ETSI TS 103 636-3 V1.4.1 (2023-01)

TECHNICAL SPECIFICATION

DECT-2020 New Radio (NR);
Part 3: Physical layer;
Release 1

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Digital Enhanced Cordless Telecommunications (DECT).

The present document is part 3 of a multi-part deliverable covering the DECT-2020 New Radio (NR) technology. Full details of the entire series can be found in part 1 [1].

DECT-2020 NR is recognized in Recommendation ITU-R M.2150 [i.1] as a component RIT fulfilling the IMT-2020 requirements of the IMT-2020 use scenarios URLLC and mMTC. The Set of Radio Interface Technology (SRIT) called "DECT 5G SRIT" is involving 3GPP NR and DECT-2020 NR.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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1 Scope

The present document is one of the parts of the specification of the DECT-2020 New Radio (NR).

The present document specifies the Physical layer and interaction between PHY and MAC layer.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] ETSI TS 103 636-1: "DECT-2020 New Radio (NR); Part 1: Overview; Release 1".

[2] ETSI TS 103 636-2: "DECT-2020 New Radio (NR); Part 2: Radio reception and transmission requirements; Release 1".

[3] ETSI TS 103 636-4: "DECT-2020 New Radio (NR); Part 4: MAC layer; Release 1".

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] Recommendation ITU-R M.2150: "Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications-2020 (IMT-2020)".

3 Definition of terms, symbols and abbreviations

3.1 Terms

Void.

3.2 Symbols

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

$\forall$	Mathematical notation for "for all"
$\wedge$	Mathematical notation for "and"
$\lfloor x \rfloor$	Mathematical notation for "floor of x" i.e. rounding towards zero
$\lceil x \rceil$	Mathematical notation for "ceiling of x" i.e. rounding towards infinity
β	Fourier transform scaling factor
μ	Subcarrier scaling factor
Δ_f^{μ}	Subcarrier spacing for given subcarrier scaling factor
$f_s^{\mu,\beta}$	Sample frequency
k_{OCC}^{β}	Occupied subcarriers for given transform scaling factor
$B_{DFT}^{\mu,\beta}$	Nominal bandwidth
$B_{TX}^{\mu,\beta}$	Transmission bandwidth
GI^{μ}	Guard interval for given subcarrier scaling factor
M_{symb}^{stream}	Number of modulated symbols in a spatial stream
M_{symb}	Number of modulated symbols
N_{CP}^{β}	Cyclic Prefix size for given transform scaling factor
N_{symb}^{DF}	Number of symbols in Data Field
$N_{symb}^{(GI+STF)}$	Number of symbols in Guard Interval and STF combined
N_{DFT}^{β}	Discrete Fourier Transform size for given Fourier transform scaling factor
N_{OCC}^{β}	Number of occupied subcarriers for given Fourier transform scaling factor
N_{re}^{DRS}	Number of DRS resource elements
N_{re}^{PCC}	Number of PCC resource elements
N_{re}^{PDC}	Number of PDC resource elements
N_{symb}^{SLOT}	Number OFDM symbols in a slot
$N_{subslot}^{SLOT}$	Number of subslots in a slot
N_{slot}^{FRAME}	Number of slots in a frame
N_{symb}^{PACKET}	Number of OFDM symbols in a transmission packet
N_{TX}	Number of transmission antennas
N_{TX}^{eff}	Effective number of transmission antennas
N_{TS}	Number of transmit streams
N_{SS}	Number of spatial streams
N_{bps}	Number of bits per symbol for given modulation
T_{frame}	Duration of a frame
T_{slot}	Duration of a slot
$T_s^{\mu,\beta}$	Sample time interval
T_{symb}^{μ}	Duration of OFDM symbol for given subcarrier scaling factor

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3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI TS 103 636-1 [1] and the following apply:

NOTE: An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in ETSI TS 103 636-1 [1].

