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Technical Specification

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Contents

Intellectual Property Rights 4
Foreword 4
1 Scope 5
2 References 5
3 Definitions, symbols and abbreviations 5
3.1 Definitions 5
3.2 Symbols 6
3.3 Abbreviations 6
6 Document structure of physical layer specification 7
6.1 Overview 7
6.2 S1.01: Physical layer – General description 7
6.3 S1.02: User Equipment physical layer capabilities 7
6.4 S1.11: Physical channels and mapping of transport channels onto physical channels (FDD) 7
6.5 S1.12: Multiplexing and channel coding (FDD) 7
6.6 S1.13: Spreading and modulation (FDD) 8
6.7 S1.14: Physical layer procedures (FDD) 8
6.8 S1.21: Physical channels and mapping of transport channels onto physical channels (TDD) 8
6.9 S1.22: Multiplexing and channel coding (TDD) 8
6.10 S1.23: Spreading and modulation (TDD) 9
6.11 S1.24: Physical layer procedures (TDD) 9
6.12 S1.31: Physical layer - Measurements 9
7 General description of Layer 1 9
7.1 Relation to other layers 9
7.1.1 General Protocol Architecture 10
7.1.2 Service provided to upper layer 10
7.2 General description of Layer 1 11
7.2.1 Multiple Access 11
7.2.2 Coding and interleaving 12
7.2.3 Modulation and spreading 12
7.2.4 Transmission and reception 12
7.2.5 Physical layer procedures 13
History 14

Intellectual Property Rights

<IPR notice shall be provided once correct notice is available within 3GPP>

Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project, Technical Specification Group Radio Access Network, Working Group 1 (3GPP TSG RAN WG1).

The contents of this TS may be subject to continuing work within the 3GPP and may change following formal TSG approval. Should the TSG modify the contents of this TS, it will be re-released with an identifying change of release date and an increase in version number as follows:

Version m.t.e

where:

- m indicates [major version number]
- x the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- y the third digit is incremented when editorial only changes have been incorporated into the specification.

1 Scope

This specification describes the documents being produced by the 3GPP TSG RAN WG1and first complete versions expected to be available by end of 1999. This specification gives also general description of the physical layer of the UTRA air interface,

The S1 series specifies Um point for the 3G mobile system. This series 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.

<Editor's Note: Relevant references should be discussed>

< 3GPP RAN S1.01 (V1.1.0): "Physical layer – General description" >

[1] 3GPP RAN S1.02 (V1.0.0): "User Equipment physical layer capabilities"

[2] 3GPP RAN S1.11 (V1.1.0): "Physical channels and mapping of transport channels onto physical channels (FDD)"

[3] 3GPP RAN S1.12 (V1.1.0): "Multiplexing and channel coding (FDD)"

[4] 3GPP RAN S1.13 (V1.1.0): "Spreading and modulation (FDD)"

[5] 3GPP RAN S1.14 (V1.1.0): "Physical layer procedures (FDD)"

[6] 3GPP RAN S1.21 (V1.1.0): "Physical channels and mapping of transport channels onto physical channels (TDD)"

[7] 3GPP RAN S1.22 (V1.1.0): "Multiplexing and channel coding (TDD)"

[8] 3GPP RAN S1.23 (V1.1.0): "Spreading and modulation (TDD)"

[9] 3GPP RAN S1.24 (V1.1.0): "Physical layer procedures (TDD)"

[10] 3GPP RAN S1.31 (V0.1.0): "Physical layer - Measurements"

[11] 3GPP RAN S2.01 (V1.0.0): "Radio Interface Protocol Architecture"

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the [following] terms and definitions [given in ... and the following] apply.

