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Contents

Foreword

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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] TS 36.201: "Evolved Universal Terrestrial Radio Access (E-UTRA); LTE physical layer; General description".

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

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

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

[6] TS 36.104: "Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception".

[7] TS 36.101: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception".

[8] TS 36.321, "Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification".

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

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

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

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

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
N_{CS}	Cyclic shift value used for random access preamble generation

$N_{\mathrm{cs}}^{(1)}$ 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

$N_{\mathrm{RB}}^{(2)}$ Bandwidth available for use by PUCCH formats 2/2a/2b, expressed in multiples of $N_{\mathrm{sc}}^{\mathrm{RB}}$

$N_{\mathrm{RB}}^{\mathrm{HO}}$ The offset used for PUSCH frequency hopping, expressed in number of resource blocks (set by higher layers)

$N_{\mathrm{ID}}^{\mathrm{cell}}$ Physical layer cell identity

$N_{\mathrm{ID}}^{\mathrm{Ncell}}$ Narrowband physical layer cell identity

$N_{\mathrm{ID}}^{\mathrm{MBSFN}}$ MBSFN area identity

$N_{\mathrm{ID}}^{\mathrm{SL}}$ Physical layer sidelink synchronization identity

$N_{\mathrm{ID}}^{\mathrm{PRS}}$ Positioning reference signal identity

$N_{\mathrm{RB}}^{\mathrm{DL}}$ Downlink bandwidth configuration, expressed in multiples of $N_{\mathrm{sc}}^{\mathrm{RB}}$

$N_{\mathrm{RB}}^{\mathrm{min,DL}}$ Smallest downlink bandwidth configuration, expressed in multiples of $N_{\mathrm{sc}}^{\mathrm{RB}}$

$N_{\mathrm{RB}}^{\mathrm{max,DL}}$ Largest downlink bandwidth configuration, expressed in multiples of $N_{\mathrm{sc}}^{\mathrm{RB}}$

$N_{\mathrm{RB}}^{\mathrm{UL}}$ Uplink bandwidth configuration, expressed in multiples of $N_{\mathrm{sc}}^{\mathrm{RB}}$

$N_{\mathrm{RB}}^{\mathrm{min,UL}}$ Smallest uplink bandwidth configuration, expressed in multiples of $N_{\mathrm{sc}}^{\mathrm{RB}}$

$N_{\mathrm{RB}}^{\mathrm{max,UL}}$ Largest uplink bandwidth configuration, expressed in multiples of $N_{\mathrm{sc}}^{\mathrm{RB}}$

$N_{\mathrm{RB}}^{\mathrm{SL}}$ Sidelink bandwidth configuration, expressed in multiples of $N_{\mathrm{sc}}^{\mathrm{RB}}$

N_{RSS} Duration of RSS measured in subframes

N_{SF} Number of scheduled subframes for NPDSCH transmission

$N_{\mathrm{symb}}^{\mathrm{NPSS}}$ Number of symbols for NPSS in a subframe

$N_{\mathrm{symb}}^{\mathrm{NSSS}}$ Number of symbols for NSSS in a subframe

$N_{\mathrm{sc}}^{\mathrm{RU}}$ Number of consecutive subcarriers in an UL resource unit for NB-IoT

$N_{\mathrm{seq}}^{\mathrm{RU}}$ Number of reference signal sequences available for the UL resource unit size

N_{RU} Number of scheduled UL resource units for NB-IoT

$N_{\mathrm{NB}}^{\mathrm{UL}}$ Total number of uplink narrowbands

$N_{\mathrm{WB}}^{\mathrm{UL}}$ Total number of uplink widebands

$N_{\mathrm{sc}}^{\mathrm{UL}}$ 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

$N_{\mathrm{abs}}^{\mathrm{PUSCH}}$ Total number of absolute subframes a PUSCH with repetition spans expressed as a number of absolute subframes

$N_{\mathrm{rep}}^{\mathrm{PUSCH}}$ Number of repetitions of a PUSCH transmission

$N_{\mathrm{NB}}^{\mathrm{ch,UL}}$ 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

$f_{\mathrm{NB,hop}}^{\mathrm{PUSCH}}$ Narrowband offset between one narrowband and the next narrowband a PUSCH hops to, expressed as a number of uplink narrowbands

$N_{\mathrm{abs}}^{\mathrm{PUCCH}}$ Total number of absolute subframes a PUCCH with repetition spans, expressed as a number of absolute subframes

$N_{\mathrm{rep}}^{\mathrm{PUCCH}}$ Number of repetitions of a PUCCH transmission

$N_{\mathrm{rep}}^{\mathrm{PRACH}}$ Number of PRACH repetitions per preamble transmission attempt

$N_{\mathrm{sf}}^{\mathrm{RA}}$ Number of subframes allowed for preamble transmission within a 1024-frame interval

$N_{\mathrm{start}}^{\mathrm{PRACH}}$ PRACH starting subframe periodicity

$N_{\mathrm{rep}}^{\mathrm{NPRACH}}$ Number of NPRACH repetitions per preamble transmission attempt

$N_{\text{period}}^{\text{NPRACH}}$ NPRACH resource periodicity

$N_{\text{scoffset}}^{\text{NPRACH}}$ Frequency location of the first sub-carrier allocated to NPRACH

