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Technical Specification

**LTE;
Evolved Universal Terrestrial Radio Access (E-UTRA);
Physical channels and modulation
(3GPP TS 36.211 version 9.1.0 Release 9)**



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1 Scope

The present document describes the physical channels for evolved 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.
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- [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 36.212: "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 36.104: "Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception".
- [7] 3GPP TS 36.101: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception".
- [8] 3GPP TS 36.321: "Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification".

3 Definitions, symbols and abbreviations

3.1 Symbols

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

(k, l)	Resource element with frequency-domain index k and time-domain index l
$a_{k,l}^{(p)}$	Value of resource element (k, l) [for antenna port p]
D	Matrix for supporting cyclic delay diversity
D_{RA}	Density of random access opportunities per radio frame
f_0	Carrier frequency

f_{RA}	PRACH resource frequency index within the considered time-domain location
M_{sc}^{PUSCH}	Scheduled bandwidth for uplink transmission, expressed as a number of subcarriers
M_{RB}^{PUSCH}	Scheduled bandwidth for uplink transmission, expressed as a number of resource blocks
$M_{bit}^{(q)}$	Number of coded bits to transmit on a physical channel [for codeword q]
$M_{symb}^{(q)}$	Number of modulation symbols to transmit on a physical channel [for codeword q]
M_{symb}^{layer}	Number of modulation symbols to transmit per layer for a physical channel
M_{symb}^{ap}	Number of modulation symbols to transmit per antenna port for a physical channel
N	A constant equal to 2048 for $\Delta f = 15$ kHz and 4096 for $\Delta f = 7.5$ kHz
$N_{CP,l}$	Downlink cyclic prefix length for OFDM symbol l in a slot
N_{CS}	Cyclic shift value used for random access preamble generation
$N_{cs}^{(1)}$	Number of cyclic shifts used for PUCCH formats 1/1a/1b in a resource block with a mix of formats 1/1a/1b and 2/2a/2b
$N_{RB}^{(2)}$	Bandwidth available for use by PUCCH formats 2/2a/2b, expressed in multiples of N_{sc}^{RB}
N_{RB}^{HO}	The offset used for PUSCH frequency hopping, expressed in number of resource blocks (set by higher layers)
N_{ID}^{cell}	Physical layer cell identity
N_{ID}^{MBSFN}	MBSFN area identity
N_{RB}^{DL}	Downlink bandwidth configuration, expressed in multiples of N_{sc}^{RB}
$N_{RB}^{min, DL}$	Smallest downlink bandwidth configuration, expressed in multiples of N_{sc}^{RB}
$N_{RB}^{max, DL}$	Largest downlink bandwidth configuration, expressed in multiples of N_{sc}^{RB}
N_{RB}^{UL}	Uplink bandwidth configuration, expressed in multiples of N_{sc}^{RB}
$N_{RB}^{min, UL}$	Smallest uplink bandwidth configuration, expressed in multiples of N_{sc}^{RB}
$N_{RB}^{max, UL}$	Largest uplink bandwidth configuration, expressed in multiples of N_{sc}^{RB}
N_{symb}^{DL}	Number of OFDM symbols in a downlink slot
N_{symb}^{UL}	Number of SC-FDMA symbols in an uplink slot
N_{sc}^{RB}	Resource block size in the frequency domain, expressed as a number of subcarriers
N_{SP}	Number of downlink to uplink switch points within the radio frame
N_{RS}^{PUCCH}	Number of reference symbols per slot for PUCCH
N_{TA}	Timing offset between uplink and downlink radio frames at the UE, expressed in units of T_s
$N_{TA\ offset}$	Fixed timing advance offset, expressed in units of T_s
$n_{PUCCH}^{(1)}$	Resource index for PUCCH formats 1/1a/1b
$n_{PUCCH}^{(2)}$	Resource index for PUCCH formats 2/2a/2b
n_{PDCCH}	Number of PDCCHs present in a subframe
n_{PRB}	Physical resource block number
n_{PRB}^{RA}	First physical resource block occupied by PRACH resource considered
$n_{PRB\ offset}^{RA}$	First physical resource block available for PRACH
n_{VRB}	Virtual resource block number
n_{RNTI}	Radio network temporary identifier
n_f	System frame number
n_s	Slot number within a radio frame
P	Number of cell-specific antenna ports
p	Antenna port number
q	Codeword number
r_{RA}	Index for PRACH versions with same preamble format and PRACH density