<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> <Explanation>

3.3 Abbreviations

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

BER	Bit Error Rate
BS	Base Station
C-	Control-
CCTrCH	Coded Composite Transport Channel
DC	Dedicated Control (SAP)
DCA	Dynamic channel allocation
DCH	Dedicated Channel
DS-CDMA	Direct-Sequence Code Division Multiple Access
FDD	Frequency Division Duplex
FEC	Forward Error Correction
FER	Frame Error Rate
GC	General Control (SAP)
GSM	Global System for Mobile Communication
L1	Layer 1 (physical layer)
L2	Layer 2 (data link layer)
L3	Layer 3 (network layer)
LAC	Link Access Control
MAC	Medium Access Control
Mcps	Mega Chip Per Second
Nt	Notification (SAP)
ODMA	Opportunity Driven Multiple Access
PCS	Personal Communications System
PHS	Persona Handyphone System
PHY	Physical layer
QPSK	Quaternary Phase Shift Keying
RACH	Random Access Channel
RF	Radio Frequency
RLC	Radio Link Control
RRC	Radio Resource Control
SAP	Service Access Point
SCH	Synchronisation Channel
SIR	Signal-to-Interference Ratio
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TFCI	Transport-Format Combination Indicator
U-	User-
UE	User Equipment
Um	U interface in a mobile network
UMTS	Universal Mobile Telecommunications System
UTRA	UMTS Terrestrial Radio Access
WCDMA	Wide-band Code Division Multiple Access

6 Document structure of physical layer specification

6.1 Overview

The physical layer specification consists of two general documents (S1.01, S1.02), four FDD mode documents (S1.11 through S1.14), four TDD mode documents (S1.21 through S1.24), and one special issue document (S1.31).

6.2 S1.01: Physical layer – General description

The scope is to describe:

- the contents of the Layer 1documents (S1 series);
- where to find information;
- a general description of Layer 1.

6.3 S1.02: User Equipment physical layer capabilities

The scope is to describe:

- the physical layer capabilities of the UE.

6.4 S1.11: Physical channels and mapping of transport channels onto physical channels (FDD)

The scope is to establish the characteristics of the Layer-1 transport channels and physical channels in the FDD mode, and to specify:

- the different transport channels that exist;
- which physical channels exist;
- what is the structure of each physical channel, slot format etc.;
- relative timing between different physical channels in the same link, and relative timing between uplink and downlink;
- mapping of data onto the physical channels.

6.5 S1.12: Multiplexing and channel coding (FDD)

The scope is to describe multiplexing, channel coding and interleaving in the FDD mode, and to specify:

- coding and multiplexing of transport channels into CCTrCHs;
- channel coding alternatives;
- coding for Layer 1 control information, such as TFCI;
- the different interleavers;
- how is rate matching done;
- multiplexing.

6.6 S1.13: Spreading and modulation (FDD)

The scope is to establish the characteristics of the spreading and modulation in the FDD mode, and to specify:

- the spreading (channelization plus scrambling);
- generation of channelization and scrambling codes;
- generation of RACH preamble codes;
- generation of SCH synchronisation codes;
- pulse-shaping filtering;
- modulation and pulse shaping;
- RF channel arrangements.

6.7 S1.14: Physical layer procedures (FDD)

The scope is to establish the characteristics of the physical layer procedures in the FDD mode, and to specify:

- power control procedures;
- random access procedure;
- paging procedure.

6.8 S1.21: Physical channels and mapping of transport channels onto physical channels (TDD)

The scope is to establish the characteristics of the Layer-1 transport channels and physical channels in the TDD mode, and to define:

- transport channels;
- physical channels, structure and contents;
- timing relationship between physical channels;
- mapping of data to the physical channels.

6.9 S1.22: Multiplexing and channel coding (TDD)

The scope is to describe multiplexing, channel coding and interleaving in the TDD mode, and to specify:

- channel coding;
- interleaving;
- rate matching;
- multiplexing.

6.10 S1.23: Spreading and modulation (TDD)

The scope is to establish the characteristics of the spreading and modulation in the TDD mode, and to specify:

- data modulation;
- spreading;
- generation of codes;
- RF channel arrangements.

6.11 S1.24: Physical layer procedures (TDD)

The scope is to establish the characteristics of the physical layer procedures in the TDD mode, and to specify:

- BS synchronisation;
- Dynamic channel allocation (DCA);
- timing advance;
- power control procedures;
- idle mode tasks.