$N_{\text{sc}}^{\text{NPRACH}}$ Number of sub-carriers allocated to NPRACH

$N_{\text{sc\_cont}}^{\text{NPRACH}}$ Number of starting sub-carriers allocated for UE initiated random access

$N_{\text{start}}^{\text{NPRACH}}$ NPRACH starting subframe

$N_{\text{MSG3}}^{\text{NPRACH}}$ Fraction for starting subcarrier index for UE support for multi-tone msg3 transmission

$N_{\text{gap,period}}$ Periodicity for NPDSCH/NPDCCH gaps

$N_{\text{gap,duration}}$ Duration for NPDSCH/NPDCCH gaps

$N_{\text{gap,threshold}}$ Threshold for applying NPDSCH/NPDCCH gaps

$N_{\text{NB}}^{\text{DL}}$ Total number of downlink narrowbands

$N_{\text{WB}}^{\text{DL}}$ Total number of downlink widebands

$N_{\text{abs}}^{\text{PDSCH}}$ Total number of absolute subframes a PDSCH with repetition spans, expressed as a number of absolute subframes

$N_{\text{rep}}^{\text{PDSCH}}$ Number of repetitions of a PDSCH transmission

$N_{\text{NB}}^{\text{ch,DL}}$ 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

$N_{\text{NB,hop}}^{\text{ch,DL}}$ Number of narrowbands over which MPDCCH or PDSCH frequency hops

$f_{\text{NB,hop}}^{\text{DL}}$ Narrowband offset between one narrowband and the next narrowband an MPDCCH or PDSCH hops to, expressed as a number of downlink narrowbands

$N_{\text{PDSCH}}^{\text{SIB1-BR}}$ Number of times a PDSCH carrying SIB1-BR is transmitted over 8 radio frames

$N_{\text{abs}}^{\text{MPDCCH}}$ Total number of absolute subframes a MPDCCH with repetition spans, expressed as a number of absolute subframes

$N_{\text{rep}}^{\text{MPDCCH}}$ Number of repetitions of a MPDCCH transmission

$N_{\text{abs,ss}}^{\text{MPDCCH}}$ Total number of absolute subframes a MPDCCH search space with maximum repetition level spans, expressed as a number of absolute subframes

$N_{\text{rep,ss}}^{\text{MPDCCH}}$ Maximum repetition level of a MPDCCH search space

$N_{\text{ECCE}}^{\text{MPDCCH}}$ Number of ECCEs in a subframe for one MPDCCH

$N_{\text{symb}}^{\text{DL}}$ Number of OFDM symbols in a downlink slot

$N_{\text{symb}}^{\text{UL}}$ Number of SC-FDMA symbols in an uplink slot

$N_{\text{symb}}^{\text{retune}}$ Number of symbols in a guard period for narrowband or wideband retuning

$N_{\text{slots}}^{\text{UL}}$ Number of consecutive slots in an UL resource unit for NB-IoT

$N_{\text{symb}}^{\text{SL}}$ Number of SC-FDMA symbols in a sidelink slot

$N_{\text{sc}}^{\text{RB}}$ 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

$N_{\text{RB}}^{\text{sb}}$ Size of each sub-band for PUSCH frequency-hopping with predefined hopping pattern, expressed as a number of resource blocks

$N_{\text{sc}}^{\text{RA}}$ Size of narrow-band random-access resource in number of subcarriers

N_{SP} Number of downlink to uplink switch points within the radio frame

$N_{\text{RS}}^{\text{PUCCH}}$ Number of reference symbols per slot for PUCCH

$N_{\text{RS}}^{\text{SPUCCH}}$ 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

$N_{\text{TA offset}}$ Fixed timing advance offset, expressed in units of T_s

$N_{\text{TA,SL}}$	Timing offset between sidelink and timing reference frames at the UE, expressed in units of T_s
$n_{\text{PUCCH}}^{(1,\tilde{p})}$	Resource index for PUCCH formats 1/1a/1b
$n_{\text{PUCCH}}^{(2,\tilde{p})}$	Resource index for PUCCH formats 2/2a/2b
$n_{\text{PUCCH}}^{(3,\tilde{p})}$	Resource index for PUCCH format 3
n_{PDCCH}	Number of PDCCHs present in a subframe
n_{PRB}	Physical resource block number
$n_{\text{PRB}}^{\text{RA}}$	First physical resource block occupied by PRACH resource considered
$n_{\text{PRB}\,\text{offset}}^{\text{RA}}$	First physical resource block available for PRACH
$n_{PRB,RSS}$	Lowest PRB number of RSS
$n_{\text{sc}}^{\text{RA}}$	Subcarrier occupied by NPRACH resource considered
n_{VRB}	Virtual resource block number
n_{RNTI}	Radio network temporary identifier
$n_{\text{ID}}^{\text{SA}}$	Sidelink group destination identity
n_{f}	System frame number
n_{s}	Slot number within a radio frame
$n_{\text{sf}}^{\text{abs}}$	Absolute subframe number
$n_{\text{sf}}^{\text{RA}}$	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 SC-FDMA/OFDM symbol l in a slot
$t_{\text{RA}}^{(0)}$	Radio frame indicator index of PRACH opportunity
$t_{\text{RA}}^{(1)}$	Half frame index of PRACH opportunity within the radio frame
$t_{\text{RA}}^{(2)}$	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
Δf_{RA}	Subcarrier spacing for the random access preamble
υ	Number of transmission layers