ARQ	Automatic Repeat reQuest
BPSK	Binary Phase Shift Keying
CP	Cyclic Prefix
CRC	Cyclic Redundancy Check
DC	Zero or DC Subcarrier
DECT	Digital Enhanced Cordless Telecommunications
DF	Data Field
DFT	Discrete Fourier Transform
DRS	Demodulation Reference Signal

FDMA	Frequency Division Multiple Access
GF	Galois Field
GI	Guard Interval
HARQ	Hybrid ARQ
MAC	Medium Access Control
OFDM	Orthogonal Frequency Division Multiplexing
PCC	Physical Control Channel
PCCC	Parallel Concatenated Convolutional Code
PDC	Physical Data Channel
PDU	Protocol Data Unit
PHY	Physical layer
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RD	Radio Device
SAP	Service Access Point
SS	Spatial Stream
STF	Synchronization Training Field
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TS	Transmit Stream
TX	Transmission

4 Physical layer principles

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4.1 General description of Physical layer

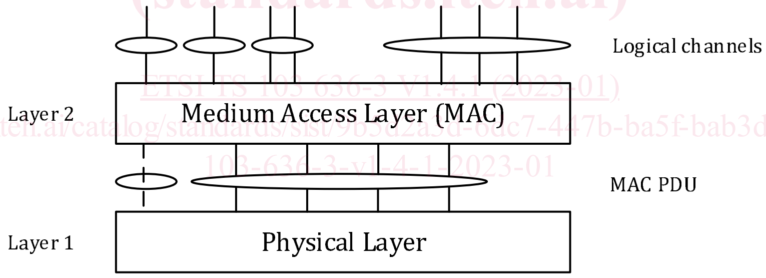

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Figure 4.1-1: Radio interface protocol architecture around the Physical layer

Figure 4.1-1 shows the DECT-2020 NR radio interface protocol architecture around the Physical layer (PHY). The physical layer interfaces the Medium Access Control (MAC) layer. The circles between different layer/sub-layers indicate Service Access Points (SAPs). The physical layer offers Physical Control Channel (PCC) and Physical Data Channel (PDC) to transmit MAC PDU(s). Different physical channels are characterized by how the information is transferred over the radio interface within single transmission packet.

The physical layer performs the following functions in order to provide the data transport service:

- Error detection on the physical channels and indication to higher layers
- FEC encoding/decoding of the physical channels
- Hybrid ARQ soft-combining
- Rate matching of the coded physical channel data to physical channels
- Mapping of the coded physical channel data onto physical channels
- Modulation and demodulation of physical channels
- Frequency and time synchronization

- Radio characteristics measurements and indication to higher layers
- Multiple Input Multiple Output (MIMO) antenna processing
- Transmit Diversity (TX diversity)
- Beamforming

The physical channels defined are:

- the Physical Control Channel (PCC);
- the Physical Data Channel (PDC).

The modulation schemes supported are:

- BPSK;
- QPSK;
- 16-QAM;
- 64-QAM;
- 256-QAM; and
- 1024-QAM.

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The channel coding in all of the physical channels is turbo coding with a rate 1/3 mother code punctured to the coderate of the channel or the selected MCS according to Table A-1. Trellis termination is used for the turbo coding. Before the turbo coding, transport blocks are segmented into byte aligned segments with a maximum codeblock size. Error detection is supported by the use of 16 or 24 bit CRC as specified for a given physical channel.

4.2 Multiple access

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The multiple access scheme for the DECT-2020 NR physical layer is based on Time Division Duplex (TDD) combined with Frequency Division Multiple Access (FDMA) and Time Division Multiple Access (TDMA). The physical layer operates with non-overlapping channels in frequency domain and non-overlapping transmission slots in time domain. Radio channel spacing is defined in ETSI TS 103 636-2 [2].

The modulation within the transmitted packets is Orthogonal Frequency Division Multiplexing (OFDM) with a Cyclic Prefix (CP).

Both frame duration (10 ms) and slot duration (0,41667 ms) ensure coexistence with legacy DECT systems.

4.3 Numerologies

In the present document, unless otherwise noted, the size of various fields in the time domain are expressed in terms of basic parameters. Subcarrier spacing is defined by the subcarrier scaling factor μ, resulting either in 27 kHz, 54 kHz, 108 kHz or 216 kHz OFDM subcarriers spacing Δ_f^{μ}. In addition, the Fourier transform scaling factor β can be set to allow different transmission bandwidths for each configuration of the subcarrier spacing. The numerologies listed in table 4.3-1 support multiple throughput and latency configurations for the network. In the table $B_{DFT}^{\mu,\beta}$ denotes the nominal bandwidth, $B_{TX}^{\mu,\beta}$ denotes the transmission bandwidth consisting of N_{OCC}^{β} occupied subcarriers and the empty DC carrier in the center of the transmission bandwidth, $T_s^{\mu,\beta}$ denotes the critical sample rate, N_{DFT}^{β} the Fourier transform size, N_{CP}^{β} denotes the cyclic prefix size in samples.

