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Evolved Universal Terrestrial Radio Access (E-UTRA);  
Physical channels and modulation  
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## 1 Scope

The present document describes the physical channels for evolved UTRA.

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## 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"

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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                               |

$D_{\text{RA}}$	Density of random access opportunities per radio frame
$f_0$	Carrier frequency
$f_{\text{RA}}$	PRACH resource frequency index within the considered time-domain location
$f_{\text{PRACH, hop}}$	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
$M_{\text{sc}}$	Bandwidth for PSBCH transmission, expressed as a number of subcarriers
$M_{\text{RB}}$	Bandwidth for PSBCH transmission, expressed as a number of resource blocks
$M_{\text{sc}}$	Bandwidth for PSCCH transmission, expressed as a number of subcarriers
$M_{\text{RB}}$	Bandwidth for PSCCH transmission, expressed as a number of resource blocks
$M_{\text{sc}}$	Bandwidth for PSDCH transmission, expressed as a number of subcarriers
$M_{\text{RB}}$	Bandwidth for PSDCH transmission, expressed as a number of resource blocks
$M_{\text{sc}}$	Scheduled bandwidth for PSSCH transmission, expressed as a number of subcarriers
$M_{\text{RB}}$	Scheduled bandwidth for PSSCH transmission, expressed as a number of resource blocks
$M_{\text{sc}}$	Scheduled bandwidth for uplink transmission, expressed as a number of subcarriers
$M_{\text{RB}}$	Scheduled bandwidth for uplink transmission, expressed as a number of resource blocks
$M_{\text{NPUSCH rep}}$	Scheduled number of repetitions of a NPUSCH transmission
$M_{\text{NPDSCH rep}}$	Scheduled number of repetitions of a NPDSCH transmission
$M_{\text{NPUSCH}}$	Scheduled bandwidth for uplink NPUSCH transmission, expressed as a number of subcarriers
$M_{\text{identical}}$	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 $q$ ]
$M_{\text{symb}}$	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
$N$	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
$N_{\text{CS}}$	Cyclic shift value used for random access preamble generation
$N_{\text{cs}}^{(1)}$	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
$N_{\text{RB}}^{(2)}$	Bandwidth available for use by PUCCH formats 2/2a/2b, expressed in multiples of $N_{\text{sc}}^{\text{RB}}$
$N_{\text{RB}}^{\text{HO}}$	The offset used for PUSCH frequency hopping, expressed in number of resource blocks (set by higher layers)
$N_{\text{ID}}^{\text{cell}}$	Physical layer cell identity
$N_{\text{ID}}^{\text{Ncell}}$	Narrowband physical layer cell identity
$N_{\text{ID}}^{\text{MBSFN}}$	MBSFN area identity
$N_{\text{ID}}^{\text{SL}}$	Physical layer sidelink synchronization identity
$N_{\text{ID}}^{\text{PRS}}$	Positioning reference signal identity
$N_{\text{RB}}^{\text{DL}}$	Downlink bandwidth configuration, expressed in multiples of $N_{\text{sc}}^{\text{RB}}$
$N_{\text{RB}}^{\text{min, DL}}$	Smallest downlink bandwidth configuration, expressed in multiples of $N_{\text{sc}}^{\text{RB}}$
$N_{\text{RB}}^{\text{max, DL}}$	Largest downlink bandwidth configuration, expressed in multiples of $N_{\text{sc}}^{\text{RB}}$
$N_{\text{RB}}^{\text{UL}}$	Uplink bandwidth configuration, expressed in multiples of $N_{\text{sc}}^{\text{RB}}$
$N_{\text{RB}}^{\text{min, UL}}$	Smallest uplink bandwidth configuration, expressed in multiples of $N_{\text{sc}}^{\text{RB}}$
$N_{\text{RB}}^{\text{max, UL}}$	Largest uplink bandwidth configuration, expressed in multiples of $N_{\text{sc}}^{\text{RB}}$

$N_{\text{RB}}^{\text{SL}}$	Sidelink bandwidth configuration, expressed in multiples of $N_{\text{sc}}^{\text{RB}}$
$N_{\text{SF}}$	Number of scheduled subframes for NPDSCH transmission
$N_{\text{symb}}^{\text{NPSS}}$	Number of symbols for NPSS in a subframe
$N_{\text{symb}}^{\text{NSSS}}$	Number of symbols for NSSS in a subframe
$N_{\text{sc}}^{\text{RU}}$	Number of consecutive subcarriers in an UL resource unit for NB-IoT
$N_{\text{seq}}^{\text{RU}}$	Number of reference signal sequences available for the UL resource unit size
$N_{\text{RU}}$	Number of scheduled UL resource units for NB-IoT
$N_{\text{NB}}^{\text{UL}}$	Total number of uplink narrowbands
$N_{\text{WB}}^{\text{UL}}$	Total number of uplink widebands
$N_{\text{sc}}^{\text{UL}}$	Number of subcarriers in the frequency domain for NB-IoT
$N_{\text{acc}}$	Number of consecutive absolute subframes over which the scrambling sequence stays the same
$N_{\text{abs}}^{\text{PUSCH}}$	Total number of absolute subframes a PUSCH with repetition spans , expressed as a number of absolute subframes
$N_{\text{rep}}^{\text{PUSCH}}$	Number of repetitions of a PUSCH transmission
$N_{\text{NB}}^{\text{ch,UL}}$	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
$f_{\text{NB,hop}}^{\text{PUSCH}}$	Narrowband offset between one narrowband and the next narrowband a PUSCH hops to, expressed as a number of uplink narrowbands
$N_{\text{abs}}^{\text{PUCCH}}$	Total number of absolute subframes a PUCCH with repetition spans, expressed as a number of absolute subframes
$N_{\text{rep}}^{\text{PUCCH}}$	Number of repetitions of a PUCCH transmission
$N_{\text{rep}}^{\text{PRACH}}$	Number of PRACH repetitions per preamble transmission attempt
$N_{\text{sf}}^{\text{RA}}$	Number of subframes allowed for preamble transmission within a 1024-frame interval
$N_{\text{start}}^{\text{PRACH}}$	PRACH starting subframe periodicity
$N_{\text{rep}}^{\text{NPRACH}}$	Number of NPRACH repetitions per preamble transmission attempt
$N_{\text{period}}^{\text{NPRACH}}$	NPRACH resource periodicity
$N_{\text{sc_offset}}^{\text{NPRACH}}$	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/NPDCCCH gaps
$N_{\text{gap,duration}}$	Duration for NPDSCH/NPDCCCH gaps
$N_{\text{gap,threshold}}$	Threshold for applying NPDDCH/NPDCCCH 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