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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
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1 Scope

The present document specifies and establishes the characteristics of the physical layer procedures in the FDD and TDD modes of E-UTRA.

2 References

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

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

- [1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".
- [2] 3GPP TS 36.201: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Layer – General Description".
- [3] 3GPP TS 36.211: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation".
- [4] 3GPP TS 36.212: "Evolved Universal Terrestrial Radio Access (E-UTRA); Multiplexing and channel coding".
- [5] 3GPP TS 36.214: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer – Measurements".
- [6] 3GPP TS 36.101: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception".
- [7] 3GPP TS 36.104: "Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception".
- [8] 3GPP TS 36.321, "Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification".
- [9] 3GPP TS 36.423, "Evolved Universal Terrestrial Radio Access (E-UTRA); X2 Application Protocol (X2AP)".
- [10] 3GPP TS 36.133, "Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for support of radio resource management".
- [11] 3GPP TS 36.331, "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC) protocol specification".
- [12] 3GPP TS 36.306: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio access capabilities".

3 Symbols and abbreviations

3.1 Symbols

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

n_f System frame number as defined in [3]

| | |
|------------------|---|
| n_s | Slot number within a radio frame as defined in [3] |
| N_{cells}^{DL} | Number of configured cells |
| N_{RB}^{DL} | Downlink bandwidth configuration, expressed in units of N_{sc}^{RB} as defined in [3] |
| N_{RB}^{UL} | Uplink bandwidth configuration, expressed in units of N_{sc}^{RB} as defined in [3] |
| N_{symb}^{UL} | Number of SC-FDMA symbols in an uplink slot as defined in [3] |
| N_{sc}^{RB} | Resource block size in the frequency domain, expressed as a number of subcarriers as defined in [3] |
| T_s | Basic time unit as defined in [3] |

3.2 Abbreviations

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

| | |
|--------|--|
| ACK | Acknowledgement |
| BCH | Broadcast Channel |
| CCE | Control Channel Element |
| CDD | Cyclic Delay Diversity |
| CG | Cell Group |
| CIF | Carrier Indicator Field |
| CQI | Channel Quality Indicator |
| CRC | Cyclic Redundancy Check |
| CRI | CSI-RS Resource Indicator |
| CSI | Channel State Information |
| CSI-IM | CSI-interference measurement |
| DAI | Downlink Assignment Index |
| DCI | Downlink Control Information |
| DL | Downlink |
| DL-SCH | Downlink Shared Channel |
| DTX | Discontinuous Transmission |
| EPDCCH | Enhanced Physical Downlink Control Channel |
| EPRE | Energy Per Resource Element |
| MCG | Master Cell Group |
| MCS | Modulation and Coding Scheme |
| NACK | Negative Acknowledgement |
| NPBCH | Narrowband Physical Broadcast Channel |
| NPDCCH | Narrowband Physical Downlink Control Channel |
| NPDSCH | Narrowband Physical Downlink Shared Channel |
| NPRACH | Narrowband Physical Random Access Channel |
| NPUSCH | Narrowband Physical Uplink Shared Channel |
| NPSS | Narrowband Primary Synchronization Signal |
| NSSS | Narrowband Secondary Synchronization Signal |
| NRS | Narrowband Reference Signal |
| PBCH | Physical Broadcast Channel |
| PCFICH | Physical Control Format Indicator Channel |
| PDCCH | Physical Downlink Control Channel |
| PDSCH | Physical Downlink Shared Channel |
| PHICH | Physical Hybrid ARQ Indicator Channel |
| PMCH | Physical Multicast Channel |
| PMI | Precoding Matrix Indicator |
| PRACH | Physical Random Access Channel |
| PRS | Positioning Reference Signal |
| PRB | Physical Resource Block |
| PSBCH | Physical Sidelink Broadcast Channel |
| PSCCH | Physical Sidelink Control Channel |
| PSCell | Primary Secondary cell |

