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LTE;
Evolved Universal Terrestrial Radio Access (E-UTRA);
Physical channels and modulation
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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 - APE 7112B
Association à but non lucratif enregistrée à la
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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.
- 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); LTE 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".

[9] 3GPP TS 36.331, "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC) Protocol specification"

[10] 3GPP TS 36.304, "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) procedures in idle mode"

[11] 3GPP TS 37.213: "Physical layer procedures for shared spectrum channel access"

[12] 3GPP TS 36.300: "Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2"

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3 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
$f_{\text{PRB,hop}}^{\text{PRACH}}$	PRACH frequency hopping offset, expressed as a number of resource blocks
$l_{\text{NPDCCHStart}}$	Start symbol in slot 0 for NPDCCH
$l_{\text{NPDSCHStart}}$	Start symbol in slot 0 for NPDSCH
$M_{\text{sc}}^{\text{PSBCH}}$	Bandwidth for PSBCH transmission, expressed as a number of subcarriers
$M_{\text{RB}}^{\text{PSBCH}}$	Bandwidth for PSBCH transmission, expressed as a number of resource blocks
$M_{\text{sc}}^{\text{PSCCH}}$	Bandwidth for PSCCH transmission, expressed as a number of subcarriers
$M_{\text{RB}}^{\text{PSCCH}}$	Bandwidth for PSCCH transmission, expressed as a number of resource blocks
$M_{\text{sc}}^{\text{PSDCH}}$	Bandwidth for PSDCH transmission, expressed as a number of subcarriers
$M_{\text{RB}}^{\text{PSDCH}}$	Bandwidth for PSDCH transmission, expressed as a number of resource blocks
$M_{\text{sc}}^{\text{PSSCH}}$	Scheduled bandwidth for PSSCH transmission, expressed as a number of subcarriers
$M_{\text{RB}}^{\text{PSSCH}}$	Scheduled bandwidth for PSSCH transmission, expressed as a number of resource blocks
$M_{\text{sc}}^{\text{PUSCH}}$	Scheduled bandwidth for uplink transmission, expressed as a number of subcarriers
$M_{\text{RB}}^{\text{PUSCH}}$	Scheduled bandwidth for uplink transmission, expressed as a number of resource blocks
$M_{\text{rep}}^{\text{NPUSCH}}$	Scheduled number of repetitions of a NPUSCH transmission
$M_{\text{rep}}^{\text{NPDSCH}}$	Scheduled number of repetitions of a NPDSCH transmission
$M_{\text{sc}}^{\text{NPUSCH}}$	Scheduled bandwidth for uplink NPUSCH transmission, expressed as a number of subcarriers
$M_{\text{identical}}^{\text{NPUSCH}}$	Number of repetitions of identical slots for NPUSCH
$M_{\text{bit}}^{(q)}$	Number of coded bits to transmit on a physical channel [for codeword q]
$M_{\text{symb}}^{(q)}$	Number of modulation symbols to transmit on a physical channel [for codeword q]
$M_{\text{symb}}^{\text{layer}}$	Number of modulation symbols to transmit per layer for a physical channel
$M_{\text{symb}}^{\text{ap}}$	Number of modulation symbols to transmit per antenna port for a physical channel
$M_{\text{sc}}^{\text{RU}}$	Number of consecutive subcarriers in an UL resource unit for PUSCH sub-PRB allocation
$M_{\text{slots}}^{\text{UL}}$	Number of slots in an UL resource unit for PUSCH sub-PRB allocation
$M_{\text{symb}}^{\text{UL}}$	Number of SC-FDMA symbols in an uplink slot for PUSCH sub-PRB allocation
	Number of subcarriers in the frequency domain for PUSCH sub-PRB allocation
$M_{\text{seq}}^{\text{RU}}$	Number of reference signal sequences available for the UL resource unit size for PUSCH sub-PRB allocation
M_{RU}	Number of scheduled UL resource units for PUSCH sub-PRB allocation
N	A constant equal to 2048 for $\Delta f = 15\,\text{kHz}$, 4096 for $\Delta f = 7.5\,\text{kHz}$ and 8192 for $\Delta f = 3.75\,\text{kHz}$
$N_{\text{CP},l}$	Downlink cyclic prefix length for OFDM symbol l in a slot

