ETSI TS 136 201 V15.3.0 (2020-04)

TECHNICAL SPECIFICATION

LTE;
Evolved Universal Terrestrial Radio Access (E-UTRA);
LTE physical layer;
General description
(3GPP TS 36.201 version 15.3.0 Release 15)

Reference
RTS/TSGR-0136201vf30

Keywords
LTE

ETSI

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
Sous-Préfecture de Grasse (06) N° 7803/88

Important notice

The present document can be downloaded from:
http://www.etsi.org/standards-search

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the prevailing version of an ETSI deliverable is the one made publicly available in PDF format at www.etsi.org/deliver.

Users of the present document should be aware that the document may be subject to revision or change of status. Information on the current status of this and other ETSI documents is available at
https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx

If you find errors in the present document, please send your comment to one of the following services:
https://portal.etsi.org/People/CommiteeSupportStaff.aspx

Copyright Notification

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (https://ipr.etsi.org/).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

Legal Notice

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

The present document may refer to technical specifications or reports using their 3GPP identities. These shall be interpreted as being references to the corresponding ETSI deliverables.

The cross reference between 3GPP and ETSI identities can be found under http://webapp.etsi.org/key/queryform.asp.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Contents

Foreword

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

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

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

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

1 Scope

The present document describes a general description of the physical layer of the E-UTRA radio interface. The present document also describes the document structure of the 3GPP physical layer specifications, i.e. TS 36.200 series. The TS 36.200 series specifies the Uu and Un points for the 3G LTE mobile system, and defines the minimum level of specifications required for basic connections in terms of mutual connectivity and compatibility.

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 36.211: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation".

[3] 3GPP TS 36.212: "Evolved Universal Terrestrial Radio Access (E-UTRA); Multiplexing and channel coding".

[4] 3GPP TS 36.213: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures".

[5] 3GPP TS 36.214: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer – Measurements".

[6] 3GPP TS 36.216: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer for relaying operation".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

Definition format

<defined term>*: <definition>.*

example: text used to clarify abstract rules by applying them literally.

3.2 Symbols

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

Symbol format

<symbol> <Explanation>

3.3 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].

BPSK	Binary Phase Shift Keying
CoMP	Coordinated Multi-Point
CP	Cyclic Prefix
CQI	Channel Quality Indicator
CRC	Cyclic Redundancy Check
CSI	Channel State Information
eNode-B	Evolved Node B
EPDCCH	Enhanced Physical Downlink Control Channel
E-UTRA	Evolved Universal Terrestrial Radio Access
FDD	Frequency Division Duplex
HARQ	Hybrid Automatic Repeat Request
LAA	Licensed-Assisted Access
LTE	Long Term Evolution
MAC	Medium Access Control
MBMS	Multimedia Broadcast and Multicast Service
MBSFN	Multicast/Broadcast over Single Frequency Network
MIMO	Multiple Input Multiple Output
MPDCCH	MTC Physical Downlink Control Channel
MTC	Machine Type Communications
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
OFDM	Orthogonal Frequency Division Multiplexing
PBCH	Physical Broadcast Channel
PCFICH	Physical Control Format Indicator Channel
PDSCH	Physical Downlink Shared Channel
PDCCH	Physical Downlink Control Channel
PHICH	Physical Hybrid ARQ Indicator Channel
PMCH	Physical Multicast Channel
PRACH	Physical Random Access Channel
ProSe	Proximity Services
PSBCH	Physical Sidelink Broadcast Channel
PSCCH	Physical Sidelink Control Channel
PSDCH	Physical Sidelink Discovery Channel
PSSCH	Physical Sidelink Shared Channel
PUCCH	Physical Uplink Control Channel
PUSCH	Physical Uplink Shared Channel
QAM	Quadrature Amplitude Modulation
QPP	Quadratic Permutation Polynomial
QPSK	Quadrature Phase Shift Keying
RLC	Radio Link Control
RN	Relay Node
R-PDCCH	Relay Physical Downlink Control Channel
RRC	Radio Resource Control
RSSI	Received Signal Strength Indicator
RSRP	Reference Signal Received Power
RSRQ	Reference Signal Received Quality
SAP	Service Access Point
SC-FDMA	Single-Carrier Frequency Division Multiple Access
SPDCCH	Short Physical Downlink Control Channel
SPUCCH	Short Physical Uplink Control Channel
TDD	Time Division Duplex

