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# Physical layer – general description

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## 2 Foreword

This specification has been produced by the 3GPP TSG RAN WG1.  
The contents of this specification are subject to change as the work continues within 3GPP TSG RAN WG1 and 3GPP TSG RAN and may change following approval by either of these two groups

## 3 Scope

This specification describes the documents being produced by the 3GPP TSG RAN WG1 and 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.

## 4 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document. <Editors: Note relevant references to be discussed>

- [1] ITU-T Recommendation G.729, “Coding of speech at 8kbit/s using conjugate-structure algebraic-code-excited linear-prediction”
- [2] ITU-T Recommendation I.361, “B-ISDN ATM layer specification”
- [3] ITU-T Recommendation I.363, “B-ISDN ATM adaptation layer (AAL) specification”
- [4] ITU-T Recommendation I.363.2, “B-ISDN ATM Adaptation layer specification: Type 2 AAL”
- [5] ITU-T Recommendation I.432-2, “B-ISDN user-network interface - Physical layer specification: 155 520 kbit/s and 622 080 kbit/s operation”
- [6] ITU-T Recommendation Q.1224, “Distributed functional plane for Intelligent Network Capability Set 2”
- [7] ITU-T Recommendation Q.FIF, “Information flows for IMT-2000”
- [8] ITU-T Recommendation Q.1701, “Framework for IMT-2000 Networks”
- [9] ITU-T Recommendation Q.1711, “Network Functional Model for IMT-2000”
- [10] ITU-T Recommendation Q.FSR-L2, “FPLMTS Signaling Requirements for Radio Interface – Layer 2 –“
  
- [11] ITU-T Recommendation Q.FSR-L3, “FPLMTS Signaling Requirements for Radio Interface – Layer 3 –“

## 5 Definitions, symbols and abbreviations

## 6 Document structure of physical layer specification

This specification consists of two general documents (S1.01, S1.02), five FDD mode documents (S1.11 through S1.15), and five TDD mode documents (S1.21 through S1.25).

### 6.1 General documents

#### **S1.01 Physical layer – general description**

- Describes the contents of the L1 documents (S1 series)
- Where to find information
- General description of L1

#### **S1.02 UE capabilities**

- Describes the capabilities of the UE
- Not clear if this belongs in TSG RAN WG1, but information is vital to TSG RAN WG1

### 6.2 FDD mode documents

#### **S1.11 Transport channels and physical channels (FDD)**

- Specifies 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

#### **S1.12 Multiplexing and channel coding (FDD)**

- Coding and multiplexing of transport channels into CCTrCHs
- Specifies channel coding alternatives
- Specifies coding for Layer 1 control information, such as TFCI
- Specifies the different interleavers
- How is rate matching done
- Multiplexing

#### **S1.13 Spreading and modulation (FDD)**

- Specifies the spreading (channelization plus scrambling)
- Generation of channelization and scrambling codes
- Generation of RACH preamble codes
- Generation of SCH synchronization codes
- Pulse-shaping filtering
- Modulation and pulse shaping
- RF channel arrangements

#### **S1.14 Physical layer procedures (FDD)**

- Power control procedures
- Random access procedure
- Paging procedure

#### **S1.15 Measurements (FDD)**

- Specifies the measurements that L1 is to perform
- Reporting of measurements to higher layers and network

- Handover measurements, idle-mode measurements etc.

## 6.3 TDD mode documents

### **S1.21 Transport channels and physical channels (TDD)**

- Defines transport channels
- Defines physical channels, structure and contents
- Timing relationship between physical channels
- Mapping of data to the physical channels

### **S1.22 Multiplexing and channel coding (TDD)**

- Specifies channel coding
- Interleaving
- Rate matching
- Multiplexing

### **S1.23 Spreading and modulation (TDD)**

- Specifies data modulation
- Spreading
- Generation of codes
- RF channel arrangements

### **S1.24 Physical layer procedures (TDD)**

- BS synchronisation
- DCA
- Timing advance
- Power control procedures
- Idle mode tasks

### **S1.25 Measurements (TDD)**

- Specifies the measurements that L1 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

< Editors Note: Figure 1 should be revised. >

< The following section comes from ARIB Section 2 >

Air-interface which is prescribed by this specification means the Um point between mobile station and network. Air-interface is composed of Layers 1, 2 and 3. Layer 1 is based on WCDMA technology and main part of this series describes the Layer-1 specification. Layers 2 and 3 of air-interface fundamentally accord with Q.FSR-L2 and Q.FSR-L3, which are standardized by ITU-T, respectively.

