_FR1_B</td><td>-120.5</td><td>-117.5</td><td>N/A</td><td>-70</td></tr>
<tr><td>NR_TDD_FR1_C</td><td>-120</td><td>-117</td><td>N/A</td><td>-70</td></tr>
<tr><td>NR_FDD_FR1_D, NR_TDD_FR1_D</td><td>-119.5</td><td>-116.5</td><td>N/A</td><td>-70</td></tr>
<tr><td>NR_FDD_FR1_E, NR_TDD_FR1_E</td><td>-119</td><td>-116</td><td>N/A</td><td>-70</td></tr>
<tr><td>NR_FDD_FR1_G</td><td>-118</td><td>-115</td><td>N/A</td><td>-70</td></tr>
<tr><td>NR_FDD_FR1_H</td><td>-117.5</td><td>-114.5</td><td>N/A</td><td>-70</td></tr>
<tr><td>TBD</td><td>TBD</td><td>TBD</td><td>NR_FDD_FR1_A, NR_TDD_FR1_A, NR_FDD_FR1_B, NR_TDD_FR1_C, NR_FDD_FR1_D, NR_TDD_FR1_D, NR_FDD_FR1_E, NR_TDD_FR1_E, NR_FDD_FR1_G, NR_FDD_FR1_H,</td><td>N/A</td><td>N/A</td><td>-70</td><td>-50</td></tr>
<tr><td colspan="8">NOTE 1: Io is assumed to have constant EPRE across the bandwidth.
NOTE 2: NR operating band groups in FR1 are as defined in Section 3.5.2.</td></tr>
</table>

10.1.19.1.2 Relative Accuracy

The relative accuracy of SSB based L1-RSRP is defined as the L1-RSRP measured from one SSB compared to the largest measured value of L1-RSRP among all SSBs of the serving cell.

The accuracy requirements in Table 10.1.19.1.2-1 are valid under the following conditions:

Conditions for L1-RSRP measurements are fulfilled according to Annex B.2.4.1 for a corresponding Band for each relevant SSB.

Table 10.1.19.1.2-1: SSB based L1-RSRP relative accuracy in FR1

Accuracy		Conditions					
			Io [Note 1] range				
Normal condition	Extreme condition	SSB Ês/Iot [Note 2]	NR operating band groups [Note 4]	Minimum Io			Maximum Io
				dBm / SCS_{SSB}			
dB	dB	dB		SCS_{SSB} = 15 kHz	SCS_{SSB} = 30 kHz	dBm/$BW_{Channel}$	dBm/$BW_{Channel}$
TBD	TBD	$\geq$-3dB	NR_FDD_FR1_A, NR_TDD_FR1_A	-121	-118	N/A	-50
			NR_FDD_FR1_B	-120.5	-117.5	N/A	-50
			NR_TDD_FR1_C	-120	-117	N/A	-50
			NR_FDD_FR1_D, NR_TDD_FR1_D	-119.5	-116.5	N/A	-50
			NR_FDD_FR1_E, NR_TDD_FR1_E	-119	-116	N/A	-50
			NR_FDD_FR1_G	-118	-115	N/A	-50
			NR_FDD_FR1_H	-117.5	-114.5	N/A	-50
TBD	TBD	TBD	Note 3	Note 3	Note 3	N/A	Note 3

NOTE 1: Io is assumed to have constant EPRE across the bandwidth.
NOTE 2: The parameter SSB Ês/Iot is the minimum SSB Ês/Iot of the pair of SSBs to which the requirement applies.
NOTE 3: The same bands and the same Io conditions for each band apply for this requirement as for the corresponding highest accuracy requirement.
NOTE 4: NR operating band groups in FR1 are as defined in Section 3.5.2.

10.1.19.2 CSI-RS based L1-RSRP accuracy requirements

10.1.19.2.1 Absolute Accuracy

Unless otherwise specified, the requirements for absolute accuracy of CSI-RS based L1-RSRP in this clause apply to all CSI-RS resources of the serving cell configured for L1-RSRP measurement.