Table 4.3-1: Supported transmission numerologies

		β	$B_{DFT}^{\mu,\beta}$[kHz]	$T_s^{\mu,\beta}$	N_{DFT}^{β}	N_{CP}^{β}	N_{OCC}^{β}	$B_{TX}^{\mu,\beta}$ [kHz]
μ	1	1	1 728	5,7870E-07	64	8	56	1 539
Δ_f^{μ} [kHz]	27	2	3 456	2,8935E-07	128	16	112	3 051
T_{symb}^{μ} [us]	41,667	4	6 912	1,4468E-07	256	32	224	6 075
$N_{symb}^{SLOT,\mu}$	10	8	13 824	7,2338E-08	512	64	448	12 123
$N_{subslot}^{SLOT,\mu}$	2	12	20 736	4,8225E-08	768	96	672	18 171
GI^{μ} [us]	18,52	16	27 648	3,6169E-08	1 024	128	896	24 219

		β	$B_{DFT}^{\mu,\beta}$[kHz]	$T_s^{\mu,\beta}$	N_{DFT}^{β}	N_{CP}^{β}	N_{OCC}^{β}	$B_{TX}^{\mu,\beta}$ [kHz]
μ	2	1	3 456	2,8935E-07	64	8	56	3 078
Δ_f^{μ} [kHz]	54	2	6 912	1,4468E-07	128	16	112	6 102
T_{symb}^{μ} [us]	20,833	4	13 824	7,2338E-08	256	32	224	12 150
$N_{symb}^{SLOT,\mu}$	20	8	27 648	3,6169E-08	512	64	448	24 246
$N_{subslot}^{SLOT,\mu}$	4	12	41 472	2,4113E-08	768	96	672	36 342
GI^{μ} [us]	20,83	16	55 296	1,8084E-08	1 024	128	896	48 438

		β	$B_{DFT}^{\mu,\beta}$[kHz]	$T_s^{\mu,\beta}$	N_{DFT}^{β}	N_{CP}^{β}	N_{OCC}^{β}	$B_{TX}^{\mu,\beta}$ [kHz]
μ	4	1	6 912	1,4468E-07	64	8	56	6 156
Δ_f^{μ} [kHz]	108	2	13 824	7,2338E-08	128	16	112	12 204
T_{symb}^{μ} [us]	10,417	4	27 648	3,6169E-08	256	32	224	24 300
$N_{symb}^{SLOT,\mu}$	40	8	55 296	1,8084E-08	512	64	448	48 492
$N_{subslot}^{SLOT,\mu}$	8	12	82 944	1,2056E-08	768	96	672	72 684
GI^{μ} [us]	10,42	16	110 592	9,0422E-09	1 024	128	896	96 876

		β	$B_{DFT}^{\mu,\beta}$[kHz]	$T_s^{\mu,\beta}$	N_{DFT}^{β}	N_{CP}^{β}	N_{OCC}^{β}	$B_{TX}^{\mu,\beta}$ [kHz]
μ	8	1	13 824	7,2338E-08	64	8	56	12 312
Δ_f^{μ} [kHz]	216	2	27 648	3,6169E-08	128	16	112	24 408
T_{symb}^{μ} [us]	5,208	4	55 296	1,8084E-08	256	32	224	48 600
$N_{symb}^{SLOT,\mu}$	80	8	110 592	9,0422E-09	512	64	448	96 984
$N_{subslot}^{SLOT,\mu}$	16	12	165 888	6,0282E-09	768	96	672	145 368
GI^{μ} [us]	10,42	16	221 184	4,5211E-09	1 024	128	896	193 752

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4.4 Frame structure

The radio frame has a duration of $T_{frame} = 10\ ms$ and consists of $N_{slot}^{FRAME} = 24$ slots with a slot duration of $T_{slot} = 0{,}41667\ ms$ as depicted in figure 4.4-1.