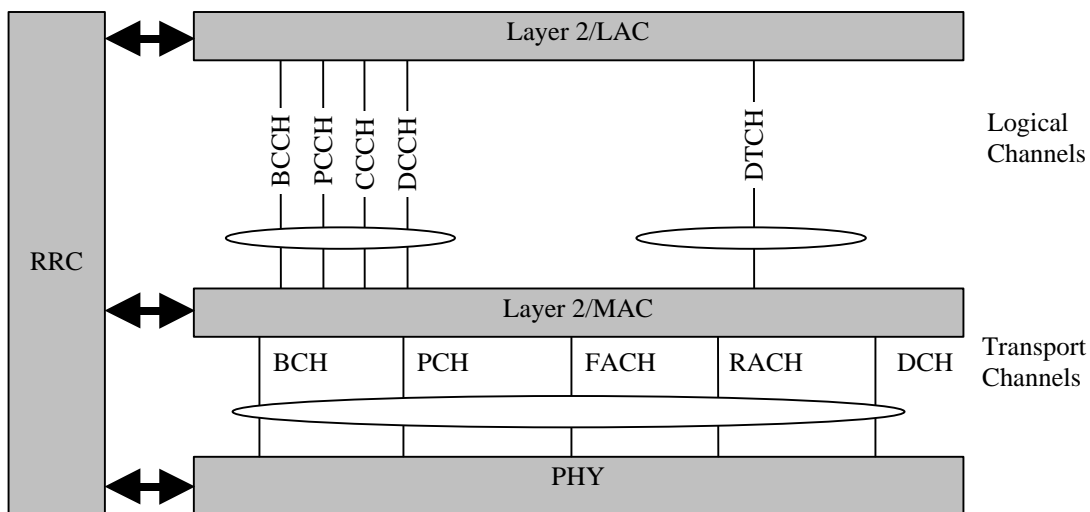


Fig. 2-1 General protocol architecture

Figure 2.1 shows the W-CDMA/UTRA radio interface protocol architecture. The circles between different sub-layers indicate Service Access Points (SAPs). The physical layer (L1) 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/LAC. 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 LAC, MAC and Physical layer via primitives.

*Remark : In Fig. 2-1, “Multicast Channel” (MCH, defined in section 3.2.1.1.2.2,) is not indicated. After detailed clarification about the feature of MCH and required functions to support it in each (sub) layer, the above Fig. 2-1 will be revised to describe an appropriate structure.*

<Editors Note Downlink Shared Channel (DSCH) is defined in ETSI only and when agreed the figures needs respective update.MCH is defined only in ARIB. To be aligned with S2.02 from TSG RAN WG2>

## 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) synchronization
- 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.

## 7.2 General description of L1

<The following section comes from ETSI xx.02 Section 5>

### 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 & TDD, for operating with paired and unpaired bands respectively. 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 information rate of the channel varies with the symbol rate being derived from the 4.096 Mc/s chip rate and the spreading factor. Spreading factors from 256 to 4 with FDD and from 16 to 1 for TDD. Thus the respective modulation symbol rates vary from 1.024 Msymbols/s to 16 ksymbols for FDD and for TDD the momentary modulation symbol rates shall vary from 4.096 Msymbols/s to 256 ksymbols/s.

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

<ODMA is defined only in ETSI>

<Editors Note: In ARIB there are additional chip rates and spreading factors range from 512 to 1 in FDD and are different in TDD as well.>

### UTRA frames

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 following section comes from ARIB Section 3.1>

## 7.2.1 Duplex operation

### 7.2.1.1 Definition of FDD and TDD Modes

The ~~W-CDMA~~UTRA air interface can operate in either FDD (Frequency Division Duplex) mode or TDD (Time Division Duplex) mode. The possibility to operate in either FDD or TDD mode allows for efficient utilization 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 frequency. 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 synchronized 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.