The accuracy requirements in Table 10.1.19.2.1-1 are valid under the following conditions:

Conditions for L1-RSRP measurements are fulfilled according to Annex B.2.4.2 for a corresponding Band for each relevant CSI-RS.

Table 10.1.19.2.1-1: CSI-RS based L1-RSRP absolute accuracy in FR1

Accuracy		Conditions					
			Io [Note 1] range				
Normal condition	Extreme condition	CSI-RS Ês/Iot	NR operating band groups [Note 2]	Minimum Io			Maximum Io
				dBm / SCS_{CSI-RS}			
dB	dB	dB		SCS_{CSI-RS} = 15 kHz	SCS_{CSI-RS} = 30 kHz	$dBm/BW_{Channel}$	$dBm/BW_{Channel}$
TBD	TBD	≥-3dB	NR_FDD_FR1_A, NR_TDD_FR1_A	-121	-118	N/A	-70
			NR_FDD_FR1_B	-120.5	-117.5	N/A	-70
			NR_TDD_FR1_C	-120	-117	N/A	-70
			NR_FDD_FR1_D, NR_TDD_FR1_D	-119.5	-116.5	N/A	-70
			NR_FDD_FR1_E, NR_TDD_FR1_E	-119	-116	N/A	-70
			NR_FDD_FR1_G	-118	-115	N/A	-70
			NR_FDD_FR1_H	-117.5	-114.5	N/A	-70
TBD	TBD	TBD	NR_FDD_FR1_A, NR_TDD_FR1_A, NR_FDD_FR1_B, NR_TDD_FR1_C, NR_FDD_FR1_D, NR_TDD_FR1_D, NR_FDD_FR1_E, NR_TDD_FR1_E, NR_FDD_FR1_G, NR_FDD_FR1_H,	N/A	N/A	-70	-50
NOTE 1: Io is assumed to have constant EPRE across the bandwidth. NOTE 2: NR operating band groups in FR1 are as defined in Section 3.5.2.							

10.1.19.2.2 Relative Accuracy

The relative accuracy of CSI-RS based L1-RSRP is defined as the L1-RSRP measured from one CSI-RS compared to the largest measured value of L1-RSRP among all CSI-RS resources of the serving cell.

The accuracy requirements in Table 10.1.19.2.2-1 are valid under the following conditions:

Conditions for L1-RSRP measurements are fulfilled according to Annex B.2.4.2 for a corresponding Band for each relevant CSI-RS.

Table 10.1.19.2.2-1: CSI-RS based L1-RSRP relative accuracy in FR1

Accuracy		Conditions					
Normal condition	Extreme condition	CSI-RS Ês/Iot Note 2	Io Note 1 range				
			NR operating band groups Note 4	Minimum Io			Maximum Io
dB	dB	dB		dBm / SCSCSI-RS		dBm/BWChannel	dBm/BWChannel
				SCSCSI-RS = 15 kHz	SCSCSI-RS = 30 kHz		
TBD	TBD	≥-3dB	NR_FDD_FR1_A, NR_TDD_FR1_A	-121	-118	N/A	-50
			NR_FDD_FR1_B	-120.5	-117.5	N/A	-50
			NR_TDD_FR1_C	-120	-117	N/A	-50
			NR_FDD_FR1_D, NR_TDD_FR1_D	-119.5	-116.5	N/A	-50
			NR_FDD_FR1_E, NR_TDD_FR1_E	-119	-116	N/A	-50
			NR_FDD_FR1_G	-118	-115	N/A	-50
			NR_FDD_FR1_H	-117.5	-114.5	N/A	-50
TBD	TBD	TBD	Note 3	Note 3	Note 3	N/A	Note 3

NOTE 1: Io is assumed to have constant EPRE across the bandwidth.
NOTE 2: The parameter CSI-RS Ês/Iot is the minimum SSB Ês/Iot of the pair of CSI-RS resources to which the requirement applies.
NOTE 3: The same bands and the same Io conditions for each band apply for this requirement as for the corresponding highest accuracy requirement.
NOTE 4: NR operating band groups in FR1 are as defined in Section 3.5.2.