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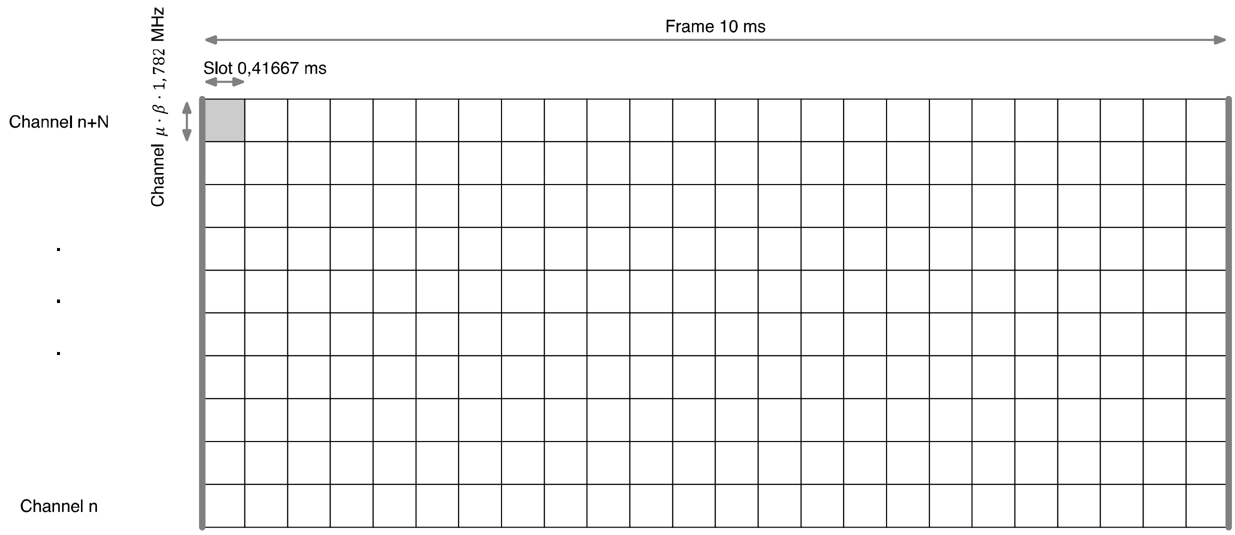

Figure 4.4-1: DECT-2020 NR frame structure

Each slot consists of $N_{symb}^{SLOT,\mu} = 10$, 20, 40 or 80 OFDM symbols depending on subcarrier scaling factor μ. Slot is further divided into $N_{subslot}^{SLOT,\mu}$ subslots according to the table 4.3-1 for each subcarrier scaling μ. Packet transmission duration is integer multiple of subslots.

Basic channel width is 1,728 MHz. Multiple adjacent basic channels can be aggregated with β and μ to form a wider transmission bandwidth ranging from 1,728 MHz to 221,184 MHz. Channel raster and numbering is specified in ETSI TS 103 636-2 [2].

4.5 Physical resources

Physical resources are mapped to resource elements $(s, k, l)_\beta$, where s may denote either transmit stream or spatial stream index, k denotes the subcarrier index and l denotes the OFDM symbol position in the time domain relative to the start of the transmission packet as depicted in figure 4.5-1. The occupied subcarriers indices are:

$$k_{OCC}^{\beta} = \left[-\frac{N_{OCC}^{\beta}}{2}, \cdots, -1, 1, \cdots, \frac{N_{OCC}^{\beta}}{2}\right],$$

Where the N_{OCC}^{β} is given by Table 4.3-1.The remaining subcarriers are the guard bands and the zero carrier (or DC carrier) which are not used for data transmission. Example of resource mappings are depicted in figures 4.5-2 and 4.5-3.

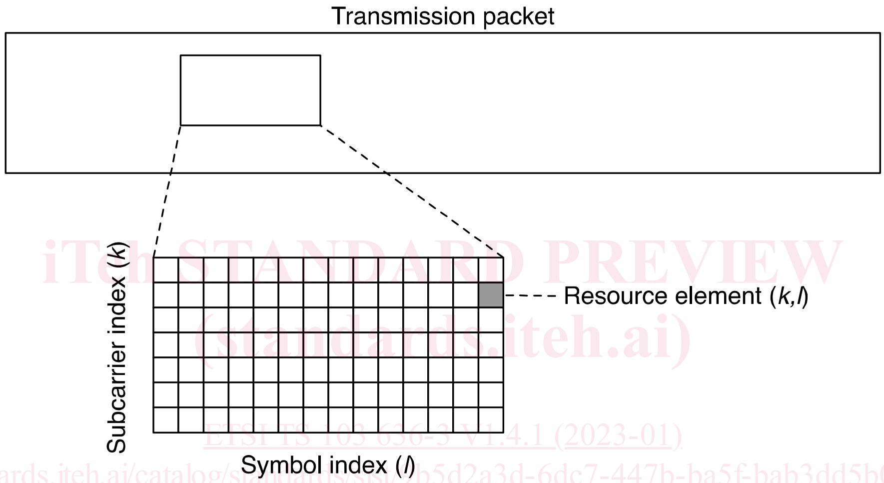

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Figure 4.5-1: Resource grid and indexing