6.12 S1.31: Physical layer - Measurements

The scope is to specify:

- the measurements that Layer 1 is to perform;
- reporting of measurements to higher layers and network;
- handover measurements, idle-mode measurements etc.

7 General description of Layer 1

7.1 Relation to other layers

7.1.1 General Protocol Architecture

Air-interface which is prescribed by this specification means the Um point between UE and network. Air-interface is composed of Layers 1, 2 and 3. Layer 1 is based on WCDMA technology and the S1 series describes the Layer-1 specification. Layers 2 and 3 of air-interface are described in the S2 and S3 series, respectively.

<Editor's Note: The following figure comes from S2.01 V0.0.1. The figure needs update to be aligned with S2.02 from TSG RAN WG2 >

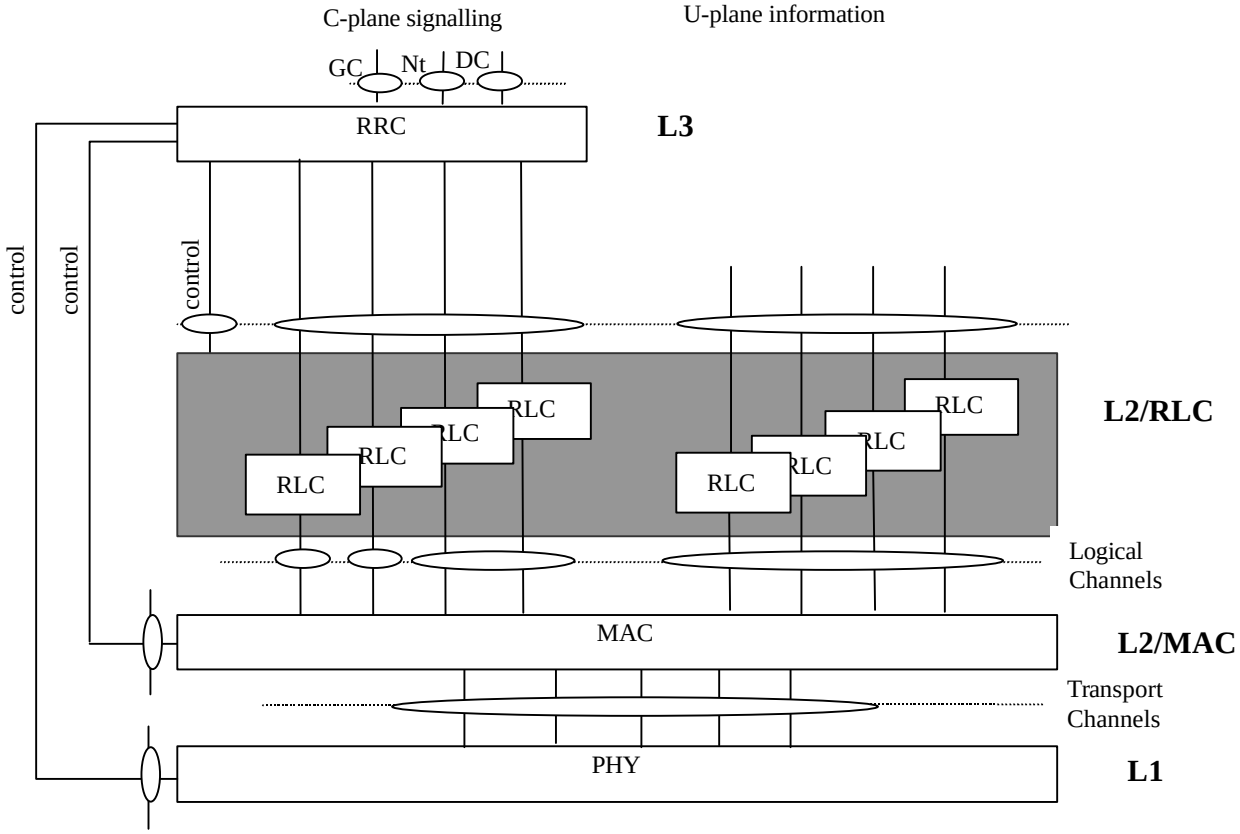

Fig. 7-1 Radio interface protocol architecture (Service Access Points marked by circles)