10.1.20 L1-RSRP accuracy requirements for FR2

10.1.20.1 SSB based L1-RSRP accuracy requirements

10.1.20.1.1 Absolute Accuracy

Unless otherwise specified, the requirements for absolute accuracy of SSB based L1-RSRP in this clause apply to all SSBs of the serving cell configured for L1-RSRP measurement.

The accuracy requirements in Table 10.1.20.1.1-1 are valid under the following conditions:

Conditions for L1-RSRP measurements are fulfilled according to Annex B.2.4.1 for a corresponding Band for each relevant SSB.

Table 10.1.20.1.1-1: SSB based L1-RSRP absolute accuracy in FR2

Accuracy		Conditions					
Normal condition	Extreme condition	SSB Ês/Iot	Io Note 1 range				
			NR operating band groups Note 2	Minimum Io			Maximum Io
				dBm / SCS_{SSB}			
dB	dB	dB		SCS_{SSB} = 120kHz	SCS_{SSB} = 240kHz	$dBm/BW_{Channel}$	$dBm/BW_{Channel}$
TBD	TBD	≥-3dB	NR_TDD_FR2_A	TBD	TBD	N/A	-70
			NR_TDD_FR2_B	TBD	TBD	N/A	-70
			NR_TDD_FR2_F	TBD	TBD	N/A	-70
			NR_TDD_FR2_G	TBD	TBD	N/A	-70
			NR_TDD_FR2_T	TBD	TBD	N/A	-70
			NR_TDD_FR2_Y	TBD	TBD	N/A	-70
TBD	TBD	TBD	NR_TDD_FR2_A, NR_TDD_FR2_B, NR_TDD_FR2_F, NR_TDD_FR2_G, NR_TDD_FR2_T, NR_TDD_FR2_Y	N/A	N/A	-70	-50
NOTE 1: Io is assumed to have constant EPRE across the bandwidth. NOTE 2: NR operating band groups in FR2 are as defined in Section 3.5.3.							

10.1.20.1.2 Relative Accuracy

The relative accuracy of SSB based L1-RSRP is defined as the L1-RSRP measured from one SSB compared to the largest measured value of L1-RSRP among all SSBs of the serving cell.

The accuracy requirements in Table 10.1.20.1.2-1 are valid under the following conditions:

Conditions for L1-RSRP measurements are fulfilled according to Annex B.2.4.1 for a corresponding Band for each relevant SSB.

Table 10.1.20.1.2-1: SSB based L1-RSRP relative accuracy in FR2

Accuracy		Conditions					
Normal condition	Extreme condition	SSB Ês/Iot Note 2	Io Note 1 range				
			NR operating band groups Note 3	Minimum Io			Maximum Io
				dBm / SCS_{SSB}			
dB	dB	dB		SCS_{SSB} = 120kHz	SCS_{SSB} = 240kHz	$dBm/BW_{Channel}$	$dBm/BW_{Channel}$
TBD	TBD	≥-3dB	NR_TDD_FR2_A	TBD	TBD	N/A	TBD
			NR_TDD_FR2_B	TBD	TBD	N/A	TBD
			NR_TDD_FR2_F	TBD	TBD	N/A	TBD
			NR_TDD_FR2_G	TBD	TBD	N/A	TBD
			NR_TDD_FR2_T	TBD	TBD	N/A	TBD
			NR_TDD_FR2_Y	TBD	TBD	N/A	TBD
NOTE 1: Io is assumed to have constant EPRE across the bandwidth. NOTE 2: The parameter SSB Ês/Iot is the minimum SSB Ês/Iot of the pair of SSBs to which the requirement applies. NOTE 3: NR operating band groups in FR2 are as defined in Section 3.5.3.							

10.1.20.2 CSI-RS based L1-RSRP accuracy requirements

10.1.20.2.1 Absolute Accuracy

Unless otherwise specified, the requirements for absolute accuracy of CSI-RS based L1-RSRP in this clause apply to all CSI-RS resources of the serving cell configured for L1-RSRP measurement.

The accuracy requirements in Table 10.1.20.2.1-1 are valid under the following conditions:

Conditions for L1-RSRP measurements are fulfilled according to Annex B.2.4.2 for a corresponding Band for each relevant CSI-RS.

