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650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
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Contents

Foreword

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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”.

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].

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

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

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

FR1: Frequency range 1 as defined in TS 38.104 [13, Section 5.1].

FR2: Frequency range 2 as defined in TS 38.104 [13, Section 5.1].

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

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

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

NSA operation mode: EN-DC operation mode, where the UE is configured at least with PSCell and E-UTRA PCell.

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.

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 TS 38.211 [6, section 7.8.3].

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 TS 38.211 [6, Section 4.1].
T_s	Reference time unit, defined in TS 38.211 [6, Section 4.1].

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].

BWP	Bandwidth Part
CA	Carrier Aggregation
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-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
NR	New Radio
NSA	Non-Standalone operation mode
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
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
SA	Standalone operation mode
SCell	Secondary Cell
SCG	Secondary Cell Group
SCS	Subcarrier Spacing
SFN	System Frame Number
SI	System Information
SIB	System Information Block
SMTC	SSB-based Measurement Timing configuration
SRS	Sounding Reference Signal
SS	Synchronization 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
SSS	Secondary Synchronization Signal
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 Notation for grouping

3.5.1 Groups of bands

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

Editor's note: intended to capture band groups.

3.5.2 Groups of numerologies

Editor's note: intended to capture numerologies groups. This section might be removed if unnecessary.

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’.

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.

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.

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.

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

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 every DRX cycle.

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 4.2.2.1-1 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 4.2.2.1-1: N_{serv}

DRX cycle length [s]	N_{serv} [number of DRX cycles]
0.32	[4]
0.64	[4]
1.28	[2]
2.56	[2]

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 SS-RSRP, SS-RSRP Ês/Iot defined in Annex XXX 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 the cell is at least [3]dB better ranked. When evaluating cells for reselection, the side conditions for SS-RSRP 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 better ranked than the serving cell, the UE shall evaluate this intra-frequency cell for the $T_{reselection}$ time. If this cell remains better ranked 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]	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)
0.32	11.52 x N1 [36 x N1]	1.28 x N1 (4 x N1)	5.12 x N1 (16 x N1)
0.64	17.92 x N1 [28 x N1]	1.28 x N1 (2 x N1)	5.12 x N1 (8 x N1)
1.28	32 x N1 [25 x N1]	1.28 x N1 (1 x N1)	6.4 x N1 (5 x N1)
2.56	33.28 x N1 [23 x N1]	2.56 x N1 (1 x N1)	7.68 x N1 (3 x N1)
NOTE 1: N1=[TBD] for frequency range FR2, and N1=1 for frequency range FR1.			

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 $\leq$ $S_{nonIntraSearchP}$ or Squal $\leq$ $S_{nonIntraSearchQ}$ 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.

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 [4.5] dB or reselections based on ranking or [4.5]dB for SSB-RSRP reselections based on absolute priorities or [TBD]dB for SSB-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 SS-RSRP, SS-RSRP Ês/Iot defined in Annex XXX 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 a margin of at least [4.5]dB for reselections based on ranking or [4.5]dB for SSB-RSRP reselections based on absolute priorities or [TBD]dB for SSB-RSRQ reselections based on absolute priorities. When evaluating cells for reselection, the side conditions for SS-RSRP apply to both serving and inter-frequency cells.

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

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

DRX cycle length [s]	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)
0.32	11.52 x N1 [36 x N1]	1.28 x N1 (4 x N1)	5.12 x N1 (16 x N1)
0.64	17.92x N1 [28 x N1]	1.28 x N1 (2 x N1)	5.12 x N1 (8 x N1)
1.28	32 x N1 [25 x N1]	1.28 x N1 (1 x N1)	6.4 x N1 (5 x N1)
2.56	58.88 x N1 [23 x N1]	2.56 x N1 (1 x N1)	7.68 x N1 (3 x N1)
NOTE 1: N1=[TBD] for frequency range FR2, and N1=1 for frequency range FR1.			

4.2.2.5 Measurements of inter-RAT E-UTRAN cells

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 EUTRA cells in the neighbour frequency list at the minimum measurement rate specified in this section. The parameter $N_{EUTRA\_carrier}$ is the number of carriers in the neighbour frequency list. The UE shall filterRSRP and RSRQ measurements of each measured EUTRA 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 half the minimum specified measurement period.

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 ($N_{EUTRA\_carrier}$) * $T_{detectEUTRA}$ when Srxlev ≤ $S_{nonIntraSearchP}$ or Squal ≤ $S_{nonIntraSearchQ}$ when $Treselection_{RAT}$ = 0 provided that the reselection criteria is met by a margin of at least 5dB for reselections based on ranking or 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 ($N_{EUTRA\_carrier}$) * $T_{measureEUTRA}$ when Srxlev ≤ $S_{nonIntraSearchP}$ or Squal ≤ $S_{nonIntraSearchQ}$.

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 EUTRA cell has met reselection criterion defined in 3GPP TS 38.304 [1] within ($N_{EUTRA\_carrier}$) * $T_{evaluateEUTRA}$ 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 5dB for reselections based on ranking or 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 EUTRA 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: $T_{detectEUTRA}$, $T_{measureEUTRA}$, and $T_{evaluateEUTRA}$

DRX cycle length [s]	$T_{detect,EUTRAN}$ [s] (number of DRX cycles)	$T_{measure,EUTRAN}$ [s] (number of DRX cycles)	$T_{evaluate,E\text{-}UTRAN}$ [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 $T_{higher\_priority\_search}$ = ([TBD] * 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

Editor's note: if handover requirements are differentiated by with beamforming and without beamforming, then two sets of requirements (with/without beamforming) could be specified in this section.

6.1.1 NR Handover

6.1.1.1 Introduction

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 clause x.x 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 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} = [3*SMTC periodicity + 5] 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_{Δ} = SMTC periodicity.

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].

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

NOTE 2: if the SMTC periodicity is not configured, the term SMTC periodicity in T_{search} and T_{Δ} shall be deemed to be replaced with SSB periodicity.

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.

Requirements in clause 6.1.1.2 also apply for this section.

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 x.x 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 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 inter-frequency cell and signal quality is sufficient for successful cell detection on the first attempt, then T_{search} = [N1*(2 or 4)* SMTC periodicity + 5] 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 20ms.

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

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].

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

NOTE 2: if the SMTC periodicity is not configured, the term SMTC periodicity in T_{search} and T_{Δ} shall be deemed to be replaced with SSB periodicity.

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 x.x 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 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 inter-frequency cell and signal quality is sufficient for successful cell detection on the first attempt, then T_{search} = [N1*(2 or 4)* SMTC periodicity + 5] 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 20ms if UE provides the measurement report within the last [TBD] ms for the target cell before the handover command is received. Otherwise $T_{processing}$ can be up 40ms.

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

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].

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

NOTE 2: if the SMTC periodicity is not configured, the term SMTC periodicity in T_{search} and T_{Δ} shall be deemed to be replaced with SSB periodicity.

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 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].

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

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

Where:

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

$T_{interruption}$: 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 $T_{RRC\_procedure\_delay}$. $T_{interruption}$ is defined in clause 6.1.1.3.

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

Editor's note: The current requirement assumes that UE still has correct SFN, frame and subframe level synchronization to the PCell during the whole procedure. In case UE has lost the SFN, frame or subframe level synchronization to the PCell, how to handle this case should be further studied.

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

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

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 *RRCConnectionReestablishmentRequest* message.

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

6.2.1.2.1 UE Re-establishment delay requirement

The UE re-establishment delay ($T_{UE\_re-establish\_delay}$) 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 ($T_{UE\_re-establish\_delay}$) requirement shall be less than:

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

The target NR cell shall be considered detectable when:

- SS-RSRP related side conditions given in Section 10.x are fulfilled for a corresponding NR Band,
- SCH_RP and SCH Ês/Iot according to Annex TBD 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.

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

T_{SI-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 PCell.

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 PCell is known.

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

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

Frequency range (FR) of target NR cell	$T_{identify\_intra\_NR}$ [ms]	
	Known NR cell	**Unknown NR cell**
FR1	MAX (200 ms, [5] x T_{SMTC})	MAX (800 ms, [10] x T_{SMTC})
FR2	MAX (400 ms, K2 x [5] x T_{SMTC})	MAX (1000 ms, (K3 x [10]) x T_{SMTC}))

Editor's note: K2 and K3 are FFS and is the number of receiver beam sweeps required to measure/detect NR cell in FR2

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

Frequency range (FR) of target NR cell	$T_{identify\_inter\_NR,\ i}$ [ms]	
	Known NR cell	**Unknown NR cell**
FR1	MAX (200 ms, [6] x $T_{SMTC,\ i}$)	MAX (800 ms, [13] x $T_{SMTC,\ i}$)
FR2	MAX (400 ms, K4 x [6] x $T_{SMTC,\ i}$)	MAX (1000 ms, (K5 x [13]) x $T_{SMTC,\ i}$))

Editor's note: K4 and K5 are FFS and is the number of receiver beam sweeps required to measure/detect NR cell in FR2

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. 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.

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].

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-RAN from NR-RAN 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, "*RRCConnectionRelease*" (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 detectable when:

- SS-RSRP related side conditions given in Section 10.x are fulfilled for a corresponding NR Band,
- SCH_RP and SCH Ês/Iot according to Annex TBD for a corresponding NR Band.

$T_{RRC\_procedure\_delay}$: It is the RRC procedure delay for processing the received message "[*RRCConnectionRelease*]" as defined in clause 11.2 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.

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	$T_{identify\text{-}NR}$
FR1	MAX (680 ms, [11] x SMTC period)
FR2	MAX (880 ms, K1x[11] x SMTC period)

Editor's note: K1 is FFS and is the number of receiver beam sweeps required to detect NR cell in FR2

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 $T_{connection\_release\_redirect\_E\text{-}UTRA}$.

The time delay ($T_{connection\_release\_redirect\_E\text{-}UTRA}$) is the time between the end of the last slot containing the RRC command, "[*RRCConnectionRelease*]" (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 ($T_{connection\_release\_redirect\_E\text{-}UTRA}$) shall be less than:

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

The target E-UTRA cell shall be considered detectable when:

- RSRP related side conditions given in Section 10.x are fulfilled for a corresponding E-UTRA Band,
- SCH_RP and SCH Ês/Iot according to Annex TBD for a corresponding E-UTRA Band.

$T_{RRC\_procedure\_delay}$: It is the RRC procedure delay for processing the received message “[*RRCConnectionRelease*]” as defined in clause 11.2 of TS 38.331 [2].