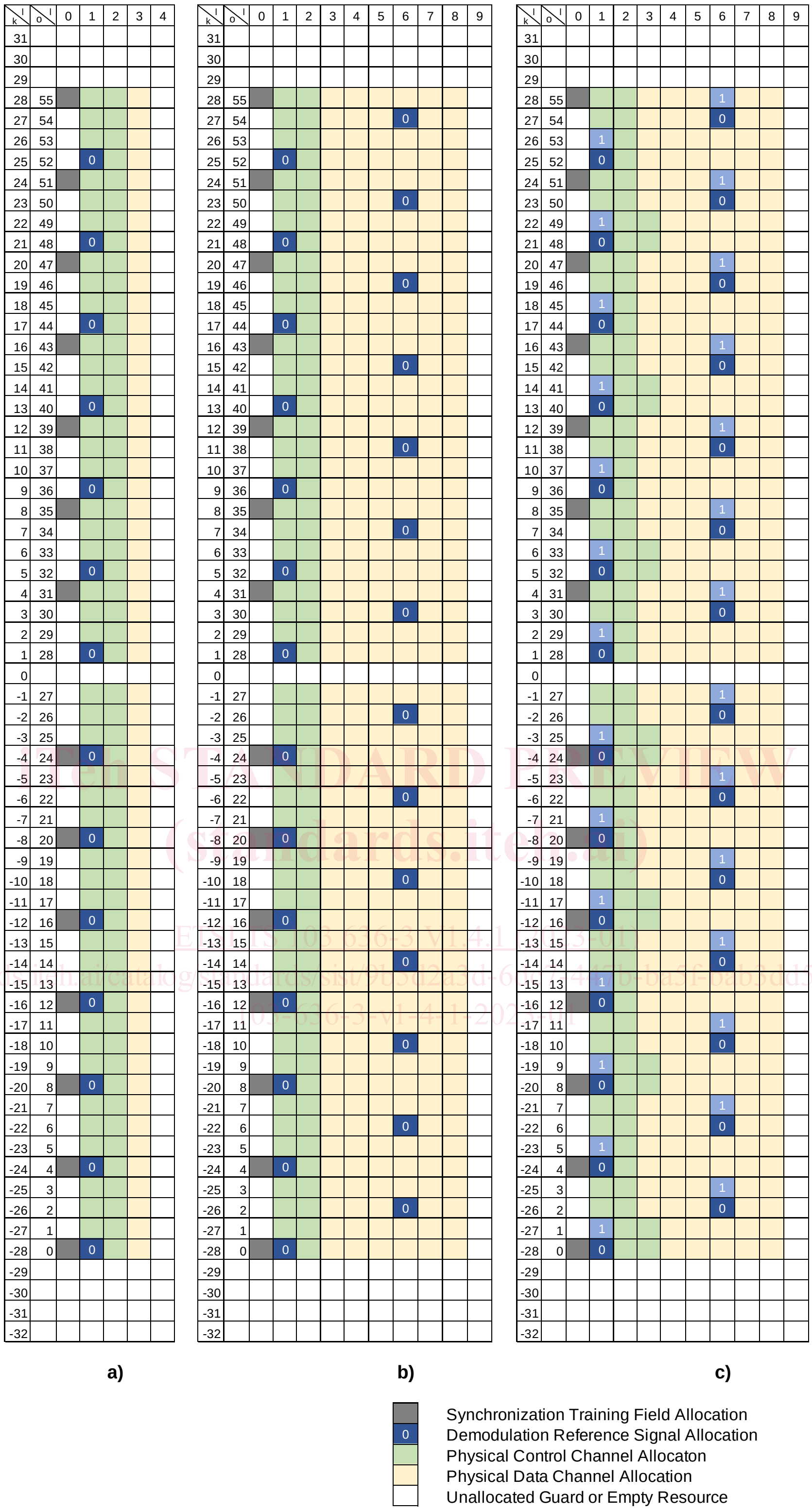

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Figure 4.5-2: Resource mapping for $(\mu, \beta) = (*, 1)$
a) Transmission from single effective antenna of one subslot duration
b) Transmission from single effective antenna of two subslots duration
c) Transmission from two effective antennas of two subslots duration