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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}^{Ncell}	Narrowband physical layer cell identity
N_{ID}^{MBSFN}	MBSFN area identity
N_{ID}^{SL}	Physical layer sidelink synchronization identity
N_{ID}^{PRS}	Positioning reference signal 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_{RB}^{SL}	Sidelink bandwidth configuration, expressed in multiples of N_{sc}^{RB}
N_{RSS}	Duration of RSS measured in subframes
N_{SF}	Number of scheduled subframes for NPDSCH transmission
N_{symb}^{NPSS}	Number of symbols for NPSS in a subframe
N_{symb}^{NSSS}	Number of symbols for NSSS in a subframe
N_{sc}^{RU}	Number of consecutive subcarriers in an UL resource unit for NB-IoT
N_{seq}^{RU}	Number of reference signal sequences available for the UL resource unit size
N_{RU}	Number of scheduled UL resource units for NB-IoT
N_{NB}^{UL}	Total number of uplink narrowbands
N_{WB}^{UL}	Total number of uplink widebands
N_{sc}^{UL}	Number of subcarriers in the frequency domain for NB-IoT
N_{acc}	Number of consecutive absolute subframes over which the scrambling sequence stays the same
N_{abs}^{PUSCH}	Total number of absolute subframes a PUSCH with repetition spans expressed as a number of absolute subframes
N_{rep}^{PUSCH}	Number of repetitions of a PUSCH transmission
$N_{NB}^{ch,UL}$	Number of consecutive absolute subframes over which PUCCH or PUSCH stays at the same narrowband before hopping to another narrowband, expressed as a number of absolute subframes
$f_{NB,hop}^{PUSCH}$	Narrowband offset between one narrowband and the next narrowband a PUSCH hops to, expressed as a number of uplink narrowbands
N_{abs}^{PUCCH}	Total number of absolute subframes a PUCCH with repetition spans, expressed as a number of absolute subframes
N_{rep}^{PUCCH}	Number of repetitions of a PUCCH transmission
N_{rep}^{PRACH}	Number of PRACH repetitions per preamble transmission attempt
N_{sf}^{RA}	Number of subframes allowed for preamble transmission within a 1024-frame interval