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

$T_{SI\text{-}E\text{-}UTRA}$: 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. $T_{SI\text{-}E\text{-}UTRA}$ = 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 connected gNB. The uplink frame transmission takes place $(N_{\text{TA}} + N_{\text{TA offset}}) \times T_{\text{c}}$ before the reception of the first detected path (in time) of the corresponding downlink frame from the reference cell. The reference cell is PSCell in case of EN-DC. 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 $(N_{\text{TA}} + N_{\text{TA offset}}) \times T_{\text{c}}$. 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.

$(N_{\text{TA}} + N_{\text{TA offset}}) \times T_{\text{c}}$ (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 $N_{\text{TA offset}}$ depends on the duplex mode of the cell in which the uplink transmission takes place and the frequency range (FR). $N_{\text{TA offset}}$ 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 *Editor's note: The final values of T_e for 120KHz SSB SCS are subject to further discussions in further meeting, and may not be outside 3*64*T_c to 3.5*64*T_c.*			

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

Frequency range and band of cell used for uplink transmission	$N_{\text{TA offset}}$ (Unit: T_C)
FDD in FR1	0
FR1 TDD band	39936 or 25600 (Note 1)
FR2	13792
NOTE 1: The UE identifies $N_{\text{TA offset}}$ based on the information [TBD] according to [TS38.331]. NOTE 2: The value of $N_{\text{TA offset}}$ that applies to the supplementary UL carrier is determined from the non-supplementary UL carrier.	

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 $(N_{\text{TA}} + N_{\text{TA offset}}) \times T_c$ 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 [200]ms.

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			

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 [TBD], 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 gNB with MAC message that implies and adjustment of the timing advance, see TS 38.321 clause 5.2.

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*+[6] for a timing advance command received in time slot *n*. 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 TS38.213.

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 boundaries of PSCell to be aggregated EN-DC

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. The requirements for asynchronous EN-DC are applicable for E-UTRA TDD- NR TDD, E-UTRA FDD- NR FDD, E-UTRA FDD-NR TDD and E-UTRA TDD-NR FDD inter-band asynchronous EN-DC.

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, 120kHz is not applied.		

The UE shall be capable of handling a maximum uplink transmission timing difference between E-UTRA PCell and PSCell as shown in Table 7.5.2-2 provided that the UE indicates that it is capable of synchronous EN-DC [16]. The requirements for synchronous EN-DC are applicable for E-UTRA TDD-NR TDD, 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 [Note1]	35.21
NOTE 1: For E-UTRA FDD- NR FDD and E-UTRA TDD- NR TDD intra-band EN-DC, 120kHz is not applied.		

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 provided the UE indicates that it is capable of asynchronous EN-DC [16]. The requirements for asynchronous EN-DC are applicable for E-UTRA FDD- NR FDD and E-UTRA TDD- NR TDD intra-band asynchronous EN-DC.

No uplink transmission timing difference is applicable for synchronous EN-DC.

7.5.4 Minimum Requirements for NR Carrier Aggregation

For inter-band carrier aggregation, the UE shall be capable of handling at least a relative transmission timing difference between slot timing of different carriers to be aggregated as shown in Table 7.5.4-1 below:

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

Frequency Range	Maximum transmission timing difference (µs)
FR1	35.21
FR2	8.5
Between FR1 and FR2	[TBD]

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 boundaries of PSCell to be aggregated for EN-DC.

A UE shall be capable of handling a relative receive timing difference between slot timing boundary of different carriers to be aggregated 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. The requirements for asynchronous EN-DC are applicable for E-UTRA TDD- NR TDD, E-UTRA FDD- NR FDD, E-UTRA FDD- NR TDD and E-UTRA TDD- NR FDD inter-band EN-DC.

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	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, 120kHz is not 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 at the UE receiver as shown in Table 7.6.2-2 provided that the UE indicates that it is capable of synchronous EN-DC[16]. The requirements for synchronous EN-DC are applicable for E-UTRA TDD- NR TDD, 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: For E-UTRA FDD- NR FDD and E-UTRA TDD- NR TDD intra-band EN-DC, 120kHz is not applied.		

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 provided the UE indicates that it is capable of asynchronous EN-DC [16]. The requirements for asynchronous EN-DC are applicable for E-UTRA FDD-NR FDD and E-UTRA TDD- NR TDD intra-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 as shown in Table 7.6.3-1 provided the UE indicates that it is only capable of synchronous EN-DC [16]. 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	[TBD]

8 Signalling characteristics

8.1 Radio Link Monitoring

8.1.1 Introduction

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 *RLM-IS-OOS-thresholdConfig* signalled by higher layers. The network can configure one of the two pairs of out-of-sync and in-sync block error rates which are shown in Table 8.1.1-1. 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.

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

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

UE shall be able to monitor up to X_{RLM-RS} RLM-RS resources of the same or different types in each corresponding carrier frequency range, where X_{RLM-RS} 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 X_{RLM-RS}

Maximum number of RLM-RS resources, X_{RLM-RS}	Carrier frequency range of PCell/PSCell
2	FR1, ≤ 3 GHz
4	FR1, > 3 GHz
8	FR2

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 pair#0	Value for BLER pair#1
DCI format	1-0	TBD
Number of control OFDM symbols	Same as the number of symbols of RMSI CORESET	
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)	Same as the number of PRBs of RMSI CORESET	
Sub-carrier spacing (kHz)	Same as the SCS of RMSI CORESET	
DMRS precoder granularity	REG bundle size	
REG bundle size	6	
CP length	Same as the CP length of RMSI CORESET	
Mapping from REG to CCE	Distributed	

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

Attribute	Value for BLER pair#0	Value for BLER pair#1
DCI payload size	1-0	TBD
Number of control OFDM symbols	Same as the number of symbols of RMSI CORESET	
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)	Same as the number of PRBs of RMSI CORESET	
Sub-carrier spacing (kHz)	Same as the SCS of RMSI CORESET	
DMRS precoder granularity	REG bundle size	
REG bundle size	6	
CP length	Same as the CP length of RMSI CORESET	
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 spatially QCLed and TDMed to CSI-RS resources configured for BM, and the QCL association is known to UE;
- N=FFS, 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 $P_{sharing\ factor}$, 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 $1/(1- T_{SSB}/MGRP)* P_{sharing\ factor}$, 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 overlapped with measurement gap ($T_{SMTCperiod} < MGRP$)
- P is $1/(1- T_{SSB}/MGRP)* P_{sharing\ factor}$, 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 ($T_{SMTCperiod} < MGRP$)
- $P_{sharing\ factor}$ is FFS

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)
non-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)
non-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.

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

Attribute	Value for BLER pair#0	Value for BLER pair#1
DCI format	1-0	TBD
Number of control OFDM symbols	Same as the number of symbols of CORESET QCLed with respective CSI-RS for RLM	
Aggregation level (CCE)	[8]	
Ratio of hypothetical PDCCH RE energy to average CSI-RS RE energy	[4]dB	
Ratio of hypothetical PDCCH DMRS energy to average CSI-RS RE energy	[4]dB	
Bandwidth (MHz)	Same as the number of PRBs of CORESET QCLed with respective CSI-RS for RLM	
Sub-carrier spacing (kHz)	Same as the SCS of CORESET QCLed with respective CSI-RS for RLM	
DMRS precoder granularity	REG bundle size	
REG bundle size	6	
CP length	Same as the CP length of CORESET QCLed with respective CSI-RS for RLM	
Mapping from REG to CCE	Distributed	

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

Attribute	Value for BLER pair#0	Value for BLER pair#1
DCI payload size	[1-0]	TBD
Number of control OFDM symbols	Same as the number of symbols of CORESET QCLed with respective CSI-RS for RLM	
Aggregation level (CCE)	[4]	
Ratio of hypothetical PDCCH RE energy to average CSI-RS RE energy	[0]dB	
Ratio of hypothetical PDCCH DMRS energy to average CSI-RS RE energy	[0]dB	
Bandwidth (MHz)	Same as the number of PRBs of CORESET QCLed with respective CSI-RS for RLM	
Sub-carrier spacing (kHz)	Same as the SCS of CORESET QCLed with respective CSI-RS for RLM	
DMRS precoder granularity	REG bundle size	
REG bundle size	6	
CP length	Same as the CP length of CORESET QCLed with respective CSI-RS for RLM	
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 spatially QCLed and TDMed to CSI-RS resources configured for BM or SSBs configured for BM, and the QCL association is known to UE;
- N=FFS, 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 $P_{sharing\ factor}$, 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 $1/(1- T_{CSI-RS} /MGRP)* P_{sharing\ factor}$, 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 overlapped with measurement gap ($T_{SMTCperiod} < MGRP$)
- P is $1/(1- T_{CSI-RS} /MGRP)* P_{sharing\ factor}$, 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 ($T_{SMTCperiod} < MGRP$)
- $P_{sharing\ factor}$ is FFS

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)
non-DRX	$\max(200, ceil(M_{out}\times P)\times T_{CSI-RS})$	$\max(100, ceil(M_{in}\times P) \times T_{CSI-RS})$
DRX ≤ 320ms	$\max(200, ceil(1.5\times M_{out}\times P)\times \max(T_{DRX}, T_{CSI-RS}))$	$\max(100, ceil(1.5\times M_{in}\times P)\times \max(T_{DRX}, T_{CSI-RS}))$
DRX > 320ms	$ceil(M_{out}\times P) \times T_{DRX}$	$ceil(M_{in}\times P) \times T_{DRX}$
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)
non-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 Void

8.1.5 Void

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, 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 non-DRX mode until the expiry or stop of T310 timer.

Editor's note: FFS whether the DRX requirements are scaled by 1.5 if DRX on-duration and RLM-RS are not aligned.

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.

- The UE is not expected to transmit PUCCH/PUSCH or receive PDCCH/PDSCH on RLM-RS symbols to be measured for radio link monitoring, except for RMSI PDCCH/PDSCH and PDCCH/PDSCH which is not required to be received by RRC_CONNECTED mode UE.

Editor's Note: FFS when intra-band carrier aggregation is performed, whether 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 or not.

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

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.

8.2 Interruption

Editor's note: intended to capture requirements for interruption due to SCell configuration/de-configuration/activation/deactivation, and PSCell addition/release and so on.

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

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 [TS 36.133].

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 PSCell DRX cycle is less than [640] ms, and [0.625%] probability of missed ACK/NACK is allowed when the configured PSCell 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 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.

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 PSCell:
  - of up to X1 slot, if the PSCell is not in the same band as any of the E-UTRA SCells being added or released, or
  - of up to max{Y1 slot + SMTC duration, 5ms} if the PSCell is in the same band as any of the E-UTRA SCells being added or released, provided the cell specific reference signals from the PSCell and the E-UTRA SCells being added or released are available in the same slot;
- an interruption on any activated SCell in SCG:
  - of up to X1 slot, if the activated SCell is not in the same band as any of the E-UTRA SCells being added or released, or
  - of up to max{Y1 slot + SMTC duration, 5ms} if the activated SCell is in the same band as any of the E-UTRA SCells being added or released, provided the cell specific reference signals from the activated SCell and the E-UTRA SCells being added or released are available in the same slot.