| | |
|-------------|---|
| PSDCH | Physical Sidelink Discovery Channel |
| PSSCH | Physical Sidelink Shared Channel |
| PSSS | Primary Sidelink Synchronisation Signal |
| PUCCH | Physical Uplink Control Channel |
| PUCCH-SCell | PUCCH SCell |
| PUSCH | Physical Uplink Shared Channel |
| PTI | Precoding Type Indicator |
| RBG | Resource Block Group |
| RE | Resource Element |
| RI | Rank Indication |
| RS | Reference Signal |
| SCG | Secondary Cell Group |
| SINR | Signal to Interference plus Noise Ratio |
| SPS C-RNTI | Semi-Persistent Scheduling C-RNTI |
| SR | Scheduling Request |
| SRS | Sounding Reference Symbol |
| SSSS | Secondary Sidelink Synchronisation Signal |
| TAG | Timing Advance Group |
| TBS | Transport Block Size |
| UCI | Uplink Control Information |
| UE | User Equipment |
| UL | Uplink |
| UL-SCH | Uplink Shared Channel |
| VRB | Virtual Resource Block |

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4 Synchronization procedures

4.1 Cell search

Cell search is the procedure by which a UE acquires time and frequency synchronization with a cell and detects the physical layer Cell ID of that cell. E-UTRA cell search supports a scalable overall transmission bandwidth corresponding to 6 resource blocks and upwards.

The following signals are transmitted in the downlink to facilitate cell search: the primary and secondary synchronization signals.

A UE may assume the antenna ports 0 – 3 and the antenna port for the primary/secondary synchronization signals of a serving cell are quasi co-located (as defined in [3]) with respect to Doppler shift and average delay.

4.2 Timing synchronization

4.2.1 Radio link monitoring

The downlink radio link quality of the primary cell shall be monitored by the UE for the purpose of indicating out-of-sync/in-sync status to higher layers.

If the UE is configured with a SCG [11] and the parameter *rlf-TimersAndConstantsSCG* is provided by the higher layers and is not set to release, the downlink radio link quality of the PSCell [11] of the SCG shall be monitored by the UE for the purpose of indicating out-of-sync/in-sync status to higher layers.

In non-DRX mode operation, the physical layer in the UE shall every radio frame assess the radio link quality, evaluated over the previous time period defined in [10], against thresholds (Q_{out} and Q_{in}) defined by relevant tests in [10].

In DRX mode operation, the physical layer in the UE shall at least once every DRX period assess the radio link quality, evaluated over the previous time period defined in [10], against thresholds (Q_{out} and Q_{in}) defined by relevant tests in [10].

If higher-layer signalling indicates certain subframes for restricted radio link monitoring, the radio link quality shall not be monitored in any subframe other than those indicated.

The physical layer in the UE shall in radio frames where the radio link quality is assessed indicate out-of-sync to higher layers when the radio link quality is worse than the threshold Q_{out} . When the radio link quality is better than the threshold Q_{in} , the physical layer in the UE shall in radio frames where the radio link quality is assessed indicate in-sync to higher layers.

4.2.2 Inter-cell synchronization

No functionality is specified in this subclause in this release.

4.2.3 Transmission timing adjustments

Upon reception of a timing advance command for a TAG containing the primary cell or PSCell, the UE shall adjust uplink transmission timing for PUCCH/PUSCH/SRS of the primary cell or PSCell based on the received timing advance command.

The UL transmission timing for PUSCH/SRS of a secondary cell is the same as the primary cell if the secondary cell and the primary cell belong to the same TAG. If the primary cell in a TAG has a frame structure type 1 and a secondary cell in the same TAG has a frame structure type 2, UE may assume that $N_{TA} \geq 624$.

If the UE is configured with a SCG, the UL transmission timing for PUSCH/SRS of a secondary cell other than the PSCell is the same as the PSCell if the secondary cell and the PSCell belong to the same TAG.

Upon reception of a timing advance command for a TAG not containing the primary cell or PSCell, if all the serving cells in the TAG have the same frame structure type, the UE shall adjust uplink transmission timing for PUSCH/SRS of all the secondary cells in the TAG based on the received timing advance command where the UL transmission timing for PUSCH/SRS is the same for all the secondary cells in the TAG.