<Section 3.1.2 “Relationship of FDD and TDD mode” is not included because it is not needed as specification>

<The following sections come from ETSI xx.02 Sections 6 through 9>

## 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 less than 10E-6 quality level over the physical layer with forward error correction (FEC).
- Turbo coding (Editor note: coding method under refinement) for the services requiring quality level 10E-6 or higher.

<Editors Note: Options seem to be as above or using Turbo codes for all services at 32 kbits/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 ~~XX.05S~~1.13 and ~~XX.44S~~1.23 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 ~~XX.05S~~1.13.
- TDD Mode: Scrambling codes with the length 16 used as defined in ~~XX.44S~~1.23.
- For separating different mobiles the following code families are defined
- FDD codes with 10 ms period (Gold code), or alternatively codes 256 chip period (VL-Kasami)
- TDD codes with period of 16 chips and midamble sequences of different length depending on the environment.

<Editors Note: This section needs update following selection for scrambling codes and their periods. In ARIB uplink period is longer and short code family is different >

## 7.2.4 Transmission and reception

The UTRA frequency bands assumed for operation are.

- i) Unpaired spectrum at 1900-1920 MHz and at 2010-2025 MHz for TDD mode operation  
Used for both base and mobile transmission
- ii) Paired spectrum:  
at 1920-1980 MHz for mobile transmit, base station to receive;  
at 2110- 2170 MHz for base station transmit, mobile to receive.
- iii) 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
- iv) Possible new spectrum allocations that may become available.

Several power classes being defined currently.

<Editors Note: PCS 1900 spectrum (1850-1990 MHz) and PHS (1895-1918.1 MHz) to be added?>

## 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. <Editors 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 MS before random access process.
- 5) Dynamic Channel Allocation (DCA) with TDD mode operation
- 6) ODMA specific procedures such as probing. <Editors Note: This is only in ETSI documents.>

<The following section comes from ARIB Section 2.2>

## ~~7.3~~ Elements for layer-to-layer communication

<Editors Note: For WG1 to decide whether this is needed or not as covered in S2.02 as wells>

### 7.3.1 Primitives between PHY and MAC

Primitives represent, in an abstract way, the logical exchange of information and control between the PHY and MAC sub-layers. They do not specify or constrain implementations or imply any particular exposed interface.

#### 7.3.1.1 Primitives

The primitives between PHY and MAC are shown in Table 2.2-1. It is used for peer-to-peer communication between MAC entities.

Table 2.2-1 Primitives between MAC sub-layer and Physical layer

Generic Name	Type				Parameters
	Request	Indication	Response	Confirm	
PHY-DATA	X	X			CHI, MU, CRC
PHY-STATUS	X	X		X	[ FFS ]
PHY-ERROR		X			[ FFS ]

##### 7.3.1.1.1 PHY-DATA Request/Indication

- PHY-DATA.Request primitive defines the transfer of data from the MAC sub-layer to the physical layer.
- PHY-DATA.Indication primitive defines the transfer of data from the physical layer.

##### 7.3.1.1.2 PHY-STATUS Request/Indication/Confirm

- PHY-STATUS.Request is used by the MAC to request status of the physical layer.
- PHY-STATUS.Indication is used by the physical layer to indicate its status.
- PHY-STATUS.Confirm is used by the physical layer to confirm its status associated with a previous PHY-STATUS.Request.
- These primitives should include a status primitive in the MS indicating. This information should flow from physical layer to layer 3, enabling RRC to conduct proper action. For example, if MS transmitter is transmitting at full power, this status information is reported by those primitives to RRC in order to restrict the transmission rate so that the quality can be maintained or release the radio bearer if this is not possible.

##### 7.3.1.1.3 PHY-ERROR Indication

- PHY-ERROR.Indication is used by physical layer to indicate that an error has occurred.