When one SCell is added or released:

- an interruption on PSCell:
  - of up to X1 slot, if the PSCell is not in the same band as any of the SCells being added or released, or
  - of up to Y1 slot + SMTC duration if the PSCell is in the same band as any of the SCells being added or released, provided the cell specific reference signals from the PSCell and the SCells being added or released are available in the same slot;
- an interruption on any activated SCell in SCG:
  - of up to X1 slot, if the activated SCell is not in the same band as any of the SCells being added or released, or
  - of up to Y1 slot + SMTC duration if the activated SCell is in the same band as any of the SCells being added or released, provided the cell specific reference signals from the activated SCell and the SCells being added or released are available in the same slot.

Table 8.2.1.2.3-1 Interruption length X1 and Y1 at SCell 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

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 PSCell:
    - of up to X2 slot, if the PSCell is not in the same band as any of the E-UTRA SCells being activated or deactivated, or
    - of up to max{Y2 slot + SMTC duration, 5ms} if the PSCell is in the same band as any of the E-UTRA SCells being activated or deactivated, provided the cell specific reference signals from the PSCell and the SCells being activated or deactivated are available in the same slot;
- an interruption on any activated SCell in SCG:
    - of up to X2 slot, if the activated SCell is not in the same band as any of the E-UTRA SCells being activated or deactivated, or
    - of up to max{Y2 slot + SMTC duration, 5ms} if the activated SCell is in the same band as any of the E-UTRA SCells being activated or deactivated, provided the cell specific reference signals from the activated SCell and the SCells being activated or deactivated are available in the same slot.

When one SCell is activated or deactivated:

- an interruption on PSCell:
    - of up to X2 slot, if the PSCell is not in the same band as any of the SCells being activated or deactivated, or
    - of up to Y2 slot + SMTC duration if the PSCell is in the same band as any of the SCells being activated or deactivated, provided the cell specific reference signals from the PSCell and the SCells being activated or deactivated are available in the same slot;
- an interruption on any activated SCell in SCG:
    - of up to X2 slot, if the activated SCell is not in the same band as any of the SCells being activated or deactivated, or
    - of up to Y2 slot + SMTC duration if the activated SCell is in the same band as any of the SCells being activated or deactivated, provided the cell specific reference signals from the deactivated SCell and the SCells being activated or deactivated are available in the same slot.

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
		Sync	Async	
0	1	1	2	1
1	0.5	1	2	1
2	0.25	3		2
3	0.125	5		4

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 8.2.1.2.5-1 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
		Sync	Async	
0	1	1	2	1
1	0.5	1	2	1
2	0.25	3		2
3	0.125	5		4

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 LTE PCell, all activated LTE SCells, PSCell and all activated SCells within the same FR as the reconfigured uplink carrier of up to [1] slot, is allowed immediately after the RRC reconfiguration procedure [2]. The interruption is for both uplink and downlink of LTE PCell, all LTE activated SCells, PSCell and all activated SCells within the same FR as the configured or de-configured UL.

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 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.

8.2.2.2 Requirements

8.2.2.2.1 Interruptions at SCell addition/release

When 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 PCell and on any activated SCell during the RRC reconfiguration procedure as follows:

- an interruption on PCell:
  - of up to the duration shown in table 8.2.2.2.1-1, if the PCell 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 PCell is in the same band as any of the SCells being added or released, provided the cell specific reference signals from the PCell and the SCells being added or released are available in the same slot;
- an interruption on any activated SCell:
  - of up to to the duration shown in table 8.2.2.2.1-1, if the activated SCell 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 SCell is in the same band as any of the SCells being added or released, provided the cell specific reference signals from the activated SCell 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)	Interruption length (slot)
0	1	1
1	0.5	2
2	0.25	4
3	0.125	8

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 + SMTC duration
1	0.5	2 + SMTC duration
2	0.25	4 + SMTC duration
3	0.125	8 + SMTC duration

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 PCell:
  - of up to the duration shown in table 8.2.2.2.2-1, if the PCell 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 PCell is in the same band as any of the SCells being activated or deactivated provided the cell specific reference signals from the PCell and the SCells being activated or deactivated are available in the same slot;
- an interruption on any activated SCell:
  - of up to the duration shown in table 8.2.2.2.2-1, if the activated SCell 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 SCell is in the same band as any of the SCells being activated or deactivated provided the cell specific reference signals from the PCell 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)	Interruption length
0	1	1
1	0.5	1
2	0.25	2
3	0.125	4

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 + SMTC duration
1	0.5	2 + SMTC duration
2	0.25	4 + SMTC duration
3	0.125	8 + SMTC duration

8.2.2.2.3 Interruptions during measurements on SCC for intra-band CA

Editors note : Interruption requirements to PCell and active Sells due to measuements on the carrier with deactivated SCell are for futher study

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 [1] slot, is allowed immediately after 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.

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 in SCG and deactivate an activated SCell in SCG in E-UTRA-NR DC.

The requirements shall apply for E-UTRA-NR DC where the E-UTRA is the master (Option 3/3a/3x in TR 38.801[1] section 10.1.2)

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 SCG.

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

Upon receiving SCG 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:

- [3ms+ 1*SMTC periodicity+4*OFDM symbol], if the SCell measurement cycle is equal to or smaller than [160ms].
- [3ms+2*SMTC periodicity+4*OFDM symbol], if the SCell measurement cycle is larger than [160ms].

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

- [3ms+ 4*SMTC periodicity+4*OFDM symbol] provided the SCell can be successfully detected on the first attempt.

If the SCell being activated is known and belongs to FR2,$T_{activation\_time}$ is [TBD]. If the SCell being activated is unknown and belongs to FR2, $T_{activation\_time}$ is [TBD].

$T_{CSI\_reporting}$ is the delay 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.

The condition for SCell in FR2 is FFS

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

The PSCell interruption specified in section 8.2 shall not occur before slot n+[T_{HARQ}] and not occur after slot *n*+[T_{HARQ} +3ms].

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 SCG

Upon receiving SCG 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 PSCell interruption specified in section 8.2 shall not occur before slot n+[T_{HARQ}] and not occur after slot *n*+[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 clause x.y in TS 38.331 [2] plus the interruption time specified in section 8.2.1.2.6.

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 clause x.y in TS 38.331 [2].

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, and inter-RAT E-UTRAN TDD requirements. These measurements may be used by the NG-RAN. The measurement quantities are defined in [TS38.215], 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].

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 [41], 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 [41], 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:

- shall not transmit any data
- [is not required to receive data from the corresponding E-UTRAN PCell, E-UTRAN SCell(s) and NR serving cells for NSA]
- [is not required to receive data from the corresponding NR serving cells for SA]

  Editor note: whether or not UE can receive signal for measurement from the corresponding serving cells within some of measurement gaps is FFS.

During the per-FR measurement gaps the UE:

- shall not transmit any data on serving cells in the corresponding frequency range
- [is not required to receive data from the corresponding E-UTRAN PCell, E-UTRAN SCell(s) and NR serving cells for NSA]
- [is not required to receive data from the corresponding NR serving cells for SA]

Editor note: whether or not UE can receive signal for measurement from the corresponding serving cells within some of measurement gaps is FFS.

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

Measurement gap pattern configuration	Serving cell	Measurement Purpose	Applicable Gap Pattern Id
Per-UE measurement gap	E-UTRA + FR1, or E-UTRA + FR2, or E-UTRA + FR1 + FR2	non-NR RAT [Note1,2]	0,1,2,3
		FR1 and/or FR2	0-11
		non-NR RAT[Note1,2] and FR1 and/or FR2	0,1,2,3
Per FR measurement gap	E-UTRA and, FR1 if configured	non-NR RAT [Note1,2]	0,1,2,3
	FR2 if configured		No gap
	E-UTRA and, FR1 if configured	FR1 only	0-11
	FR2 if configured		No gap
	E-UTRA and, FR1 if configured	FR2 only	No gap
	FR2 if configured		12-23
	E-UTRA and, FR1 if configured	non-NR RAT [Note1,2] and FR1	0,1,2,3
	FR2 if configured		No gap
	E-UTRA and, FR1 if configured	FR1 and FR2	0-11
	FR2 if configured		12-23

	E-UTRA and, FR1 if configured	non-NR RAT Note1,2 and FR2	0,1,2,3
	FR2 if configured		12-23
	E-UTRA and, FR1 if configured	non-NR RAT Note1,2 and FR1 and FR2	0,1,2,3
	FR2 if configured		12-23
Note: 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: Non-NR RAT includes E-UTRA, UTRA and/or GSM. NOTE 2: The gap pattern 2 and 3 are supported by UEs which support shortMeasurementGap-r14. 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.			

For E-UTRA-NR dual connectivity, when serving cells are on 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;

When serving cells are in E-UTRA, 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

Measurement gap pattern configuration	Serving cell	Measurement Purpose NOTE 2	Applicable Gap Pattern Id
Per-UE measurement gap	FR1, or FR1 + FR2	E-UTRA only	0,1,2,3
		FR1 and/or FR2	0-11
		E-UTRAN and FR1 and/or FR2	0,1,2,3
	FR2	E-UTRA only	0,1,2,3
		FR1 only	0-11
		FR1 and FR2	0-11
		E-UTRAN and FR1 and/or FR2	0,1,2,3
		FR2 only	12-23
Per FR measurement gap	FR1 if configured	E-UTRA only	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	0,1,2,3
	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	0,1,2,3
	FR2 if configured		12-23

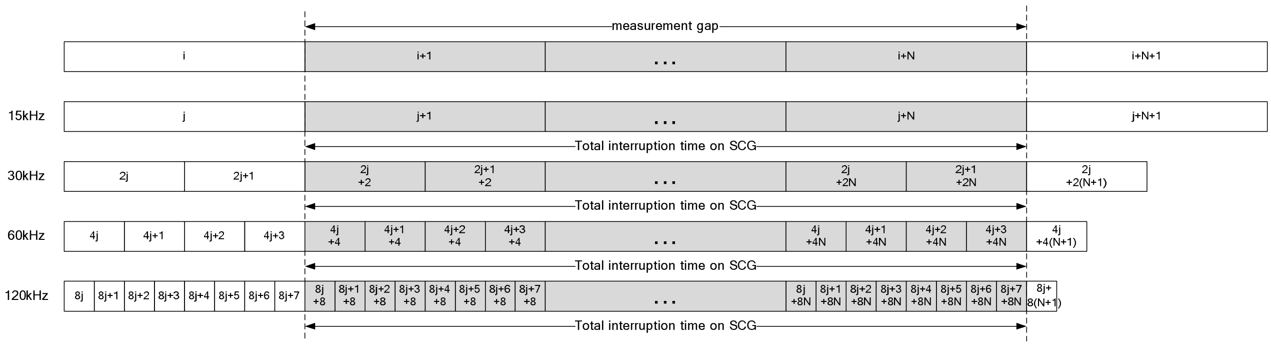
	FR1 if configured	E-UTRA and FR1 and FR2	0,1,2,3
	FR2 if configured		12-23
NOTE 1: When E-UTRA inter-RAT RSTD measurements are configured and the UE requires measurement gaps for performing such measurements, only Gap Pattern #0 can be used. NOTE 2: Measurement purpose which includes E-UTRA measurements includes also inter-RAT E-UTRA RSRP and RSRQ measurements for E-CID			