Q_m	Modulation order: 2 for QPSK, 4 for 16QAM and 6 for 64QAM transmissions
$s_l^{(p)}(t)$	Time-continuous baseband signal for antenna port p and OFDM symbol l in a slot
$t_{RA}^{(0)}$	Radio frame indicator index of PRACH opportunity
$t_{RA}^{(1)}$	Half frame index of PRACH opportunity within the radio frame
$t_{RA}^{(2)}$	Uplink subframe number for start of PRACH opportunity within the half frame
T_f	Radio frame duration
T_s	Basic time unit
T_{slot}	Slot duration
W	Precoding matrix for downlink spatial multiplexing
β_{PRACH}	Amplitude scaling for PRACH
β_{PUCCH}	Amplitude scaling for PUCCH
β_{PUSCH}	Amplitude scaling for PUSCH
β_{SRS}	Amplitude scaling for sounding reference symbols
Δf	Subcarrier spacing
Δf_{RA}	Subcarrier spacing for the random access preamble
v	Number of transmission layers

3.2 Abbreviations

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

CCE	Control channel element
CDD	Cyclic delay diversity
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
PRACH	Physical random access channel
PUCCH	Physical uplink control channel
PUSCH	Physical uplink shared channel

4 Frame structure

Throughout this specification, unless otherwise noted, the size of various fields in the time domain is expressed as a number of time units $T_s = 1/(15000 \times 2048)$ seconds.

Downlink and uplink transmissions are organized into radio frames with $T_f = 307200 \times T_s = 10$ ms duration. Two radio frame structures are supported:

- Type 1, applicable to FDD,
- Type 2, applicable to TDD.

4.1 Frame structure type 1

Frame structure type 1 is applicable to both full duplex and half duplex FDD. Each radio frame is $T_f = 307200 \cdot T_s = 10$ ms long and consists of 20 slots of length $T_{slot} = 15360 \cdot T_s = 0.5$ ms, numbered from 0 to 19. A subframe is defined as two consecutive slots where subframe i consists of slots $2i$ and $2i + 1$.

For FDD, 10 subframes are available for downlink transmission and 10 subframes are available for uplink transmissions in each 10 ms interval. Uplink and downlink transmissions are separated in the frequency domain. In half-duplex FDD operation, the UE cannot transmit and receive at the same time while there are no such restrictions in full-duplex FDD.

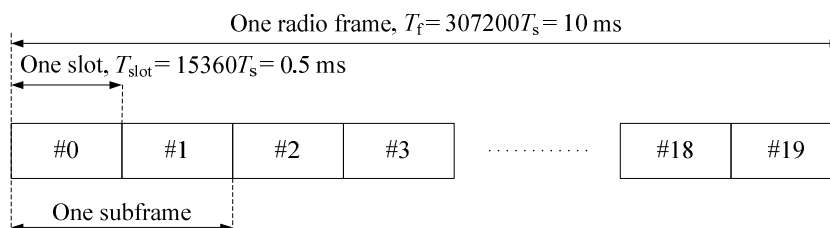


Figure 4.1-1: Frame structure type 1.

4.2 Frame structure type 2

Frame structure type 2 is applicable to TDD. Each radio frame of length $T_f = 307200 \cdot T_s = 10$ ms consists of two half-frames of length $153600 \cdot T_s = 5$ ms each. Each half-frame consists of five subframes of length $30720 \cdot T_s = 1$ ms. The supported uplink-downlink configurations are listed in Table 4.2-2 where, for each subframe in a radio frame, 'D' denotes the subframe is reserved for downlink transmissions, 'U' denotes the subframe is reserved for uplink transmissions and 'S' denotes a special subframe with the three fields DwPTS, GP and UpPTS. The length of DwPTS and UpPTS is given by Table 4.2-1 subject to the total length of DwPTS, GP and UpPTS being equal to $30720 \cdot T_s = 1$ ms. Each subframe i is defined as two slots, $2i$ and $2i+1$ of length $T_{slot} = 15360 \cdot T_s = 0.5$ ms in each subframe.

