IEEE P802.22  
Wireless RANs

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| Proposed Text for the IEEE802.22b | | | | |
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|  |  |  |  |  |

Abstract

This document contains the proposed text for the draft standard of the IEEE 802.22b

r0: Proposed modification (July. 2013)

r1: Constellation on MD-TCM QAM has been added (Sept. 2013)

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1. PHY

*[Start of proposed text. No changes are made to the paragraphs before Table 198.]*

***Change Table 198 as indicated.***

1. — System parameters for WRAN

|  |  |  |
| --- | --- | --- |
| **Parameters** | **Specification** | **Remark** |
| Frequency range | 54~862 MHz\* |  |
| Channel bandwidth | 6, 7, or 8 MHz | According to regulatory domain (see 1236H**Error! Reference source not found.**). |
| Data rate | 4.54 to 31.78 Mbit/s | See 1237HTable 202 |
| Spectral Efficiency | 0.76 to 5.3 bit/(s·Hz) | See 1238HTable 202 |
| Payload modulation | QPSK, 16-QAM, 64-QAM, 256-QAM (optional), MD-TCM (optional) | BPSK used for preambles, pilots and CDMA codes. |
| Transmit EIRP | 4W maximum for CPEs. 4W maximum for BS’s in the USA regulatory domain. | Maximum EIRP for BS’s may vary in other regulatory domains. |
| Multiple Access | OFDMA |  |
| FFT Size (NFFT) | 2048 |  |
| Cyclic Prefix Modes | 1/4, 1/8, 1/16, 1/32 |  |
| Duplex | TDD |  |

\* Frequency range allocated to the Television Broadcasting Service in various parts of the world.

See Annex A for further details.

The following subclauses provide details on the various aspects of the PHY specifications.

*[End of proposed text.]*

*[Start of proposed text.]*

9.2 Data Rates

1247HTable 202 defines the different PHY modulation and encoding modes with their associated parameters along with an example of the resulting gross data rates in the case of the 6 MHz channel bandwidth.

***Change Table 202 as indicated.***

Table 202 — PHY Modes and their related modulations, coding rates  
and data rates for TCP = TFFT/16

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **PHY Mode** | **Modulation** | **Coding Rate** | **Data rate (Mb/s)** | **Spectral Efficiency5 (for 6 MHz bandwidth)** |
| 1 1 | BPSK | Uncoded | 6 | 6 |
| 2 2 | QPSK | 1/2 Repetition: 4 | 6 | 6 |
| 3 3 | QPSK | 1/2 Repetition: 3 | 6 | 6 |
| 4 4 | QPSK | 1/2 Repetition: 2 | 6 | 6 |
| 5 | QPSK | 1/2 | 4.54 | 0.76 |
| 6 | QPSK | 2/3 | 6.05 | 1.01 |
| 7 | QPSK | 3/4 | 6.81 | 1.13 |
| 8 | QPSK | 5/6 | 7.56 | 1.26 |
| 9 | 16-QAM | 1/2 | 9.08 | 1.51 |
| 10 | 16-QAM | 2/3 | 12.10 | 2.02 |
| 11 | 16-QAM | 3/4 | 13.61 | 2.27 |
| 12 | 16-QAM | 5/6 | 15.13 | 2.52 |
| 13 | 64-QAM | 1/2 | 13.61 | 2.27 |
| 14 | 64-QAM | 2/3 | 18.15 | 3.03 |
| 15 | 64-QAM | 3/4 | 20.42 | 3.40 |
| 16 | 64-QAM | 5/6 | 22.69 | 3.78 |
| 17 | 256-QAM | 1/2 | 18.16 | 3.03 |
| 18 | 256-QAM | 2/3 | 24.2 | 4.03 |
| 19 | 256-QAM | 3/4 | 27.24 | 4.54 |
| 20 | 256-QAM | 5/6 | 30.24 | 5.04 |
| 21 | 256-QAM | 7/8 | 31.78 | 5.30 |
| 22 | 4D-48TCM | 10/11 for  2 \*2D symbol | 22.69 | 3.78 |
| 23 | 4D-192TCM | 14/15 for  2 \*2D symbol | 31.78 | 5.30 |

Note 1: Mode 1 is only used for CDMA opportunistic bursts.