In NR standalone operation, 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;

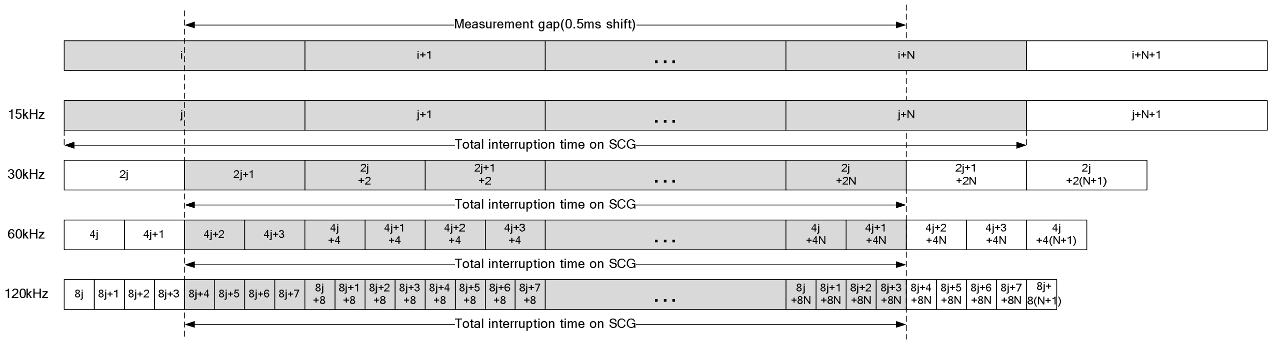
- 20ms for FR2 NR measurements
- 40ms for FR1 NR measurements
- 40ms for LTE measurements
- 40ms for FR1+LTE measurements

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.

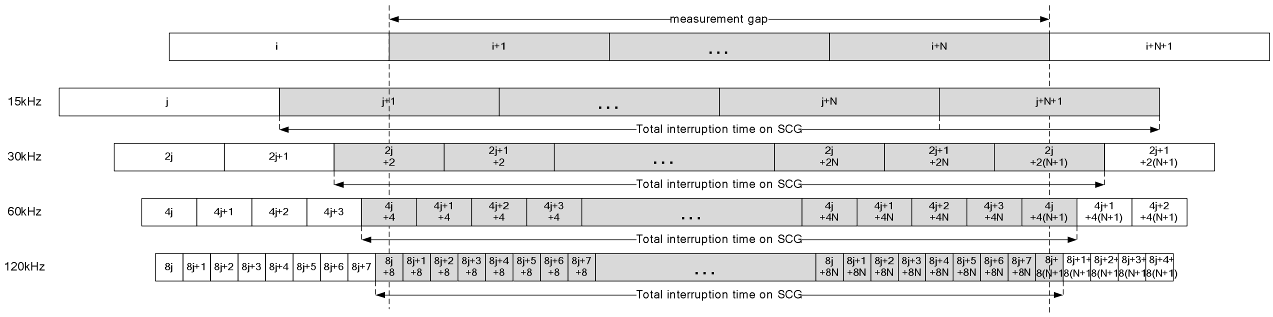
For E-UTRA-NR dual connectivity, if UE is not capable of per-FR-gap, total interruption time on SCG during MGL is defined only when MGL(N) = 6ms, 4ms and 3ms. And if the UE supporting EN-DC is configured with PSCell, during the total interruption time as shown in Figure 9.1.2-1, the UE shall not transmit and receive any data in SCG.



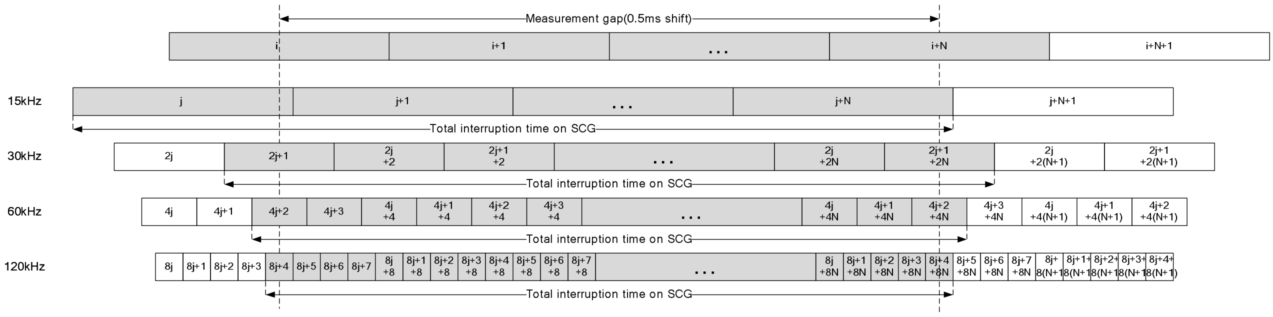
(a) Measurement gap with MGL = N(ms) with MG timing advance of 0ms for synchronous EN-DC



(b) Measurement gap with MGL = N(ms) with MG timing advance of 0.5ms for synchronous EN-DC



(c) Measurement gap with MGL = N(ms) with MG timing advance of 0ms for asynchronous EN-DC



(d) Measurement gap with MGL = N(ms) with MG timing advance of 0.5ms for asynchronous EN-DC

Figure 9.1.2-1: Measurement GAP and total interruption time on MCG and SCG

The corresponding total number of interrupted slots on SCG during MGL is listed in Table9.1.2-4 and Table9.1.2-4a for synchronous EN-DC and asynchronous EN-DC respectively.

Table 9.1.2-4: Total number of interrupted slots on SCG during MGL for Synchronous EN-DC with per-UE measurement gap or per-FR measurement gap for FR1

NR SCS (kHz)	Total number of interrupted slots on SCG					
	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	5	4
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.						

Table 9.1.2-4a: Total number of interrupted slots on SCG during MGL for Asynchronous EN-DC with per-UE measurement gap or per-FR measurement gap for FR1

NR SCS (kHz)	Total number of interrupted slots on SCG					
	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 in case with 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]

Measurement gap sharing shall be applies when UE requires measurement gaps to identify and measure intra-frequency cells or when SMTC configured for intra-frequency measurement are fully overlapping with measurement gaps, and when UE is configured to identify and measure cells on inter-frequency carriers and inter-RAT carriers.When network signals “01”, “10” or “11”, where X is a signalled RRC parameter TBD and is defined as in Table 9.1.2-5,

- the performance of intra-frequency measurements with no measurement gaps as specified in section 9.2.5, when SMTC configured for intra-frequency measurement are fully overlapping with measurement gaps, shall consider the factor $K_{intra} = 1 / X * 100$,

- the performance of intra-frequency measurements with measurement gaps as specified in section 9.2.6 shall consider the factor $K_{intra} = 1 / X * 100$,

- the performance of inter-frequency measurement as specified in section 9.3 and the performance of inter-RAT measurement as specified in section 9.4 shall consider the factor $K_{inter} = 1 / (100 – X) * 100$,

When network signals “00” indicating equal splitting gap sharing, X is not applied and the performance of intra-frequency measurements as specified in section 9.2.5 and section 9.2.6, the performance of inter-frequency measurement as specified in section 9.3 and the performance of inter-RAT measurement as specified in section 9.4 are FFS.

Table 9.1.2-5: Value of parameter X

Network signaling ParameterName (to be determined by RAN2)	Value of X (%)
‘00’	Equal splitting
‘01’	[25]
‘10’	[50]
‘11’	[75]

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 E-UTRA-NR dual connectivity operation with E-UTRA PCell.

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 E-UTRA-NR dual connectivity operation, the effective total number of frequencies excluding the frequencies of the PSCell, SCells, E-UTRA PCell, and E-UTRA SCells being monitored is $N_{freq,\ NSA}$, which is defined as:

$N_{freq,\ NSA} = N_{freq,\ NSA,\ NR} + N_{freq,\ NSA,\ E\text{-}UTRA} + N_{freq,\ NSA,\ UTRA} + M_{NSA,\ GSM}$,

where

$N_{freq,\ NSA,\ E\text{-}UTRA}$ is the number of E-UTRA inter-frequency carriers being monitored (FDD and TDD) as configured by E-UTRA PCell.

$N_{freq,\ NSA,\ NR} \leq N_{freq,\ NSA,\ NR,\ inter\text{-}RAT} + N_{freq,\ NSA,\ NR,\ inter\text{-}freq}$

where

$N_{freq,\ NSA,\ NR,\ inter\text{-}RAT}$ is the number of NR inter-RAT carriers being monitored as configured by E-UTRA PCell [15]

$N_{freq,\ NSA,\ NR,\ inter\text{-}freq}$ is the number of NR inter-frequency carriers being monitored as configured by PSCell

$N_{freq,\ NSA,\ UTRA}$ is the number of UTRA inter-RAT carriers being monitored as configured by E-UTRA PCell (FDD and TDD)

$M_{NSA,\ GSM}$ 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. $M_{NSA,\ GSM}$ is equal to 0 if no GSM carrier is being monitored. For a MGRP of 40 ms, $M_{NSA,\ GSM}$ is equal to 1 if cells on up to 32 GSM carriers are being measured. For a MGRP of 80 ms, $M_{NSA,\ GSM}$ 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 at least a PCell.

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.

$N_{freq,\ SA,\ NR}$ is the number of NR inter-frequency carriers being monitored as configured by PCell.

9.1.3.2 NSA: Maximum allowed layers for multiple monitoring

If a UE is configured with E-UTRA-NR dual connectivity 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 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)

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 configured by E-UTRA PCell and/or PSCell.

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 8.2.1.1b.1 of [15].

NOTE 2: When the E-UTRA PCell and PSCell configure the same NR carrier frequency layer to be monitored by the UE, this layer shall be counted only once to the total number of effective carrier frequency layers, unless the configured NR carrier frequency layers to be monitored have different subcarrier spacing or different RSSI measurement resources.

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 at least a PCell, 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

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.

9.1.4 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 criteriaapplicable 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 not configured of EN-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 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 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.		