Uplink-downlink configurations with both 5 ms and 10 ms downlink-to-uplink switch-point periodicity are supported.

In case of 5 ms downlink-to-uplink switch-point periodicity, the special subframe exists in both half-frames.

In case of 10 ms downlink-to-uplink switch-point periodicity, the special subframe exists in the first half-frame only.

Subframes 0 and 5 and DwPTS are always reserved for downlink transmission. UpPTS and the subframe immediately following the special subframe are always reserved for uplink transmission.

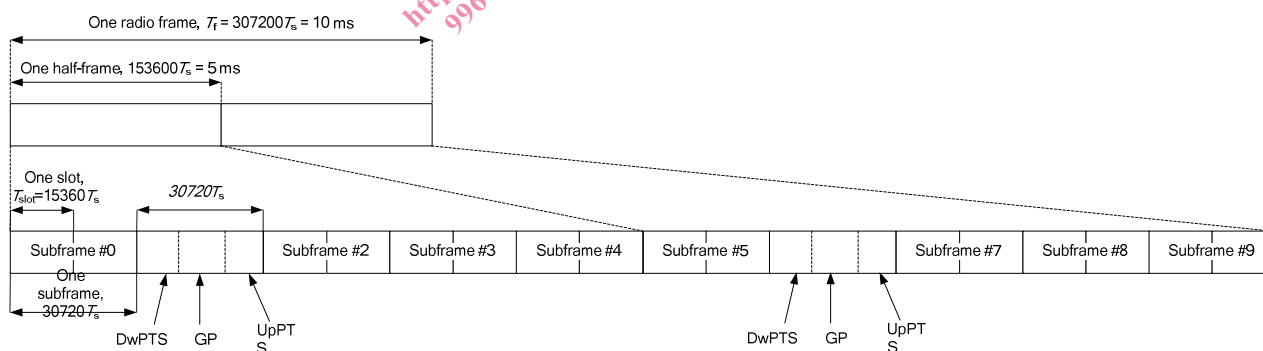


Figure 4.2-1: Frame structure type 2 (for 5 ms switch-point periodicity).

Table 4.2-1: Configuration of special subframe (lengths of DwPTS/GP/UpPTS).

Special subframe configuration	Normal cyclic prefix in downlink			Extended cyclic prefix in downlink		
	DwPTS	UpPTS		DwPTS	UpPTS	
		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink
0	$6592 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$	$7680 \cdot T_s$	$2192 \cdot T_s$	$2560 \cdot T_s$
1	$19760 \cdot T_s$			$20480 \cdot T_s$		
2	$21952 \cdot T_s$			$23040 \cdot T_s$		
3	$24144 \cdot T_s$			$25600 \cdot T_s$		
4	$26336 \cdot T_s$			$7680 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$
5	$6592 \cdot T_s$	$4384 \cdot T_s$	$5120 \cdot T_s$	$20480 \cdot T_s$		
6	$19760 \cdot T_s$			$23040 \cdot T_s$		
7	$21952 \cdot T_s$			-	-	-
8	$24144 \cdot T_s$			-	-	-

Table 4.2-2: Uplink-downlink configurations.

Uplink-downlink configuration	Downlink-to-Uplink Switch-point periodicity	Subframe number									
		0	1	2	3	4	5	6	7	8	9
0	5 ms	D	S	U	U	U	D	S	U	U	U
1	5 ms	D	S	U	U	D	D	S	U	U	D
2	5 ms	D	S	U	D	D	D	S	U	D	D
3	10 ms	D	S	U	U	U	D	D	D	D	D
4	10 ms	D	S	U	U	D	D	D	D	D	D
5	10 ms	D	S	U	D	D	D	D	D	D	D
6	5 ms	D	S	U	U	U	D	S	U	U	D

5 Uplink

5.1 Overview

The smallest resource unit for uplink transmissions is denoted a resource element and is defined in section 5.2.2.