Upon reception of a timing advance command for a TAG not containing the primary cell or PSCell, if a serving cell in the TAG has a different frame structure type compared to the frame structure type of another serving cell in the same TAG, the UE shall adjust uplink transmission timing for PUSCH/SRS of all the secondary cells in the TAG by using $N_{TAoffset} = 624$ regardless of the frame structure type of the serving cells and based on the received timing advance command where the UL transmission timing for PUSCH/SRS is the same for all the secondary cells in the TAG. $N_{TAoffset}$ is described in [3].

The timing advance command for a TAG indicates the change of the uplink timing relative to the current uplink timing for the TAG as multiples of $16 T_s$. The start timing of the random access preamble is specified in [3].

In case of random access response, an 11-bit timing advance command [8], T_A , for a TAG indicates N_{TA} values by index values of $T_A = 0, 1, 2, \dots, 256$ if the UE is configured with a SCG, and $T_A = 0, 1, 2, \dots, 1282$ otherwise, where an amount of the time alignment for the TAG is given by $N_{TA} = T_A \times 16$. N_{TA} is defined in [3].

In other cases, a 6-bit timing advance command [8], T_A , for a TAG indicates adjustment of the current N_{TA} value, $N_{TA,old}$, to the new N_{TA} value, $N_{TA,new}$, by index values of $T_A = 0, 1, 2, \dots, 63$, where $N_{TA,new} = N_{TA,old} + (T_A - 31) \times 16$. Here, adjustment of N_{TA} value by a positive or a negative amount indicates advancing or delaying the uplink transmission timing for the TAG by a given amount respectively.

For a non-BL/CE UE, for a timing advance command received on subframe n , the corresponding adjustment of the uplink transmission timing shall apply from the beginning of subframe $n+6$. For serving cells in the same TAG, when the UE's uplink PUCCH/PUSCH/SRS transmissions in subframe n and subframe $n+1$ are overlapped due to the timing adjustment, the UE shall complete transmission of subframe n and not transmit the overlapped part of subframe $n+1$.

For a BL/CE UE, for a timing advance command received on subframe n , the corresponding adjustment of the uplink transmission timing shall apply for the uplink PUCCH/PUSCH/SRS transmissions in subframe $n+6$. When the BL/CE UE's uplink PUCCH/PUSCH/SRS transmissions in subframe n and subframe $n+1$ are on the same narrowband and are overlapped due to the timing adjustment, the UE shall complete transmission of subframe n and not transmit in subframe $n+1$ until the first available symbol that has no overlapping portion with subframe n . When the BL/CE UE's uplink PUCCH/PUSCH/SRS transmissions in subframe n and subframe $n+1$ are on different narrowbands, and the timing adjustment occurs in the guard period for narrowband retuning, the UE shall not transmit in subframe $n+1$ until the first available symbol that has no overlapping portion with subframe n and which does not reduce the guard period.

If the received downlink timing changes and is not compensated or is only partly compensated by the uplink timing adjustment without timing advance command as specified in [10], the UE changes N_{TA} accordingly.

4.3 Timing for Secondary Cell Activation / Deactivation

When a UE receives an activation command [8] for a secondary cell in subframe n , the corresponding actions in [8] shall be applied no later than the minimum requirement defined in [10] and no earlier than subframe $n+8$, except for the following:

- the actions related to CSI reporting on a serving cell which is active in subframe $n+8$
- the actions related to the *sCellDeactivationTimer* associated with the secondary cell [8]

which shall be applied in subframe $n+8$.

- the actions related to CSI reporting on a serving cell which is not active in subframe $n+8$

which shall be applied in the earliest subframe after $n+8$ in which the serving cell is active.

When a UE receives a deactivation command [8] for a secondary cell or the *sCellDeactivationTimer* associated with the secondary cell expires in subframe n , the corresponding actions in [8] shall apply no later than the minimum requirement defined in [10], except for the actions related to CSI reporting on a serving cell which is active which shall be applied in subframe $n+8$.