9.2 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 can perform intra-frequency SSB based measurements without measurement gaps under the following conditions:

- the SSB is completely contained in the downlink operating bandwidth of the UE, and;
- the SSB has the same subcarrier spacing as the downlink data transmission to the UE, and;
- the UE is measuring on FR1;
- the serving cell data transmissions to the UE have the same subcarrier spacing as the SSB to be measured

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 this section apply if

- SCH_RP and SCH Ês/Iot according to Annex TBD 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, the UE shall be capable of monitoring at least 8 cells.

For each intra-frequency layer, during each layer 1 measurement period, the UE shall be capable of monitoring at least [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 the UE shall be capable of monitoring at least [6] cells on a single serving carrier (PCC or PSCC or 1 SCC if PCC/PSCC is in a band different from SCC) out of all the serving carriers configured in the same band.

For each intra-frequency layer, during each layer 1 measurement period, the UE shall be capable of monitoring at least [24] SSB with different SSB index and/or PCI on a single serving carrier (PCC or PSCC or 1 SCC if PCC/PSCC is in a band different from SCC) out of all the serving carriers configured in the same band. UE shall be capable of monitoring [1~ 4] SSB(s) on serving cell for each of the other serving carrier(s) in the same band. UE shall be capable of performing RSRP and RSRQ on all above-mentioned SSBs

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.x,10.y and 10.z, 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.x,10.y and 10.z, 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.x,10.y and 10.z, 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 than $T_{\text{identify intra without index}}$ 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 ≤ TBD seconds 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 ± TBD Ts and the L3 filter has not been used. When L3 filtering is used, an additional delay can be expected.

9.2.5 Intrafrequency measurements with no measurement gaps

9.2.5.1 Intrafrequency cell identification

Editor's Note :The requirements below have been derived without considering gap sharing when all SMTC occasion are fully overlapping with measurement gaps.

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, or the UE has been indicated that the neighbour cell is synchronous with the serving cell. 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 $T_{\text{identify\_intra\_without\_index}}$.

$$T_{\text{identify\_intra\_without\_index}} = K_{ca} (T_{\text{PSS/SSS\_sync}} + T_{\text{SSB\_measurement\_period}}) \text{ ms}$$

$$T_{\text{identify\_intra\_with\_index}} = K_{ca} (T_{\text{PSS/SSS\_sync}} + T_{\text{SSB\_measurement\_period}} + T_{\text{SSB\_time\_index}}) \text{ ms}$$

Where:

$T_{\text{PSS/SSS\_sync}}$: it is the time period used in PSS/SSS detection given in table 9.2.5.1-1, 9.2.5.1-2, 9.2.5.1-5 (deactivated Scell) or 9.2.5.1-6 (deactivated SCell)

$T_{\text{SSB\_time\_index}}$: it is the time period used to acquire the index of the SSB being measured given in table 9.2.5.1-3 or 9.2.5.1-4 or 9.2.5.1-7 (deactivated SCell) or 9.2.5.1-8 (deactivated SCell)

$T_{\text{SSB\_measurement\_period}}$: 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)

K_{ca}: For FR1, K_{ca} =1 for measurements on frequencies corresponding to PCell or PSCell, and K_{ca} =number of configured SCells for measurements on frequencies corresponding to FR1 only SCells

Editor's note : K_{ca} for SCells on FR1 assumes that all Scell SMTC are overlapping(definition FFS). K_{ca} definition may be revised for non overlapping Scell SMTCs.

Editor's note:K_{ca} is FFS if any FR2 serving cells are configured

When intrafrequency SMTC is fully non overlapping with measurement gaps, Kp=1

When intrafrequency is partially overlapping with measurent gaps, Kp = 1/(1- (SMTC period /MGRP)), where SMTC period < MGRP

Editor's note : It is FFS how requirements are defined for the case that SMTC are fully overlapping with measurement gap

Editor's note: It is FFS if the same scaling factor can be applied for FR2 in case of partial overlap between SMTC and measurement gap

Table 9.2.5.1-1: Time period for PSS/SSS detection, (Frequency range FR1)

DRX cycle	T_{PSS/SSS_sync}
No DRX	max[600ms, ceil([5] x K_p) x SMTC period]Note 1
DRX cycle≤ 320ms	max[600ms, ceil(1.5x [5] x K_p) x max(SMTC period,DRX cycle)]
DRX cycle>320ms	Ceil([5] x K_p) x DRX cycle
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}
No DRX	max[600ms, ceil([5] x K_p) x N_1 x SMTC period]Note 1
DRX cycle≤ 320ms	max[600ms, ceil(1.5 x [5] x K_p) x N_1 x max(SMTC period,DRX cycle)]
DRX cycle>320ms	Ceil([5] x K_p) x N_1 x DRX cycle
...	...
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	$T_{SSB\_time\_index}$
No DRX	max[120ms, ceil(3 x K_p) x SMTC period]Note 1
DRX cycle≤ 320ms	max[120ms, ceil (1.5 x 3 x K_p) x max(SMTC period,DRX cycle)]
DRX cycle>320ms	Ceil(3 x K_p) x DRX cycle
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 time index detection (Frequency range FR2)

DRX cycle	$T_{SSB\_time\_index}$
No DRX	max[200ms, ceil([5] x K_p) x N_2 x SMTC period]Note 1
DRX cycle≤ 320ms	max[200ms, ceil (1.5 x[5] x K_p) x N_2 x max(SMTC period,DRX cycle)]
DRX cycle>320ms	Ceil([5] x K_p) x N_2 x DRX cycle
...	...
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 9.2.5.1-5: Time period for PSS/SSS detection, deactivated SCell (Frequency range FR1)

DRX cycle	T_{PSS/SSS_sync}
No DRX	[5] x measCycleSCell
DRX cycle≤ 320ms	[5] x max(measCycleSCell, 1.5xDRX cycle)
DRX cycle> 320ms	[5] x max(measCycleSCell, DRX cycle)

Table 9.2.5.1-6: Time period for PSS/SSS detection, deactivated SCell (Frequency range FR2)

DRX cycle	T_{PSS/SSS_sync}
No DRX	TBD
DRX	TBD

Table 9.2.5.1-7: Time period for time index detection, deactivated SCell (Frequency range FR1)

DRX cycle	$T_{SSB\_time\_index}$
No DRX	[3] x measCycleSCell
DRX cycle≤ 320ms	[3] x max(measCycleSCell, 1.5xDRX cycle)
DRX cycle> 320ms	[3] x max(measCycleSCell, DRX cycle)

Table 9.2.5.1-8: Time period for time index detection, deactivated SCell (Frequency range FR2)

DRX cycle	$T_{SSB\_time\_index}$
No DRX	TBD
DRX	TBD

9.2.5.2 Measurement period

Editor's Note : The requirements below have been derived so far assuming no configured Scell or E-UTRA SCell. The requirements when one or more SCells or E-UTRA SCells are configured is for further study. The requirements below have been derived without considering gap sharing when all SMTC occasion are fully overlapping with measurement gaps.

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).

Table 9.2.5.2-1: Measurement period for intrafrequency measurements without gaps(Frequency FR1)

DRX cycle	$T_{SSB\_measurement\_period}$
No DRX	max[200ms, ceil(5 x K_p) x SMTC period]^Note 1^
DRX cycle≤ 320ms	max[200ms, ceil(1.5x 5 x K_p) x max(SMTC period,DRX cycle)]
DRX cycle>320ms	ceil(5 x K_p) x DRX cycle
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	$T_{SSB\_measurement\_period}$
No DRX	max[400ms, ceil(5 x K_p) x N_3 x SMTC period]^Note 1^
DRX cycle≤ 320ms	max[400ms, ceil(1.5x 5 x K_p) x N_3 x max(SMTC period,DRX cycle)]
DRX cycle>320ms	ceil(5 xK_p) x N_3 x DRX cycle
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	$T_{SSB\_measurement\_period}$
No DRX	[5] x measCycleSCell
DRX cycle≤ 320ms	[5] x max(measCycleSCell, 1.5xDRX cycle)
DRX cycle> 320ms	[5] x max(measCycleSCell, DRX cycle)

Table 9.2.5.2-4: Measurement period for intrafrequency measurements without gaps (deactivated SCell) (Frequency range FR2)

DRX cycle	$T_{SSB\_measurement\_period}$
No DRX	TBD
DRX	TBD

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 and on frequency range FR2, there are restrictions on the scheduling availability as described in the following clauses.

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 *useServingCellTimingForSync* is enabled the UE is not expected to transmit PUCCH/PUSCH or receive PDCCH/PDSCH on SSB symbols to be measured, and on 1 data symbol before each consecutive SSB symbols and 1 data symbol after each consecutive SSB symbols within SMTC window duration

- If *useServingCellTimingForSync* is not enabled the UE is not expected to transmit PUCCH/PUSCH or receive PDCCH/PDSCH on all symbols within SMTC window duration

When intra-band carrier aggregation is performed, the scheduling restrictions apply to all serving cells on the 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 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 or receive PDCCH/PDSCH on SSB symbols to be measured, 1 symbol before each consecutive SSB symbols and 1 data symbol after each consecutive SSB symbols within SMTC window duration (it is assumed that *useServingCellTimingForSync* is always enabled for FR2)

The following scheduling restriction applies to SS-RSRQ measurement on an FR2 intra-frequency cell

- UE is not expected to transmit PUCCH/PUSCH or receive PDCCH/PDSCH on SSB symbols to be measured, RSSI measurement symbols, 1 data symbol before each consecutive SSB/RSSI symbols and 1 data symbol after each consecutive SSB/RSSI symbols within SMTC window duration (it is assumed that *useServingCellTimingForSync* is always enabled for FR2)

When intra-band carrier aggregation is performed, the scheduling restrictions apply to all serving cells on the band. When inter-band carrier aggregation within FR2 is performed, the scheduling restrictions apply to all serving cells on the bands.

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 Intra gap sharing

[Editor's note : This is being studied]

9.2.6.2 Intrafrequency cell identification

Editor's Note : The impact of gap sharing between intrafrequency and interfrequency measurements has not been include in the requirements below.

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, or the UE has been indicated that the neighbour cell is synchronous with the serving cell.. 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 $T_{identify\_intra\_without\_index.}$

$$T_{identify\_intra\_without\_index} = T_{PSS/SSS\_sync} + T_{SSB\_measurement\_period} \text{ ms}$$

$$T_{identify\_intra\_with\_index} = T_{PSS/SSS\_sync} + T_{SSB\_measurement\_period} + T_{SSB\_time\_index}$$

Where:

T_{PSS/SSS_sync}: it is the time period used in PSS/SSS detection given in table 9.2.6.2-1, 9.2.6.2-2, or 9.2.6.2-1(deactivated SCell)

$T_{SSB\_time\_index}$: it is the time period used to acquire the index of the SSB being measured given in table 9.2.6.2-3 or 9.2.6.2-5 or 9.2.6.2-7(deactivated SCell) or or 9.2.6.2-8(deactivated SCell).