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N_{start}^{PRACH}	PRACH starting subframe periodicity
N_{rep}^{NPRACH}	Number of NPRACH repetitions per preamble transmission attempt
N_{period}^{NPRACH}	NPRACH resource periodicity
$N_{scoffset}^{NPRACH}$	Frequency location of the first sub-carrier allocated to NPRACH
N_{sc}^{NPRACH}	Number of sub-carriers allocated to NPRACH
$N_{sc\_cont}^{NPRACH}$	Number of starting sub-carriers allocated for UE initiated random access
N_{start}^{NPRACH}	NPRACH starting subframe
N_{MSG3}^{NPRACH}	Fraction for starting subcarrier index for UE support for multi-tone msg3 transmission
$N_{gap,period}$	Periodicity for NPDSCH/NPDCCH gaps
$N_{gap,duration}$	Duration for NPDSCH/NPDCCH gaps
$N_{gap,threshold}$	Threshold for applying NPDDCH/NPDCCH gaps
N_{NB}^{DL}	Total number of downlink narrowbands
N_{WB}^{DL}	Total number of downlink widebands
N_{abs}^{PDSCH}	Total number of absolute subframes a PDSCH with repetition spans, expressed as a number of absolute subframes
N_{rep}^{PDSCH}	Number of repetitions of a PDSCH transmission
$N_{NB}^{ch,DL}$	Number of consecutive absolute subframes over which MPDCCH or PDSCH stays at the same narrowband before hopping to another narrowband, expressed as a number of absolute subframes
$N_{NB,hop}^{ch,DL}$	Number of narrowbands over which MPDCCH or PDSCH frequency hops
$f_{NB,hop}^{DL}$	Narrowband offset between one narrowband and the next narrowband an MPDCCH or PDSCH hops to, expressed as a number of downlink narrowbands
$N_{PDSCH}^{SIB1\text{-}BR}$	Number of times a PDSCH carrying SIB1-BR is transmitted over 8 radio frames
N_{abs}^{MPDCCH}	Total number of absolute subframes a MPDCCH with repetition spans, expressed as a number of absolute subframes
N_{rep}^{MPDCCH}	Number of repetitions of a MPDCCH transmission
$N_{abs,ss}^{MPDCCH}$	Total number of absolute subframes a MPDCCH search space with maximum repetition level spans, expressed as a number of absolute subframes
$N_{rep,ss}^{MPDCCH}$	Maximum repetition level of a MPDCCH search space
N_{ECCE}^{MPDCCH}	Number of ECCEs in a subframe for one MPDCCH
N_{symb}^{DL}	Number of OFDM symbols in a downlink slot
N_{symb}^{UL}	Number of SC-FDMA symbols in an uplink slot
N_{symb}^{retune}	Number of symbols in a guard period for narrowband or wideband retuning
N_{slots}^{UL}	Number of consecutive slots in an UL resource unit for NB-IoT
N_{symb}^{SL}	Number of SC-FDMA symbols in a sidelink slot
N_{sc}^{RB}	Resource block size in the frequency domain, expressed as a number of subcarriers
N_{sb}	Number of sub-bands for PUSCH frequency-hopping with predefined hopping pattern
N_{RB}^{sb}	Size of each sub-band for PUSCH frequency-hopping with predefined hopping pattern, expressed as a number of resource blocks
N_{sc}^{RA}	Size of narrow-band random-access resource in 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

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N_{RS}^{SPUCCH}	Number of reference symbols per subslot or per slot for SPUCCH
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
$N_{TA,SL}$	Timing offset between sidelink and timing reference frames at the UE, expressed in units of T_s
$n_{PUCCH}^{(1,\tilde{p})}$	Resource index for PUCCH formats 1/1a/1b
$n_{PUCCH}^{(2,\tilde{p})}$	Resource index for PUCCH formats 2/2a/2b
$n_{PUCCH}^{(3,\tilde{p})}$	Resource index for PUCCH format 3
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
$n_{PRBoffset}^{RA}$	First physical resource block available for PRACH
$n_{PRB,RSS}$	Lowest PRB number of RSS
n_{sc}^{RA}	Subcarrier occupied by NPRACH resource considered
n_{VRB}	Virtual resource block number
n_{RNTI}	Radio network temporary identifier
n_{ID}^{SA}	Sidelink group destination identity
n_f	System frame number
n_s	Slot number within a radio frame
n_{sf}^{abs}	Absolute subframe number
n_{sf}^{RA}	Index for subframes allowed for preamble transmission
O_{RSS}	Starting frame offset of RSS in each RSS period
P	Number of antenna ports used for transmission of a channel
p	Antenna port number
P_{RSS}	Period of RSS measured in frames
q	Codeword number
r_{RA}	Index for PRACH versions with same preamble format and PRACH density
Q_m	Modulation order: 1 for π/2-BPSK, 2 for QPSK, 4 for 16QAM, 6 for 64QAM and 8 for 256QAM 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_{NPRACH}	Amplitude scaling for NPRACH
β_{PUCCH}	Amplitude scaling for PUCCH
β_{PUSCH}	Amplitude scaling for PUSCH
β_{NPUSCH}	Amplitude scaling for NPUSCH
β_{SPUCCH}	Amplitude scaling for SPUCCH
β_{SRS}	Amplitude scaling for sounding reference symbols
Δf	Subcarrier spacing

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