Figure 7-1 shows the UTRA radio interface protocol architecture. The circles between different sub-layers indicate Service Access Points (SAPs). The physical layer (Layer 1) offers different Transport channels to L2/MAC. A transport channel is characterized by how the information is transferred over the radio interface. L2/MAC offers different Logical channels to L2/RLC. A logical channel is characterized by the type of information transferred. Physical channels are defined in the physical layer. In the FDD mode a physical channel is characterized by the code, frequency and in the reverse link the relative phase (I/Q). In the TDD mode the physical channels is also characterized by the timeslot. RRC controls RLC, MAC and Physical layer via primitives.

7.1.2 Service provided to upper layer

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

- FEC encoding/decoding of transport channels
- Macrodiversity distribution/combining and soft handover execution
- Multiplexing/demultiplexing of transport channels and of coded composite transport channels
- Mapping of coded composite transport channels on physical channels

- Modulation and spreading/demodulation and despreading of physical channels
- Frequency and time (chip, bit, slot, frame) synchronisation
- Closed-loop power control
- Power weighting and combining of physical channels
- RF processing
- Error detection
- Rate matching (data multiplexed on DCH)
- Radio characteristics measurements including FER, SIR, Interference Power, etc.

When network elements (UEs and network) provide compatible service bearers (for example support a speech bearer) they should be assured of successful interworking. Moreover, different implementation options of the same (optional) feature would lead to incompatibility between UE and network. Therefore, this shall be avoided.

7.2 General description of Layer 1

7.2.1 Multiple Access

The access scheme is Direct-Sequence Code Division Multiple Access (DS-CDMA) with information spread over approximately 5 MHz bandwidth, thus also often denoted as Wideband CDMA (WCDMA) due that nature.

UTRA has two modes, FDD (Frequency Division Duplex) & TDD (Time Division Duplex), for operating with paired and unpaired bands respectively. The possibility to operate in either FDD or TDD mode allows for efficient utilisation of the available spectrum according to the frequency allocation in different regions. FDD and TDD modes are defined as follows;

FDD: A duplex method whereby forward link and reverse link transmissions use two separated radio frequencies. In the FDD, each forward and reverse link uses the different frequency band. A pair of frequency bands which have specified separation shall be assigned for the system.

TDD: A duplex method whereby forward link and reverse link transmissions are carried over same radio frequency by using synchronised time intervals. In the TDD, time slots in a physical channel are divided into transmission and reception part. Information on forward link and reverse link are transmitted reciprocally.

In UTRA TDD there is TDMA component in the multiple access in addition to DS-CDMA. Thus the multiple access has been also often denoted as TDMA/CDMA due added TDMA nature.

The carrier separation is 4.6-5 MHz depending on the deployment scenario with 200 kHz carrier raster. A 10 ms radio frame is divided into 16 0.625 ms slots. A physical channel is therefore defined as a code (or number of codes) and additionally in TDD mode the sequence of 0.625 ms time slots completes the definition of a physical channel. The both UTRA modes use 72-frame multiframe structure. The resulting longer frame duration is under discussion (hyperframe etc.) <Editor's note: Some discussion on the terminology between multiframe/superframe etc. needed >

The information rate of the channel varies with the symbol rate being derived from the 4.096 M chips/s chip rate and the spreading factor. Spreading factors are from 256 to 4 with FDD uplink, from512 to 4 with FDD downlink, and from 16 to 1 for TDD uplink and downlink. Thus the respective modulation symbol rates vary from 1.024 M symbols/s to 16 k symbols/s (8 k symbols/s) for FDD uplink (downlink), and for TDD the momentary modulation symbol rates shall vary from 4.096 M symbols/s to 256 k symbols/s.