$T_{SSB\_measurement\_period}$: equal to a measurement period of SSB based measurement given in table 9.2.6.2-1, 9.2.6.2-2, 9.2.6.2-3 (deactivated Scell) or 9.2.6.2-4(deactivated SCell)

Table 9.2.6.2-1: Time period for PSS/SSS detection (Frequency range FR1)

DRX cycle	T_{PSS/SSS_sync}
No DRX	max[600ms, [5] x max(MGRP, SMTC period)]
DRX cycle≤ 320ms	max[600ms, ceil(1.5x [5]) x max(MGRP, SMTC period,DRX cycle)]
DRX cycle>320ms	[5] x max(MGRP, DRX cycle)

Table 9.2.6.2-2: Time period for PSS/SSS detection (Frequency range FR2)

DRX cycle	T_{PSS/SSS_sync}
No DRX	max[600ms, [5] x N_1 x max(MGRP, SMTC period)]
DRX cycle≤ 320ms	max[600ms, ceil(1.5x [5]) x N_1 x max(MGRP, SMTC period, DRX cycle)]
DRX cycle>320ms	[5] x N_1 x max(MGRP, DRX cycle)
...	...
Editor's note: The values of N_1 in the following tables are to be updated.	

Table 9.2.6.2-3: Time period for time index detection (Frequency range FR1)

DRX cycle	$T_{SSB\_time\_index}$
No DRX	max[120ms, 3 x max(MGRP, SMTC period)]
DRX cycle≤ 320ms	max[120ms, ceil(1.5x 3) x max(MGRP, SMTC period,DRX cycle)]
DRX cycle>320ms	3 x max(MGRP, DRX cycle)

Table 9.2.6.2-4: Time period for time index detection (Frequency range FR2)

DRX cycle	$T_{SSB\_time\_index}$
No DRX	max[200ms, [5] x N_2 x max(MGRP, SMTC period)]
DRX cycle≤ 320ms	max[200ms, ceil(1.5x [5]) x N_2 x max(MGRP, SMTC period, DRX cycle)] Note 1
DRX cycle>320ms	[5] x N_2 x max(MGRP, DRX cycle)
...	...
Editor's note: The values of N_2 in the following tables are to be updated.	

Table 9.2.6.2-5: Time period for PSS/SSS detection, deactivated SCell (Frequency range FR1)

DRX cycle	T_{PSS/SSS_sync}
No DRX	[5] x measCycleSCell
DRX cycle≤ 320ms	[5] x max(measCycleSCell, 1.5xDRX cycle)
DRX cycle>320ms	[5] x max(measCycleSCell, DRX cycle)

Table 9.2.6.2-6: Time period for PSS/SSS detection, deactivated SCell (Frequency range FR2)

DRX cycle	T_{PSS/SSS_sync}
No DRX	TBD
DRX	TBD

Table 9.2.6.2-7: Time period for time index detection (Frequency range FR1), deactivated SCell

DRX cycle	$T_{SSB\_time\_index}$
No DRX	[3] x measCycleSCell
DRX cycle≤ 320ms	[3] x max(measCycleSCell, 1.5xDRX cycle)
DRX cycle>320ms	[3] x max(measCycleSCell, DRX cycle)

Table 9.2.6.2-8: Time period for time index detection (Frequency range FR2), deactivated SCell

DRX cycle	$T_{SSB\_time\_index}$
No DRX	TBD
DRX	TBD

9.2.6.3 Intrafrequency Measurement Period

Editor's Note : The requirements below have been derived so far assuming no configured Scell or E-UTRA SCell. The requirements when one or more SCells or E-UTRA SCells are configured is for further study. . The impact of gap sharing between intrafrequency and interfrequency measurements has not been include in the requirements below.

The measurement period for FR1 intrafrequency measurements with gaps is as shown in table 9.2.6.3-1 or 9.2.6.3-3(deactivated Scell)

The measurement period for FR2 intrafrequency measurements with gaps is as shown in table 9.2.6.3-2 or 9.2.6.3-4(deactivated Scell)

Editor's note: The values of X, Y and N in the following tables are to be updated.

Table 9.2.6.3-1: Measurement period for intrafrequency measurements with gaps(Frequency Range FR1)

DRX cycle	$T_{SSB\_measurement\_period}$
No DRX	max[200ms, 5 x max(MGRP, SMTC period)]
DRX cycle≤ 320ms	max[200ms, ceil(1.5x 5) x max(MGRP, SMTC period,DRX cycle)]
DRX cycle>320ms	5 x max(MGRP, DRX cycle)

Table 9.2.6.3-2: Measurement period for intrafrequency measurements with gaps(Frequency Range FR2)

DRX cycle	$T_{SSB\_measurement\_period}$
No DRX	max[400ms, 5 x N_3 x max(MGRP, SMTC period)]
DRX cycle≤ 320ms	max[400ms, ceil(1.5 x 5) x N_3 x max(MGRP, SMTC period, DRX cycle)] Note 1
DRX cycle>320ms	5 x N_3 x max(MGRP, DRX cycle)
...	...
Editor's note: The values N_3 in the following tables are to be updated.	

Table 9.2.6.3-3: Measurement period for intrafrequency measurements with gaps, deactivated SCell (Frequency Range FR1)

DRX cycle	$T_{SSB\_measurement\_period}$
No DRX	[5] x measCycleSCell
DRX cycle≤ 320ms	[5] x max(measCycleSCell, 1.5xDRX cycle)
DRX cycle>320ms	[5] x max(measCycleSCell, DRX cycle)

Table 9.2.6.3-4: Measurement period for intrafrequency measurements with gaps, deactivated SCell (Frequency Range FR2)

DRX cycle	$T_{SSB\_measurement\_period}$
No DRX	TBD
DRX	TBD

9.3 NR inter-frequency measurements

Editor's note: DRX and non DRX requirement might be separately defined in this section. The numerology and BW combinations might be reflected in the requirement table.

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, the switching time is 0,25ms Otherwise the switching time is 0.5ms.

9.3.2 Requirements applicability

A cell shall be considered detectable when:

- [SS-RSRP] related side conditions given in Section [TBD] are fulfilled for a corresponding Band,
- [SS-RSRQ] related side conditions given in Clause [TBD] are fulfilled for a corresponding Band,
- [SS-SINR] related side conditions given in Section [TBD] are fulfilled for a corresponding Band,
- [SCH_RP] and [SCH Ês/Iot] according to Annex [TBD] for a corresponding Band.

Editors note: requirements for both per UE measurement gap and per-FR measurement gap will be captured in this section.

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, the UE shall be capable of monitoring at least 4 cells.

For each inter-frequency layer, during each layer 1 measurement period, the UE shall be capable of monitoring at least [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, the UE shall be capable of monitoring at least 4 cells.

For each inter-frequency layer, during each layer 1 measurement period, the UE shall be capable of monitoring at least [10] SSBs with different SSB index and/or PCI on the inter-frequency layer. The UE shall be capable of monitoring at least one SSB per 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. 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 $T_{SSB\_time\_index\_inter}$.

$$T_{identify\_inter\_without\_index} = (T_{PSS/SSS\_sync\_inter} + T_{SSB\_measurement\_period\_inter})\ ms$$

$$T_{identify\_inter\_with\_index} = (T_{PSS/SSS\_sync\_inter} + T_{SSB\_measurement\_period\_inter} + T_{SSB\_time\_index\_inter})\ ms$$

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.

Table 9.3.4-1: Time period for PSS/SSS detection, (Frequency range FR1)

Condition	T_{PSS/SSS_sync_inter}
No DRX	max[[TBD]ms, [TBD] x max[MGRP, SMTC period] x CSF_{inter}] Note 1, Note 2
DRX cycle ≤ [320]ms	max[[TBD]ms, [TBD] x max(MGRP, SMTC period, DRX cycle) x CSF_{inter}] Note 1, Note 2
DRX cycle > [320]ms	[TBD] x DRX cycle x CSF_{inter} Note 2
NOTE 1: If different SMTC periodicities are configured for different inter-frequency carriers, the SMTC period in the requirement is the SMTC period of the inter-frequency carrier being identified NOTE 2: CSF_{inter} is a carrier specific scaling factor and is determined according to section [9.3.6]	

Table 9.3.4-2: Time period for PSS/SSS detection, (Frequency range FR2)

Condition	T_{PSS/SSS_sync_inter}
No DRX	max[[TBD]ms, [TBD] x N_4 x max[MGRP, SMTC period] x CSF_{inter}] [Note 1, Note 2]
DRX cycle ≤ [320]ms	max[[TBD]ms, [TBD] x N_4 x max(MGRP, SMTC period, DRX cycle) x CSF_{inter}] [Note 1, Note 2]
DRX cycle > [320]ms	[TBD] x N_4 x DRX cycle x CSF_{inter} [Note 2]
NOTE 1: If different SMTC periodicities are configured for different inter-frequency carriers, the SMTC period in the requirement is the SMTC period of the inter-frequency carrier being identified NOTE 2: CSF_{inter} is a carrier specific scaling factor and is determined according to section [9.3.6]	

Table 9.3.4-3: Time period for time index detection (Frequency range FR1)

Condition	$T_{SSB\_time\_index\_inter}$
No DRX	max[[TBD]ms, [TBD] x max[MGRP, SMTC period] x CSF_{inter}] [Note 1, Note 2]
DRX cycle ≤ [320]ms	max[[TBD]ms, [TBD] x max(MGRP, SMTC period, DRX cycle) x CSF_{inter}] [Note 1, Note 2]
DRX cycle > [320]ms	[TBD] x DRX cycle x CSF_{inter} [Note 2]
NOTE 1: If different SMTC periodicities are configured for different inter-frequency carriers, the SMTC period in the requirement is the SMTC period of the inter-frequency carrier being identified NOTE 2: CSF_{inter} is a carrier specific scaling factor and is determined according to section [9.3.6]	

Table 9.3.4-4: Time period for time index detection (Frequency range FR2)

Condition	$T_{SSB\_time\_index\_inter}$
No DRX	max[[TBD]ms, [TBD] x N_5 x max[MGRP, SMTC period] x CSF_{inter}] [Note 1, Note 2]
DRX cycle ≤ [320]ms	max[[TBD]ms, [TBD] x N_5 x max(MGRP, SMTC period, DRX cycle) x CSF_{inter}] [Note 1, Note 2]
DRX cycle > [320]ms	[TBD] x N_4 x DRX cycle x CSF_{inter} [Note 2]
NOTE 1: If different SMTC periodicities are configured for different inter-frequency carriers, the SMTC period in the requirement is the SMTC period of the inter-frequency carrier being identified NOTE 2: CSF_{inter} is a carrier specific scaling factor and is determined according to section [9.3.6]	