Table 10.1.20.2.1-1: CSI-RS based L1-RSRP absolute accuracy in FR2

Accuracy		Conditions					
Normal condition	Extreme condition	CSI-RS Ês/Iot	Io Note 1 range				
			NR operating band groups Note 2	Minimum Io			Maximum Io
				dBm / SCS_{CSI-RS}		dBm/$BW_{Channel}$	dBm/$BW_{Channel}$
dB	dB	dB		SCS_{CSI-RS} = 60kHz	SCS_{CSI-RS} = 120kHz		
TBD	TBD	≥-3dB	NR_TDD_FR2_A	TBD	TBD	N/A	-70
			NR_TDD_FR2_B	TBD	TBD	N/A	-70
			NR_TDD_FR2_F	TBD	TBD	N/A	-70
			NR_TDD_FR2_G	TBD	TBD	N/A	-70
			NR_TDD_FR2_T	TBD	TBD	N/A	-70
			NR_TDD_FR2_Y	TBD	TBD	N/A	-70
TBD	TBD	TBD	NR_TDD_FR2_A, NR_TDD_FR2_B, NR_TDD_FR2_F, NR_TDD_FR2_G, NR_TDD_FR2_T, NR_TDD_FR2_Y	N/A	N/A	-70	-50

NOTE 1: Io is assumed to have constant EPRE across the bandwidth.
NOTE 2: NR operating band groups in FR2 are as defined in Section 3.5.3.

10.1.20.2.2 Relative Accuracy

The relative accuracy of CSI-RS based L1-RSRP is defined as the L1-RSRP measured from one CSI-RS compared to the largest measured value of L1-RSRP among all CSI-RS resources of the serving cell.

The accuracy requirements in Table 10.1.20.2.2-1 are valid under the following conditions:

Conditions for L1-RSRP measurements are fulfilled according to Annex B.2.4.2 for a corresponding Band for each relevant CSI-RS.

Table 10.1.20.2.2-1: CSI-RS based L1-RSRP relative accuracy in FR2

Accuracy		Conditions					
Normal condition	Extreme condition	CSI-RS Ês/Iot Note 2	Io Note 1 range				
			NR operating band groups Note 3	Minimum Io			Maximum Io
				dBm / SCS_{CSI-RS}		dBm/$BW_{Channel}$	dBm/$BW_{Channel}$
dB	dB	dB		SCS_{CSI-RS} = 60kHz	SCS_{CSI-RS} = 120kHz		
TBD	TBD	≥-3dB	NR_TDD_FR2_A	TBD	TBD	N/A	TBD
			NR_TDD_FR2_B	TBD	TBD	N/A	TBD
			NR_TDD_FR2_F	TBD	TBD	N/A	TBD
			NR_TDD_FR2_G	TBD	TBD	N/A	TBD
			NR_TDD_FR2_T	TBD	TBD	N/A	TBD
			NR_TDD_FR2_Y	TBD	TBD	N/A	TBD

NOTE 1: Io is assumed to have constant EPRE across the bandwidth.
NOTE 2: The parameter CSI-RS Ês/Iot is the minimum CSI-RS Ês/Iot of the pair of CSI-RS resources to which the requirement applies.
NOTE 3: NR operating band groups in FR2 are as defined in Section 3.5.3.

10.1.21 SFTD accuracy requirements

10.1.21.1 SFTD acuracy requirements for NE-DC

The SFN and frame timing difference (SFTD) is measured between PCell and E-UTRAN PSCell under NE-DC.

The accuracy requirements in Table 10.1.21.1-4 are appilicable under the following conditions:

For PCell SFN and frame timing measurement:

Conditions defined in TS 38.101-1 [18] Clause 7.3 for reference sensitivity are fulfilled.

Conditions defined in TS 38.101-2 [19] Clause 7.3 for reference sensitivity are fulfilled.

Io range deifined in Table 10.1.21.1-1 for FR1.

Io range deifined in Table 10.1.21.1-2 for FR2.