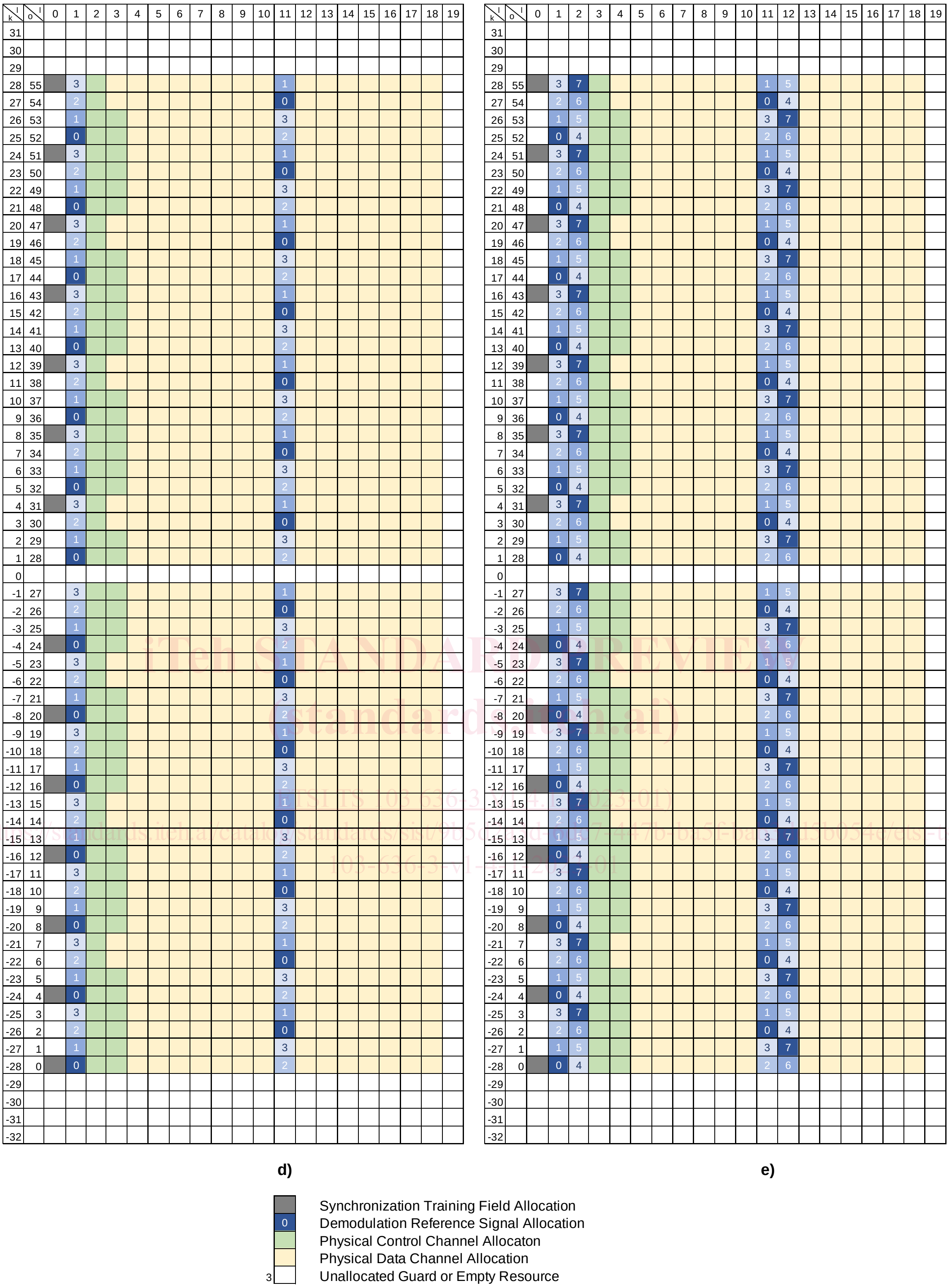

Figure 4.5-3: Resource mapping for $(\mu, \beta) = (*, 1)$
d) Transmission from four effective antennas of four subslots duration
e) Transmission from eight effective antennas of four subslots duration

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