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 [TBD], [TBD], and [TBD], 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	$T_{SSB\_measurement\_period\_inter}$
No DRX	max[[TBD]ms, [TBD] x max[MGRP, SMTC period] x CSF_{inter}] [Note 1, Note 2]
DRX cycle ≤ [320]ms	max[[TBD]ms, [TBD] x max(MGRP, SMTC period, DRX cycle) x CSF_{inter}] [Note 1, Note 2]
DRX cycle > [320]ms	[TBD] x DRX cycle x CSF_{inter} [Note 2]
...	...
NOTE 1: If different SMTC periodicities are configured for different inter-frequency carriers, the SMTC period in the requirement is the SMTC period of the inter-frequency carrier being measured NOTE 2: CSF_{inter} is a carrier specific scaling factor and is determined according to section [9.3.6]	

Table 9.3.5-2: Measurement period for inter-frequency measurements with gaps (Frequency FR2)

Condition	$T_{SSB\_measurement\_period\_inter}$
No DRX	max[[TBD]ms, [TBD] x N_6 x max[MGRP, SMTC period] x CSF_{inter}] Note 1, Note 2
DRX cycle ≤ [320]ms	max[[TBD]ms, [TBD] x N_6 x max(MGRP, SMTC period, DRX cycle) x CSF_{inter}] Note 1, Note 2
DRX cycle > [320]ms	[TBD] x N_4 x DRX cycle x CSF_{inter} Note 2
...	...
NOTE 1: If different SMTC periodicities are configured for different inter-frequency carriers, the SMTC period in the requirement is the SMTC period of the inter-frequency carrier being measured NOTE 2: CSF_{inter} is a carrier specific scaling factor and is determined according to section [9.3.6]	

TBD [*Editor's note: Physical layer measurement period for both non-DRX and DRX*]

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 [TBD], 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 [TBD], respectively.

The first report in event triggered periodic measurement reporting shall meet the requirements specified in clause [TBD].

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 [TBD], 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}.] 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 [$T_{identify\text{-}inter}$] defined in clause [TBD]. When L3 filtering is used an additional delay can be expected.

If a cell which has been detectable at least for the time period [$T_{identify\_inter}$] defined in clause [TBD] and then triggers the measurement report as per TS 38.331 [TBD], the event triggered measurement reporting delay shall be less than [$T_{Measurement\_Period\_Inter\_FDD}$]defined in clause [TBD] 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. When L3 filtering is used an additional delay can be expected.

Editor's note: To be captured once the RAN2 work progresses.

9.3.7 Derivation of CSF_{inter}

Editors note: this section includes how to determine the scaling factor used in determining the UE cell detection, Index detection and measurement requirements.

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
NOTE 1: When determing UE requirements using Tinter1 for GP2 and GP3, Tinter1 = [60] for GP2 and Tinter1 = [30] for GP3 shall be used. NOTE 2: Measurement gaps pattern configurations applicability are as specified in Table 9.1.2-1.			

Editor's note: a note to be added in Table 9.4.1-1 on that measurement gap patterns #2 and #3 are supported only by the UEs which have a corresponding capability once RAN2 specifies the capability.

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 measuements.

In the requirements, an E-UTRAN FDD cell is considered to be detectable when:

- RSRP related side conditions given in Section 10.x are fulfilled for a corresponding Band,
- RSRQ related side conditions given in Section 10.y are fulfilled for a corresponding Band,
- RS-SINR related side conditions given in Section 10.z are fulfilled for a corresponding Band,
- SCH_RP and SCH Ês/Iot according to Annex TBD for a corresponding Band.

9.4.2.2 Requirements when no DRX is used

When the UE requires measurement gaps to idenitify and measurement inter-RAT cells and an appropriate measurement gap pattern is scheduled, the UE shall be able to identify a new detectable FDD cell within $T_{Identify,\ E\text{-}UTRAN\ FDD}$ according to the following expression:

$$T_{Identify,E-UTRAN\ FDD} = T_{BasicIdentify} * \frac{480}{T_{Inter1}} * K \quad ms,$$

where:

$T_{BasicIdentify}$ = 480 ms,

T_{Inter1} is defined in Section 9.4.1,

K=TBD and depends at least on $N_{freq, SA}$ defined in Section 9.1.3.3 and whether and how gaps are shared.

Identification of a cell shall include detection of the cell and additionally performing a single measurement with measurement period of $T_{Measure, E-UTRAN FDD}$ defined in Table 9.4.2.2-1.

Table 9.4.2.2-1: Measurement period and measurement bandwidth

Configuration	Physical Layer Measurement period: $T_{Measure, E-UTRAN FDD}$ [ms]	Measurement bandwidth [RB]
0	480 x TBD	6
1 (Note 1)	240 x TBD	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 E-UTRAN FDD cells per E-UTRA FDD carrier frequency layer 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.x.
The NR – E-UTRAN FDD RSRQ measurement accuracy for all measured cells shall be as specified in Section 10.y.
The NR – E-UTRAN FDD RS-SINR measurement accuracy for all measured cells shall be as specified in Section 10.z.

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 $T_{Identify, E-UTRAN FDD}$ 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)	$T_{Identify, E-UTRAN FDD}$ (s) (DRX cycles)	
	Gap period = 40 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*K)	7.68*K (30*K)
0.32	6.4*K (20*K)	7.68*K (24*K)
0.32< DRX-cycle ≤10.24	Note1 (20*K)	Note1 (20*K)
NOTE1: The time depends on the DRX cycle length. NOTE2: K=TBD and depends at least on $N_{freq, SA}$ defined in Section 9.1.3.3.		

When DRX is in use, the UE shall be capable of performing NR – E-UTRAN FDD RSRP and RSRQ measurements of at least 4 E-UTRAN FDD cells per E-UTRA FDD frequency layer 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 and RSRQ measurements to higher layers with the measurement period $T_{measure, E-UTRAN FDD}$ 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)	$T_{measure, E-UTRAN FDD}$ (s) (DRX cycles)
≤0.08	Non-DRX requirements in Section 9.4.2.2 apply
0< DRX-cycle ≤10.24	Note1 (5*K)
NOTE1: The time depends on the DRX cycle length. NOTE2: K=TBD and depends at least on $N_{freq, SA}$ defined in Section 9.1.3.3.	

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.x.
The NR – E-UTRAN FDD RSRQ measurement accuracy for all measured cells shall be as specified in Section 10.y.
The NR – E-UTRAN FDD RS-SINR measurement accuracy for all measured cells shall be as specified in Section 10.z.

Editor's note: gap sharing to be accounted for.

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.x, 10.2.y, and 10.2.z, 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.x, 10.2.y, and 10.2.z, 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.x, 10.2.y, and 10.2.z, 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 ≤ TBD 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 measuements.

In the requirements, an E-UTRAN TDD cell is considered to be detectable when:

- RSRP related side conditions given in Section 10.x are fulfilled for a corresponding Band,
- RSRQ related side conditions given in Section 10.y are fulfilled for a corresponding Band,
- RS-SINR related side conditions given in Section 10.z are fulfilled for a corresponding Band,
- SCH_RP and SCH Ês/Iot according to Annex TBD for a corresponding Band.

9.4.3.2 Requirements when no DRX is used

When the UE requires measurement gaps to idenitify and measurement inter-RAT cells and an appropriate measurement gap pattern is scheduled, the UE shall be able to identify a new detectable FDD cell within $T_{Identify, E-UTRAN TDD}$ according to the following expression:

- When configuration 0 or configuration 1 in Table 9.4.3.2-1 is applied,

$$T_{Identify,E-UTRAN\ TDD} = T_{BasicIdentify} * \frac{480}{T_{Inter1}} * K \quad ms\ ,$$

- When configuration 2 or configuration 3 in Table 9.4.3.2-1 is applied,

$$T_{Identify,E-UTRAN\ TDD} = (T_{BasicIdentify} * \frac{480}{T_{Inter1}} + 240) * K \quad ms\ ,$$

where:

$T_{BasicIdentify}$ = 480 ms,

T_{Inter1} is defined in Section 9.4.1,

K=TBD and depends at least on $N_{freq, SA}$ defined in Section 9.1.3.3 and whether and how gaps are shared.

Identification of a cell shall include detection of the cell and additionally performing a single measurement with measurement period of $T_{Measure, E-UTRAN TDD}$ defined in Table 9.4.3.2-1.

Table 9.4.3.2-1: $T_{Measure, E-UTRAN TDD}$ for different configurations

Configuration	Measurement bandwidth [RB]	Number of UL/DL sub-frames per half frame (5 ms)		DwPTS		$T_{Measure, E-UTRAN TDD}$ [ms]
		DL	UL	Normal CP	Extended CP	
0	6	2	2	$19760 \cdot T_s$	$20480 \cdot T_s$	480 x K
1 (Note 1)	50	2	2	$19760 \cdot T_s$	$20480 \cdot T_s$	240 x K
NOTE 1: This configuration is optional. NOTE 2: K=TBD and depends at least on $N_{freq, SA}$ defined in Section 9.1.3.3.						

The UE shall be capable of identifying and performing NR – E-UTRAN TDD RSRP, RSRQ, and RS-SINR measurements of at least 4 E-UTRAN TDD cells per E-UTRA TDD carrier frequency layer 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.x.
The NR – E-UTRAN TDD RSRQ measurement accuracy for all measured cells shall be as specified in Section 10.y.
The NR – E-UTRAN TDD RS-SINR measurement accuracy for all measured cells shall be as specified in Section 10.z.

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 $T_{Identify, E-UTRAN TDD}$ 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)	$T_{Identify, E-UTRAN TDD}$ (s) (DRX cycles)	
	Gap period = 40 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*K)	7.68*K (30*K)
0.32	6.4*K (20*K)	7.68*K (24*K)
0.32< DRX-cycle ≤10.24	Note1 (20*K)	Note1 (20*K)
NOTE 1: The time depends on the DRX cycle length. NOTE 2: K=TBD and depends at least on $N_{freq, SA}$ defined in Section 9.1.3.3.		

When DRX is in use, the UE shall be capable of performing NR – E-UTRAN TDD RSRP and RSRQ measurements of at least 4 E-UTRAN TDD cells per E-UTRA TDD frequency layer 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 and RSRQ 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*K)
0.128<DRX-cycle≤10.24	Note1 (5*K)
NOTE 1: The time depends on the DRX cycle length. NOTE 2: K=TBD and depends at least on $N_{freq,\ SA}$ defined in Section 9.1.3.3.	