5.1.1 Physical channels

An uplink physical channel corresponds to a set of resource elements carrying information originating from higher layers and is the interface defined between 36.212 and 36.211. The following uplink physical channels are defined:

- Physical Uplink Shared Channel, PUSCH
- Physical Uplink Control Channel, PUCCH
- Physical Random Access Channel, PRACH

5.1.2 Physical signals

An uplink physical signal is used by the physical layer but does not carry information originating from higher layers. The following uplink physical signals are defined:

- Reference signal

5.2 Slot structure and physical resources

5.2.1 Resource grid

The transmitted signal in each slot is described by a resource grid of $N_{RB}^{UL} N_{sc}^{RB}$ subcarriers and N_{symb}^{UL} SC-FDMA symbols. The resource grid is illustrated in Figure 5.2.1-1. The quantity N_{RB}^{UL} depends on the uplink transmission bandwidth configured in the cell and shall fulfil

$$N_{RB}^{min, UL} \leq N_{RB}^{UL} \leq N_{RB}^{max, UL}$$

where $N_{RB}^{min, UL} = 6$ and $N_{RB}^{max, UL} = 110$ are the smallest and largest uplink bandwidths, respectively, supported by the current version of this specification. The set of allowed values for N_{RB}^{UL} is given by [7].

The number of SC-FDMA symbols in a slot depends on the cyclic prefix length configured by the higher layer parameter *UL-CyclicPrefixLength* and is given in Table 5.2.3-1.

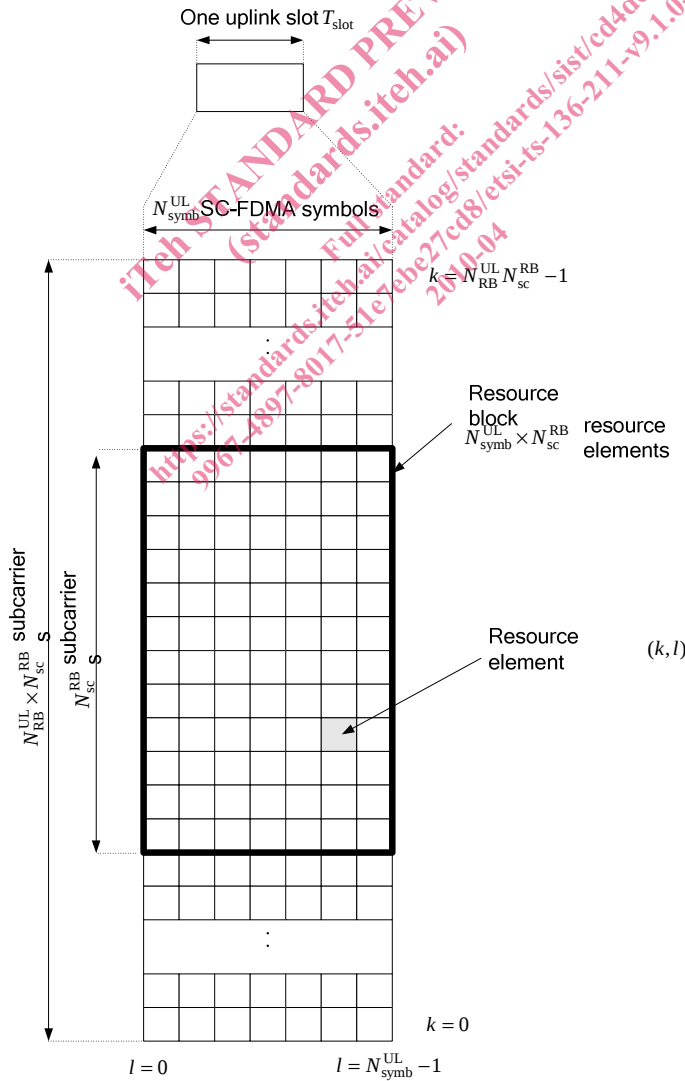


Figure 5.2.1-1: Uplink resource grid.