Other conditions are TBD

Table 10.1.21.1-1: PCell Io range conditions in FR1

Parameter	**Io [Note 1] range**			
	NR operating band groups [Note 2]	**Minimum Io**		**Maximum Io**
Conditions		**dBm/ SCS$_{SSB}$**		**dBm/BW$_{Channel}$**
		SCS$_{SSB}$ = 15 kHz	**SCS$_{SSB}$ = 30 kHz**	
	NR_FDD_FR1_A, NR_TDD_FR1_A	-121	-118	-50
	NR_FDD_FR1_B	-120.5	-117.5	-50
	NR_TDD_FR1_C	-120	-117	-50
	NR_FDD_FR1_D, NR_TDD_FR1_D	-119.5	-116.5	-50
	NR_FDD_FR1_E, NR_TDD_FR1_E	-119	-116	-50
	NR_FDD_FR1_G	-118	-115	-50
	NR_FDD_FR1_H	-117.5	-114.5	-50
NOTE 1: Io is assumed to have constant EPRE across the bandwidth. NOTE 2: NR operating band groups are as defined in Section 3.5.2.				

Table 10.1.21.1-2: PCell Io range conditions in FR2

Parameter	**Io [Note 1] range**			
	NR operating band groups [Note 2]	**Minimum Io**		**Maximum Io**
Conditions		**dBm/ SCS$_{SSB}$**		**dBm/BW$_{Channel}$**
		SCS$_{SSB}$ = 120 kHz	**SCS$_{SSB}$ = 240 kHz**	
	NR_TDD_FR2_A	TBD	TBD	-50
	NR_TDD_FR2_B	TBD	TBD	-50
	NR_TDD_FR2_F	TBD	TBD	-50
	NR_TDD_FR2_G	TBD	TBD	-50
	NR_TDD_FR2_T	TBD	TBD	-50
	NR_TDD_FR2_Y	TBD	TBD	-50
NOTE 1: Io is assumed to have constant EPRE across the bandwidth. NOTE 2: NR operating band groups are as defined in Section 3.5.3.				

For E-UTRA PSCell SFN and frame timing measurement:

Cell specific reference signals are transmitted either from one, two or four antenna ports.

Conditions defined in TS 36.101 [25] Clause 7.3 for reference sensitivity are fulfilled.

No changes to the uplink transmission timing are applied during the measurement period.

RSRP|$_{dBm}$ according to Annex B.3.5 in TS 36.101 [25] for a corresponding Band.

Io range deifined in Table 10.1.21.1-3.

Table 10.1.21.1-3: E-UTRA PSCell Io range conditions

Parameter	Io Note 1 range		
	E-UTRA operating band groups Note 3	Minimum Io	Maximum Io
Conditions		dBm/15kHz Note 2	dBm/$BW_{Channel}$
	FDD_A, TDD_A	-121	-50
	FDD_C, TDD_C	-120	-50
	FDD_D	-119.5	-50
	FDD_E, TDD_E	-119	-50
	FDD_F	-118.5	-50
	FDD_G	-118	-50
	FDD_H	-117.5	-50
	FDD_N	-114.5	-50
NOTE 1: When in dBm/15kHz, the minimum Io condition is expressed as the average Io per RE over all REs in that symbol. Io may be different in different symbols within a subframe. NOTE 2: The condition level is increased by Δ>0, when applicable, as described in Sections B.4.2 and B.4.3 in TS36.133 [15]. NOTE 3: E-UTRA operating band groups are as defined in Section 3.5 in TS 36.133 [15].			

Table 10.1.21.1-4: SFTD measurement accuracy

Accuracy	Conditions	
	Ês/Iot Note 2	Frequency range
Ts Note 1	dB	
[40]*64*Tc	≥ [-3] dB	FR1
[40]*64*Tc		FR2
NOTE 1: Tc is the basic timing unit defined in TS 38.211 [6]. NOTE 2: The parameter Ês/Iot is the minimum Ês/Iot of the pair of cells to which the requirement applies.		

10.2 E-UTRAN measurements

10.2.1 Introduction

Accuracy requirements for measurements on E-UTRAN carrier frequencies are specified in Section 10.2 and apply for UE in SA or NR-DC operation mode.