TX Diversity	Transmit Diversity
UE	User Equipment
V2X	Vehicle-to-Everything

4 General description of LTE Layer 1

4.1 Relation to other layers

4.1.1 General protocol architecture

The radio interface described in this specification covers the interface between the User Equipment (UE) and the network, and sidelink transmissions between UEs. The radio interface is composed of the Layer 1, 2 and 3. The TS 36.200 series describes the Layer 1 (Physical Layer) specifications. Layers 2 and 3 are described in the 36.300 series.

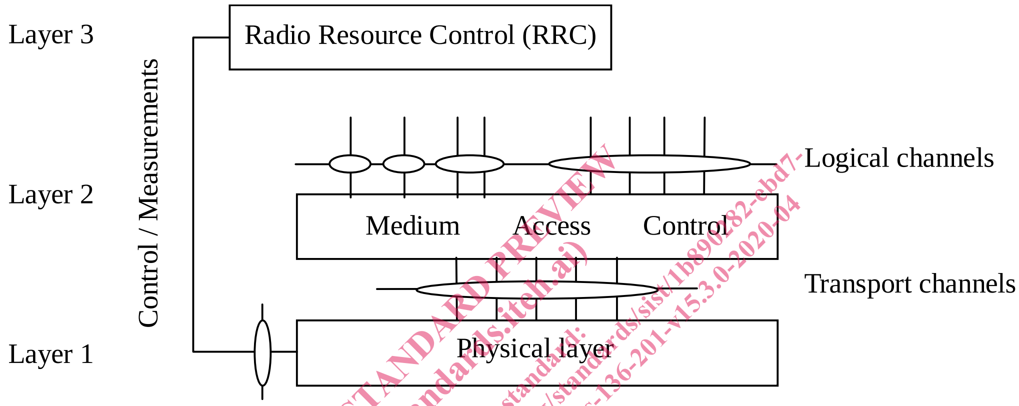

Figure 1: Radio interface protocol architecture around the physical layer

Figure 1 shows the E-UTRA radio interface protocol architecture around the physical layer (Layer 1). The physical layer interfaces the Medium Access Control (MAC) sub-layer of Layer 2 and the Radio Resource Control (RRC) Layer of Layer 3. The circles between different layer/sub-layers indicate Service Access Points (SAPs). The physical layer offers a transport channel to MAC. The transport channel is characterized by how the information is transferred over the radio interface. MAC offers different logical channels to the Radio Link Control (RLC) sub-layer of Layer 2. A logical channel is characterized by the type of information transferred.

4.1.2 Service provided to higher layers

The physical layer offers data transport services to higher layers. The access to these services is through the use of a transport channel via the MAC sub-layer. The physical layer is expected to perform the following functions in order to provide the data transport service:

- Error detection on the transport channel and indication to higher layers
- FEC encoding/decoding of the transport channel
- Hybrid ARQ soft-combining
- Rate matching of the coded transport channel to physical channels
- Mapping of the coded transport channel onto physical channels
- Power weighting of physical channels
- Modulation and demodulation of physical channels
- Frequency and time synchronisation

- Radio characteristics measurements and indication to higher layers
- Multiple Input Multiple Output (MIMO) antenna processing
- Transmit Diversity (TX diversity)
- Beamforming
- RF processing. (Note: RF processing aspects are specified in the TS 36.100 series)

4.2 General description of Layer 1

4.2.1 Multiple access

The multiple access scheme for the LTE physical layer is based on Orthogonal Frequency Division Multiplexing (OFDM) with a cyclic prefix (CP) in the downlink, and on Single-Carrier Frequency Division Multiple Access (SC-FDMA) with a cyclic prefix in the uplink and sidelink. To support transmission in paired and unpaired spectrum, two duplex modes are supported: Frequency Division Duplex (FDD), supporting full duplex and half duplex operation, and Time Division Duplex (TDD).