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.x.
The NR – E-UTRAN TDD RSRQ measurement accuracy for all measured cells shall be as specified in Section 10.y.
The NR – E-UTRAN TDD RS-SINR measurement accuracy for all measured cells shall be as specified in Section 10.z.

Editor's note: gap sharing to be accounted for.

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.x, 10.2.y, and 10.2.z, 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.x, 10.2.y, and 10.2.z, 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.x, 10.2.y, and 10.2.z, 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 $T_{Identify,\ E\text{-}UTRAN\ TDD}$ 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 $T_{Identify,\ E\text{-}UTRAN\ TDD}$ becomes undetectable for a period ≤ TBD 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 $T_{Measure,\ E\text{-}UTRAN\ TDD}$ 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 measuements requested via LPP [22].

9.4.4.1.2 Requirements

Editor's note: sharing factor is not yet taken into account in this section.

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 $\mathrm{T}_{\text{RSTD InterRAT, E-UTRAN FDD}}$ ms as given below:

$$\mathrm{T}_{\text{RSTD InterRAT, E-UTRAN FDD}} = T_{\text{PRS}} \cdot (M - 1) + \Delta \qquad ms \qquad ,$$

where

$\mathrm{T}_{\text{RSTD InterRAT, E-UTRAN FDD}}$ is the total time for detecting and measuring at least *n* cells,

T_{PRS} is the 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≤ N_{PRS} ≤6) consecutive downlink positioning subframes defined in TS 36.211 [23],

$\Delta = 160 \cdot \left\lceil \frac{n}{M} \right\rceil$ 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 $\mathrm{T}_{\text{RSTD InterRAT, E-UTRAN FDD}}$

Positioning subframe configuration period T_{PRS}	Number of PRS positioning occasions M	
	f2 Note1	f1 and f2 Note2
160 ms	16	32
>160 ms	8	16
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 $\mathrm{T}_{\text{RSTD InterRAT, E-UTRAN FDD}}$ provided:

$\left(\text{PRS } \hat{\mathrm{E}}_{\mathrm{s}} / \text{Iot}\right)_{ref}$ ≥-6 dB for all Frequency Bands for the reference cell,

$\left(\text{PRS } \hat{\mathrm{E}}_{\mathrm{s}} / \text{Iot}\right)_{i}$ ≥-13 dB for all Frequency Bands for neighbour cell *i*,

$\left(\text{PRS } \hat{\mathrm{E}}_{\mathrm{s}} / \text{Iot}\right)_{ref}$ and $\left(\text{PRS } \hat{\mathrm{E}}_{\mathrm{s}} / \text{Iot}\right)_{i}$ conditions apply for all subframes of at least $L = \frac{M}{2}$ PRS positioning occasions,

PRP 1,2$|_{\text{dBm}}$ according to Annex TBD 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 $\text{T}_{\text{RSTD InterRAT, E-UTRAN FDD}}$ 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 as specified in [TS 38.355], 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 TBD.

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.

9.4.4.2 SA: NR − E-UTRAN TDD RSTD measurements

9.4.4.2.1 Introduction

The requirements are applicable for NR−E-UTRAN TDD RSTD measuements requested via LPP [22].

9.4.4.2.2 Requirements

Editor's note: sharing factor is not yet taken into account in this section.

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 $\text{T}_{\text{RSTD InterRAT, E-UTRAN TDD}}$ ms as given below:

$$\text{T}_{\text{RSTD InterRAT, E-UTRAN TDD}} = T_{\text{PRS}} \cdot (M - 1) + \Delta \quad ms \quad ,$$

where

$\text{T}_{\text{RSTD InterRAT, E-UTRAN TDD}}$ 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 [16], 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,

$\Delta = 160 \cdot \left\lceil \frac{n}{M} \right\rceil$ 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 $T_{\text{RSTD InterRAT, E-UTRAN TDD}}$

Positioning subframe configuration period T_{PRS}	Number of PRS positioning occasions M	
	f2 Note1	f1 and f2 Note2
160 ms	16	32
>160 ms	8	16
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 $T_{\text{RSTD InterRAT, E-UTRAN TDD}}$ provided:

$\left(\text{PRS } \hat{E}_s / \text{Iot}\right)_{ref}$ ≥-6 dB for all Frequency Bands for the reference cell,

$\left(\text{PRS } \hat{E}_s / \text{Iot}\right)_i$ ≥-13 dB for all Frequency Bands for neighbour cell *i*,

$\left(\text{PRS } \hat{E}_s / \text{Iot}\right)_{ref}$ and $\left(\text{PRS } \hat{E}_s / \text{Iot}\right)_i$ conditions apply for all subframes of at least $L = \frac{M}{2}$ PRS positioning occasions,

PRP 1,2$|_{\text{dBm}}$ according to Annex TBD for a corresponding Band

$\text{PRS } \hat{E}_s / \text{Iot}$ is as defined in Section 9.4.4.1.2.

The time $T_{\text{RSTD InterRAT, E-UTRAN TDD}}$ 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 as specified in [TS 38.355], 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 TBD.

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 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.

9.4.5 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.

Editor's note: sharing factor is not yet taken into account in this section.

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 TBD1 and TBD2, 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.

Editor's note: sharing factor is not yet taken into account in this section.

9.4.5.2.3 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 TBD3 and TBD4, respectively.

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.

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.

The accuracy requirements in Table 10.1.2.1.1-1 are valid under the following conditions:

[TBD]

Table 10.1.2.1.1-1: SS RSRP Intra frequency absolute accuracy

Accuracy		Conditions				
Normal condition	Extreme condition	Ês/Iot	Io Note 1 range			
			NR operating band groups	Minimum Io		Maximum Io
dB	dB	dB		dBm/SSB sub carrier spacing	$dBm/BW_{Channel}$	$dBm/BW_{Channel}$
±[4.5]	±[9]	≥[-6] dB	TBD	TBD	N/A	-70
			TBD	TBD	N/A	-70
			TBD	TBD	N/A	-70
			TBD	TBD	N/A	-70
±[8]	±[11]	≥[-6] dB	All	N/A	-70	-50
NOTE 1: Io is assumed to have constant EPRE across the bandwidth.						

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.

The accuracy requirements in Table 10.1.2.1.2-1 are valid under the following conditions:

[TBD]

Table 10.1.2.1.2-1: SS RSRP Intra frequency relative accuracy

Accuracy		Conditions			
			Io Note 1 range		
Normal condition	Extreme condition	Ês/Iot Note 2	NR operating band groups	Minimum Io	Maximum Io
dB	dB	dB		dBm/SSB sub carrier spacing	dBm/BW$_{Channel}$
[±2]	[±3]	≥[-3] dB	TBD	TBD	-50
			TBD	TBD	-50
			TBD	TBD	-50
			TBD	TBD	-50
±[3]	±[3]	≥[-6] dB	Note 3	Note 3	Note 3

NOTE 1: Io is assumed to have constant EPRE across the bandwidth.
NOTE 2: The parameter Ês/Iot is the minimum 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.

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

10.1.3.2 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 Aboslute Accuracy of SS RSRP

The requirements for absolute accuracy of SS RSRP in this clause apply to a cell 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:

[TBD]

Table 10.1.4.1.1-1: SS RSRP Inter frequency absolute accuracy

Accuracy		Conditions				
			Io Note 1 range			
Normal condition	Extreme condition	Ês/Iot	E-UTRA operating band groups	Minimum Io		Maximum Io
dB	dB	dB		dBm/SSB sub carrier spacing	dBm/BW$_{Channel}$	dBm/BW$_{Channel}$
±[4.5]	±[9]	≥[-6] dB	TBD	TBD	N/A	-70
			TBD	TBD	N/A	-70
			TBD	TBD	N/A	-70
			TBD	TBD	N/A	-70
±[8]	±[11]	≥[-6] dB	All	N/A	-70	-50

NOTE 1: Io is assumed to have constant EPRE across the bandwidth.

10.1.4.1.2 Relative Accuracy of SS RSRP

The relative accuracy of SS RSRP in inter frequency case is defined as the RSRP measured from one cell compared to the RSRP measured from another cell on a different frequency.

The accuracy requirements in Table 10.1.4.1.2-1 are valid under the following conditions:

[TBD]

Table 10.1.4.1.2-1: SS RSRP Inter frequency relative accuracy

Accuracy		Conditions			
Normal condition	Extreme condition	Ês/Iot Note 2	Io Note 1 range		
			E-UTRA operating band groups	Minimum Io	Maximum Io
dB	dB	dB		dBm/SSB sub carrier spacing	$dBm/BW_{Channel}$
±[4.5]	±[6]	≥[-6] dB	TBD	TBD	-50
			TBD	TBD	-50
			TBD	TBD	-50
			TBD	TBD	-50
NOTE 1: Io is assumed to have constant EPRE across the bandwidth.					
NOTE 2: The parameter Ês/Iot is the minimum Ês/Iot of the pair of cells to which the requirement applies.					

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

10.1.5.2 Inter-frequency [CSI-RS RSRP] accuracy requirements

10.1.6 Intra-frequency RSRQ accuracy requirements for FR1

10.1.7 Intra-frequency RSRQ accuracy requirements for FR2

10.1.8 Inter-frequency RSRQ accuracy requirements for FR1

10.1.9 Inter-frequency RSRQ accuracy requirements for FR2

10.1.10 Power Headroom

10.2 E-UTRAN measurements

10.2.1 E-UTRAN RSRP measurements

10.2.2 E-UTRAN RSRQ measurements

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.

Annex A (normative): Test Cases

Editor's note: TBD in the performance part of NR WID. The conducted and OTA testing criteria might be specified in the annex A before test cases configuration

Annex B (normative): Conditions for RRM requirements applicability for operating bands

Editor's note: intended to capture the condition for RRM requirements for different operating bands. FFS if the conditions for RRM requirements applicability for numerologies shall be specified.

Annex C (informative): Change history

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2017-05	RAN4#83	R4-1706324				Specification skeleton	0.0.1
2017-09						Email approved	0.1.0
2017-09	RAN4-NR AH #3	R4-1709413				Capture TPs approved in the meeting	0.2.0
2017-10	RAN4#84 -Bis	R4-1711985				Capture TPs approved in the meeting	0.3.0
2017-12	RAN4#85	R4-1714546				Capture TPs approved in RAN4#85	0.4.0
2017-12	RAN#78	RP-172407				v1.0.0 submitted for plenary approval	1.0.0
2017-12	RAN#78					Approved by plenary – Rel-15 spec under change control	15.0.0
2018-03	RAN#79	RP-180264	0032		B	CR to TS38.133	15.1.0
2018-06	RAN#80	RP-181075	0037		B	CR to TS 38.133: Implementation of endorsed draft CRs from RAN4 #86bis and RAN4 #87	15.2.0

History

Document history		
V15.2.0	July 2018	Publication