The requirements in Section 10.2 are applicable for a UE:

- in RRC_CONNECTED state
- performing measurements with appropriate measurement gaps according to section 9.1.2.
- that is synchronised to the cell that is measured.

The reported measurement result after layer 1 filtering shall be an estimate of the average value of the measured quantity over the measurement period. The reference point for the measurement result after layer 1 filtering is referred to as point B in the measurement model described in TS 36.300 [24].

The accuracy requirements of E-UTRA measurements in this clause are valid for the reported measurement result after layer 1 filtering. The accuracy requirements are verified from the measurement report at point D in the measurement model having the layer 3 filtering disabled.

If the UE needs measurement gaps to perform the inter-RAT NR — E-UTRAN FDD and NR — E-UTRAN TDD measurements, the relevant measurement procedure and measurement gap patterns stated in Section 9.1.2 shall apply.

10.2.2 E-UTRAN RSRP measurements

NOTE: This measurement is for handover between NR and E-UTRAN.

The measurement period of E-UTRA RSRP in RRC_CONNECTED state is specified in section 9.4.2 and 9.4.3.

The accuracy requirements of E-UTRA RSRP measurements in RRC_CONNECTED state and the corresponding side conditions shall be the same as the inter-frequency RSRP Accuracy Requirements in TS 36.133 [15, Section 9.1.3].

The reporting range and mapping specified for RSRP measurements in TS 36.133 [15, Section 9.1.4] shall apply.

10.2.3 E-UTRAN RSRQ measurements

NOTE: This measurement is for handover between NR and E-UTRAN.

The measurement period of E-UTRA RSRQ in RRC_CONNECTED state is specified in section 9.4.2 and 9.4.3.

The accuracy requirements of E-UTRA RSRQ measurements in RRC_CONNECTED state and the corresponding side conditions shall be the same as the inter-frequency RSRQ Accuracy Requirements in TS 36.133 [15, Section 9.1.6].

The requirements for accuracy of E-UTRA RSRQ measurements in RRC_CONNECTED state and the corresponding side conditions shall be the same as the inter-frequency RSRQ Accuracy Requirements in TS 36.133 [15, Section 9.1.6].

The reporting range and mapping specified for RSRQ measurements in TS 36.133 [15, Section 9.1.7] shall apply.

10.2.4 E-UTRAN RSTD measurements

The requirements in this section are valid for UE supporting this capability.

The measurement period is specified in Sections 9.4.4.1 and 9.4.4.2 for inter-RAT NR — E-UTRAN FDD and inter-RAT NR — E-UTRAN TDD RSTD measurements, respectively.

The accuracy requirements and the corresponding side conditions shall be the same as the inter-frequency measurement accuracy requirements for RSTD measurements in RRC_CONNECTED in TS 36.133 [15, Section 9.1.10.2].

If the UE needs measurement gaps to perform the inter-RAT NR — E-UTRAN FDD and NR — E-UTRAN TDD RSTD measurements, the relevant measurement procedure and measurement gap patterns stated in Section 9.1.2 shall apply.

The reporting range and mapping for the inter-RAT NR — E-UTRAN FDD and NR — E-UTRAN TDD RSTD measurements is the same as specified for RSTD measurements in TS 36.133 [15, Sections 9.1.10.3 and 9.1.10.4].

10.2.5 E-UTRAN RS-SINR measurements

NOTE: This measurement is for handover between NR and E-UTRAN.

The measurement period of E-UTRA RS-SINR in RRC_CONNECTED state is specified in section 9.4.2 and 9.4.3.

The accuracy requirements of E-UTRA RS-SINR measurements in RRC_CONNECTED state and the corresponding side conditions shall be the same as the inter-frequency RS-SINR Accuracy Requirements in TS 36.133 [15, Section 9.1.17.3].

The reporting range and mapping for E-UTRA RS-SINR measurements shall be the same as specified for RS-SINR measurements in TS 36.133 [15, 9.1.17.1].

11 Measurements Performance Requirements for NR network

Editor's note: network side measurement and mapping tables may be specified in this section. If RAN4 decides to move NR network requirements to gNodeB specification, this section might be removed.