Note 2: Mode 2 is only used for SCH packet transmission.

Note 3: Mode 3 is only used for CBP transmission.

Note 4: Mode 4 is only used for FCH transmission.

Note 5: Spectral efficiency informative values are calculated assuming continuous stream of 1440 data subcarriers for the given modulation and FEC modes (i.e., assuming no TTG, RTG and superframe and frame headers).

Note 6: These modes are for control signal transmissions and there is no need to specify data rate or spectral efficiency.

*[End of proposed text.]*

* 1. Channel coding

*[Start of proposed text.]*

* + 1. Forward Error Correction (FEC)

*[No changes are made to the text before Subclause 9.7.2.1.2.]*

9.7.2.1.2 Puncturing

***Change Table 208 as indicated.***

Table 208 — Puncturing and bit-insertion for the different coding rates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Code rate** | 1/2 | 2/3 | 3/4 | 5/6 | 7/8 |
| **Convolutional coder output** | A1B1 | A1B1~~A~~~~2~~B2 | A1B1~~A~~~~2~~B2A3~~B~~~~3~~ | A1B1~~A~~~~2~~B2A3~~B~~~~3~~~~A~~~~4~~B4A5~~B~~~~5~~ | A1B1~~A~~~~2~~B2~~A~~~~3~~B3~~A~~~~4~~B4  A5~~B~~~~5~~~~A~~~~6~~B6A7~~B~~~~7~~ |
| **Puncturer output/bit-inserter input** | A1B1 | A1B1B2 | A1B1B2A3 | A1B1B2A3B4A5 | A1B1B2B3B4A5B6A7 |
| **Decoder input** | A1B1 | A1B10B2 | A1B10B2A30 | A1B10B2A300B4A50 | A1B10B20B30B4A500B6A70 |

9.7.2.1.3 OFDM slot concatenation

The encoding block size shall depend on the number of OFDM slots allocated and the modulation specified for the current transmission. Concatenation of a number of OFDM slots shall be performed in order to allow for transmission of larger blocks of coding where it is possible, with the limitation of not exceeding the largest block size for the corresponding modulation and coding. 1339HTable 209 specifies the concatenation index for different modulations and coding.

For any modulation and coding, the following parameters are defined:

— j: index dependent on the modulation level and FEC rate

— n: number of allocated OFDM slots

— k: floor (n / j)

— m: n mod j

1340HTable 210 shows the rules used for OFDM slot concatenation.

***Change Table 209 as indicated.***

Table 209 — Concatenation index for different modulations and coding

|  |  |
| --- | --- |
| **Modulation and Rate** | **j** |
| QPSK 1/2 | 12 |
| QPSK 2/3 | 9 |
| QPSK 3/4 | 8 |
| QPSK 5/6 | 7 |
| 16-QAM 1/2 | 6 |
| 16-QAM 2/3 | 4 |
| 16-QAM 3/4 | 4 |
| 16-QAM 5/6 | 3 |
| 64-QAM 1/2 | 4 |
| 64-QAM 2/3 | 3 |
| 64-QAM 3/4 | 2 |
| 64-QAM 5/6 | 2 |
| 256-QAM 1/2 | 3 |
| 256-QAM 2/3 | 2 |
| 256-QAM 3/4 | 2 |
| 256-QAM 5/6 | 1 |
| 256-QAM 7/8 | 1 |

1. — OFDM slot concatenation rule

|  |  |
| --- | --- |
| **Number of OFDM slots** | **Concatenated slots** |
| n ≤ j | 1 block of n slots |
| n > j | If (n mod j =0)  k blocks of j slots  else  (k-1) blocks of j slots  1 block of ceil((m+j)/2) slots  1 block of floor((m+j)/2) slots |

1341HTable 211 defines the basic sizes of the useful data payloads (in bytes) to be encoded in relation with the selected modulation type, encoding rate and concatenation rule.