### 7.3.1.2 Parameters

- CHI: Channel Indication which identifies the transport channel.
- Message Unit (MU): It contains the information to be transmitted or received by the physical layer.
- CRC: CRC check result of MU

## 7.3.2 Primitives between PHY and RRC

### 7.3.2.1 Primitives

The primitives between PHY and RRC are shown in Table 2.2-2.

Table 2.2-2 Primitives between PHY and RRC

Generic Name	Type				Parameters
	Request	Indication	Response	Confirm	
RPHY-DCH-CONNECT	X			X	[ FFS ]
RPHY-DCH-DISCONNECT	X	X		X	[ FFS ]
RPHY-RL-CONNECT	X			X	[ FFS ]
RPHY-RL-DISCONNECT	X	X		X	[ FFS ]
RPHY-STATUS	X	X		X	[ FFS ]
RPHY-ERROR		X			[ FFS ]

#### 7.3.2.1.1 PHY-DCH-CONNECT Request/Confirm

- PHY-DCH-CONNECT.Request is used by the RRC either to create a new DCH or to modify an existing one at L1. It also activates connection of the DCH to certain RL(s) at specified time.
- PHY-DCH-CONNECT.Confirm is used by the physical layer to confirm creation or modification of the DCH and activation of the DCH connection.

#### 7.3.2.1.2 PHY-DCH-DISCONNECT Request/Indication/Confirm

- PHY-DCH-DISCONNECT.Request is used by the RRC to disconnect and clear a DCH.
- PHY-DCH-DISCONNECT.Indication is used by the physical layer to indicate disconnection of the DCH.
- PHY-DCH-DISCONNECT.Confirm is used by the physical layer to confirm the disconnection of the DCH.

#### 7.3.2.1.3 PHY-RL(\*)-CONNECT Request/Confirm

- PHY-RL-CONNECT.Request is used by the RRC to set radio link parameters at L1.
- PHY-RL-CONNECT.Confirm is used by the physical layer to confirm the changes.

*[(\*) Assumed definition for "RL" (radio link) : A Radio Link is a bi-directional connection between a terminal and a base station sector. Each RL is comprised of all the channels that are associated with the same physical layer control channel (DPCCH).]*

#### 7.3.2.1.4 PHY-RL-DISCONNECT Request/Indication/Confirm

- PHY-RL-DISCONNECT.Request is used by the RRC to request disconnection of a radio link.
- PHY-RL-DISCONNECT.Indication is used by the physical layer to indicate disconnection of the radio link.
- PHY-RL-DISCONNECT.Confirm is used by the physical layer to confirm the disconnection of the RL.

#### 7.3.2.1.5 PHY-STATUS Request/Indication/Confirm

- PHY-STATUS.Request is used by the RRC to request status of the physical layer.
- PHY-STATUS.Indication is used by the physical layer to indicate its status.
- PHY-STATUS.Confirm is used by the physical layer to confirm its status associated with a previous PHY-STATUS.Request.
- These primitives should include a status primitive in the MS indicating. This information should flow from physical layer to layer 3, enabling RRC to conduct proper action. For example, if MS transmitter is transmitting at full power, this status information is reported by those primitives to RRC in order to restrict the transmission rate so that the quality can be maintained or release the radio bearer if this is not possible.

### 7.3.2.1.6 PHY-ERROR Indication

- PHY-ERROR.Indication is used by physical layer to indicate that an error has occurred.

### 7.3.2.2 Parameter

FFS

## History

<b>Document history</b>		
0.0.1	1999-02-12	New document merged from ETSI & ARIB, produced jointly by the editors. To be updated after the conclusions from Ad Hoc.
<p>1<sup>st</sup> temporary editor for S1.01, Physical Layer – General Description, is: Antti Toskala, Nokia Telecommunications, email: antti.toskala@ntc.nokia.com</p> <p>2<sup>nd</sup> temporary editor for S1.01, Physical Layer – General Description, is: Takashi Mochizuki, NEC Corp., email: mochizuki@pccrd.fc.nec.co.jp</p> <p>This document is written in Microsoft Word 97.</p>		