Furthermore, relaying between nodes can be used by means of Opportunity Driven Multiple Access (ODMA) in TDD mode.

7.2.2 Coding and interleaving

For the channel coding in UTRA two options are supported:

- Convolutional coding, either 1/2 rate or 1/3 rate for packet data and services requiring quality level 10^{-3} or lower over the physical layer with forward error correction (FEC).
- Turbo coding, for the services requiring higher than 10^{-3} quality level. <Editor's note: Turbo coding method under refinement >

<Editor's Note: Options seem to be as above or using Turbo codes for all services at 32 k bits/s and above as in ARIB. To be updated after Ad Hoc #5 outcome >

7.2.3 Modulation and spreading

The UTRA modulation scheme is QPSK with root raised cosine pulse shaping with roll-of factor 0.22.

With CDMA nature the spreading (& scrambling) process is closely associated with modulation. In UTRA different families of spreading codes are used to spread the signal.

- For separating channels from same source, channelisation codes derived with the code tree structure as given in S1.13 and S1.23 are used.
- For separating different base station the following solutions are supported:
  - FDD mode: Gold codes with 10 ms period [of 40960 chips] used, with the actual code itself length 2^{41}-1 chips, as defined in S1.13; <The value 40960 is based on a chip rate of 4.096 Mcps. The actual code length will be shorten. >
  - TDD mode: Scrambling codes with the length 16 used as defined in S1.23.
- For separating different mobiles the following code families are defined:
  - FDD mode: Gold codes with 10 ms period, or alternatively S(2) codes 256 chip period;
  - TDD mode: codes with period of 16 chips and midamble sequences of different length depending on the environment.

7.2.4 Transmission and reception

The UTRA frequency bands assumed for operation are:

1) Unpaired spectrum at 1900-1920 MHz and at 2010-2025 MHz
for TDD mode operation, and used for both base and mobile transmission;
(1895-1918.1 MHz band is occupied by PHS in Japan. 1850-1990 MHz band is occupied by PCS 1900 in U.S.)

2) Paired spectrum:
at 1920-1980 MHz for mobile transmit, base station to receive;
at 2110- 2170 MHz for base station transmit, mobile to receive;

3) Other bands, such as GSM 900 band and GSM 1800 band and other bands that can be used being currently occupied by other cellular systems;

4) Possible new spectrum allocations that may become available.

Several power classes are being defined currently.

7.2.5 Physical layer procedures

There are several physical layer procedures involved with UTRA operation. Such a procedures covered by physical layer description are:

1) The power control, with both fast closed loop and slow quality loop for FDD mode and for TDD mode open loop power control together with slow closed loop; <Editor's Note: TDD fast power control is FFS >

2) Handover measurements for handover within UTRA. Specific features being determined in addition to the relative strength of the base station, for the FDD mode the timing relation between for the base stations for support of asynchronous soft handover;

3) The measurement procedures for preparation for handover to GSM900/GSM1800;

4) The measurements procedures for UE before random access process;

5) Dynamic Channel Allocation (DCA) with TDD mode operation;

6) ODMA specific procedures such as probing.

History

Document history		
V0.0.1	1999-02-12	New document merged from ETSI & ARIB, produced jointly by the editors. To be updated after the conclusions from Ad Hocs. Forwarded to TSG/RAN/WG1 for agreement.
V1.0.0	1999-03-05	Agreed by 3GPP TSG.
V1.0.1	1999-03-17	Update References and Section 6 “Document structure”. Remove Section 7.3 “Elements for layer-to-layer communication”.
V1.1.0	1999-03-24	Approved by 3GPP/TSG/RAN/WG1. Update the document titles of S1.11, S1.21, and S1.31.
V1.1.1	1999-04-20	Add sentences proposed in R1-99255 into Section 7.1.2. Reflect Turbo coding working assumptions. Approved by 3GPP RAN WG1.
V2.0.0	1999-04-23	Approved by 3GPP TSG RAN.

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This document is written in Microsoft Word 97.