***Change Table 211 as indicated.***

Table 211 — Useful data payload in bytes for an FEC block

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **QPSK** | | | | **16-QAM** | | | | **64-QAM** | | | | **256-QAM** | | | | |
| **R=**  **1/2** | **R=**  **2/3** | **R=**  **3/4** | **R=**  **5/6** | **R=**  **1/2** | **R=**  **2/3** | **R=**  **3/4** | **R=**  **5/6** | **R=**  **1/2** | **R=**  **2/3** | **R=**  **3/4** | **R=**  **5/6** | **R=**  **1/2** | **R=**  **2/3** | **R=**  **3/4** | **R=**  **5/6** | **R=**  **7/8** |
| 3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6 |  |  |  | 6 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 8 |  |  |  | 8 |  |  |  |  |  |  |  |  |  |  |  |
| 9 |  | 9 |  |  |  | 9 |  | 9 |  |  |  |  |  |  |  |  |
|  |  |  | 10 |  |  |  | 10 |  |  |  |  |  |  |  |  |  |
| 12 | 12 |  |  | 12 |  |  |  |  | 12 |  |  | 12 |  |  |  |  |
| 15 |  |  | 15 |  |  |  |  |  |  |  | 15 |  |  |  |  |  |
|  | 16 |  |  |  | 16 |  |  |  |  |  |  |  | 16 |  |  |  |
| 18 |  | 18 |  | 18 |  | 18 |  | 18 |  |  |  |  |  | 18 |  |  |
|  | 20 |  | 20 |  |  |  | 20 |  |  |  |  |  |  |  | 20 |  |
| 21 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 21 |
| 24 | 24 |  |  | 24 | 24 |  |  |  | 24 |  |  | 24 |  |  |  |  |
|  |  |  | 25 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 27 |  | 27 |  |  |  | 27 |  | 27 |  | 27 |  |  |  |  |  |  |
|  | 28 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 30 |  |  | 30 | 30 |  |  | 30 |  |  |  | 30 |  |  |  |  |  |
|  | 32 |  |  |  | 32 |  |  |  |  |  |  |  | 32 |  |  |  |
| 33 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | 35 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 36 | 36 | 36 |  | 36 |  | 36 |  | 36 | 36 |  |  | 36 |  | 36 |  |  |

*[End of proposed text.]*

*[Start of proposed text.]*

* 1. Constellation mapping and modulation
     1. Data modulation

***Change the following text as indicated.***

* + - 1. Conventional QPSK and QAM

The output of the bit interleaver is entered serially to the constellation mapper. The input data to the mapper is first divided into groups of number of coded bits per carrier, i.e., NCBPC (see 1373HTable 226) bits and then converted into complex numbers representing QPSK, 16-QAM, 64-QAM, or 256-QAM constellation points. The mapping for QPSK, 16-QAM, 64-QAM, and 256-QAM is performed according to Gray-coding constellation mapping, as shown in 1374HFigure 150, 1375HFigure 151, 1376HFigure 152, and Figure XXX, respectively where b0 represents the most significant modulation bit for all constellations.

***Add new Figure XXX after Figure 152 as indicated.***



Figure XXX — Gray Mapping for 256-QAM

The complex value number is scaled by a modulation dependent normalization factor KMOD. 1377HTable 226 shows the KMOD values for the different modulation types defined in this subclause. The number of coded bits per slot (NCBPS) and the number of data bits per slot for the different modulation constellation and coding rate combinations are summarized in 1378HTable 227. Note that an OFDM slot corresponds to one OFDM symbol by one sub-channel).

***Change Table 226 and Table 227 as indicated.***

Table 226 — Number of coded bit per carrier and normalization factor  
for different modulation constellations

|  |  |  |
| --- | --- | --- |
| **Modulation Type** | **NCBPC** | **KMOD** |
| QPSK | 2 |  |
| 16-QAM | 4 |  |
| 64-QAM | 6 |  |
| 256-QAM | 8 |  |

Table 227 — Number of coded bits per OFDM slot (NCBPS) and corresponding number of  
data bits for different modulation constellation and coding rate combinations

|  |  |  |  |
| --- | --- | --- | --- |
| **Constellation type** | **Coding rate** | **NCBPS** | **Corresponding number of data bits** |
| QPSK | 1/2 | 48 | 24 |
| QPSK | 2/3 | 48 | 32 |
| QPSK | 3/4 | 48 | 36 |
| QPSK | 5/6 | 48 | 40 |
| 16-QAM | 1/2 | 96 | 48 |
| 16-QAM | 2/3 | 96 | 64 |
| 16-QAM | 3/4 | 96 | 72 |
| 16-QAM | 5/6 | 96 | 80 |
| 64-QAM | ½ | 144 | 72 |
| 64-QAM | 2/3 | 144 | 96 |
| 64-QAM | 3/4 | 144 | 108 |
| 64-QAM | 5/6 | 144 | 120 |
| 256-QAM | 1/2 | 192 | 96 |
| 256-QAM | 2/3 | 192 | 128 |
| 256-QAM | 3/4 | 192 | 144 |
| 256-QAM | 5/6 | 192 | 160 |
| 256-QAM | 7/8 | 192 | 168 |