The Layer 1 is defined in a bandwidth agnostic way based on resource blocks, allowing the LTE Layer 1 to adapt to various spectrum allocations. A resource block spans either 12 sub-carriers with a sub-carrier bandwidth of 15kHz or 24 sub-carriers with a sub-carrier bandwidth of 7.5kHz each over a slot duration of 0.5ms, or 144 sub-carriers with a sub-carrier bandwidth of 1.25kHz over a slot duration of 1ms. Narrowband operation is also defined, whereby certain UEs may operate using a maximum transmission and reception bandwidth of 6 contiguous resource blocks within the total system bandwidth; for narrowband operation, sub-resource-block operation may also be used in the uplink, using 2, 3 or 6 sub-carriers.

For Narrowband Internet of Things (NB-IoT) operation, a UE operates in the downlink using 12 sub-carriers with a sub-carrier bandwidth of 15kHz, and in the uplink using a single sub-carrier with a sub-carrier bandwidth of either 3.75kHz or 15kHz or alternatively 3, 6 or 12 sub-carriers with a sub-carrier bandwidth of 15kHz.

The radio frame structure type 1 is only applicable to FDD (for both full duplex and half duplex operation) and has a duration of 10ms and consists of 20 slots with a slot duration of 0.5ms. Two adjacent slots form one sub-frame of length 1ms, except when the sub-carrier bandwidth is 1.25kHz, in which case one slot forms one sub-frame. When the sub-carrier bandwidth is 15kHz, a slot can be further subdivided into three subslots of length 2 or 3 OFDM or SC-FDMA symbols for reduced latency operation.

The radio frame structure type 2 is only applicable to TDD and consists of two half-frames with a duration of 5ms each and containing each either 10 slots of length 0.5ms, or 8 slots of length 0.5ms and three special fields (DwPTS, GP and UpPTS) which have configurable individual lengths and a total length of 1ms. A subframe consists of two adjacent slots, except for subframes which consist of DwPTS, GP and UpPTS, namely subframe 1 and, in some configurations, subframe 6. Both 5ms and 10ms downlink-to-uplink switch-point periodicity are supported. Further details on the LTE frame structure are specified in [2]. Adaptation of the uplink-downlink subframe configuration via Layer 1 signalling is supported.

The radio frame structure type 3 is only applicable to LAA secondary cell operation. It has a duration of 10ms and consists of 20 slots with a slot duration of 0.5ms. Two adjacent slots form one subframe of length 1ms. Any subframe may be available for downlink or uplink transmission. For downlink transmission, the eNB shall perform the channel access procedures as specified in [4] prior to transmitting. A downlink or uplink transmission may start at the subframe boundary or later, and may end at the subframe boundary or earlier. For uplink transmission, the UE shall perform the channel access procedures as specified in [4] prior to transmitting.

To support a Multimedia Broadcast and Multicast Service (MBMS), LTE offers the possibility to transmit Multicast/Broadcast over a Single Frequency Network (MBSFN), where a time-synchronized common waveform is transmitted from multiple cells for a given duration. MBSFN transmission enables highly efficient MBMS, allowing for over-the-air combining of multi-cell transmissions in the UE, where the cyclic prefix is utilized to cover the difference in the propagation delays, which makes the MBSFN transmission appear to the UE as a transmission from a single large cell. Transmission on a dedicated carrier for MBSFN is supported, as well as transmission of MBSFN on a carrier with both MBMS transmissions and point-to-point transmissions using time division multiplexing. In addition to the 15kHz sub-carrier bandwidth, the sub-carrier bandwidth of 7.5kHz with a longer CP and the sub-carrier bandwidth of 1.25kHz with very long CP (200µs) are both supported on dedicated MBSFN carriers, whereas MBSFN subframes that are time-