*[End of proposed text.]*

*[Start of proposed text.]*

* + - 1. QAM with multidimensional trellis coded modulation

The output of the multidimensional trellis encoder is entered to the constellation mapper. The input data to the mapper has a group of number of coded bits per two carriers, i.e., NCBPC bits and then converted into complex numbers representing 48-QAM, or 192-QAM constellation points. The mapping for 48-QAM and 192-QAM are performed according to constellation mapping, as shown in Figure YYY and ZZZ, respectively.

I

Q

1

3

5

7

-1

-5

-3

-7

1

3

5

7

-1

-3

-5

-7

*ˆ*Figure YYY --- Constellation of one 2D symbol for MD-TCM 48 QAM

I

Q

1

3

7

5

9

11

13

15

-1

-3

-7

-5

-9

-11

-13

-15

1

3

5

7

9

11

13

15

-1

-3

-5

-7

-9

-11

-13

-15

*ˆ*Figure ZZZ --- Constellation of one 2D symbol for MD-TCM 192 QAM

*[End of proposed text.]*

*[Start of proposed text.]*

* 1. Control mechanisms
     1. Downstream synchronization

*[No changes are made to the text.]*

* + 1. Upstream synchronization

*[No changes are made to the text.]*

* + 1. Opportunistic upstream bursts

*[No changes are made to the text.]*

* + 1. Power control

*[No changes are made to the text.]*

* + - 1. Transmit Power control boundaries and EIRP limits

*[No changes are made to the text]*

* + - 1. Transmit Power Control mechanism

*[No changes are made to the paragraphs before Table 228.]*

***Change Table 228 as indicated.***

Table 228 — Normalized CNR per modulation for BER= 2\*10-4

|  |  |  |
| --- | --- | --- |
| **Modulation - FEC rate** | **Normalized CNR (dB)** | |
| **AWGN**  **(default)** | **Multipath Channel**8F**[[1]](#footnote-1)** *(informative)* |
| CDMA code | 1.2 | 5 |
| QPSK, rate: 1/2 | 4.3 | 8.1 |
| QPSK, rate: 2/3 | 6.1 | 11.6 |
| QPSK, rate: 3/4 | 7.1 | 14.0 |
| QPSK, rate: 5/6 | 8.1 | 17.8 |
| 16-QAM, rate: 1/2 | 10.2 | 14.8 |
| 16-QAM, rate: 2/3 | 12.4 | 20.3 |
| 16-QAM, rate: 3/4 | 13.5 | 24.6 |
| 16-QAM, rate: 5/6 | 14.8 | 28.6 |
| 64-QAM, rate: 1/2 | 15.6 | 20.5 |
| 64-QAM, rate: 2/3 | 18.3 | 26.2 |
| 64-QAM, rate: 3/4 | 19.7 | 31.8 |
| 64-QAM, rate: 5/6 | 20.9 | 40.4 |
| 256-QAM, rate: 1/2 | 19.4 | TBD |
| 256-QAM, rate: 2/3 | 22.6 | TBD |
| 256-QAM, rate: 3/4 | 24.2 | TBD |
| 256-QAM, rate: 5/6 | 26.2 | TBD |
| 256-QAM, rate: 7/8 | 27.5 | TBD |

*[End of proposed text.]*

*[Start of proposed text.]*

* 1. Receiver Requirements
     1. Receiver minimum sensitivity

The receiver minimum sensitivity level, RSS, is defined as the minimum power, measured at the antenna port, at which the bit error rate performance is equal to the required limit. The equation is given as follows.

RSS (dBm) = Reference Thermal Noise Density Level

+ Noise Figure

+ Effective Channel Bandwidth

+ Required Signal-to-Noise Ratio

+ Receiver Implementation Margin

+ Interference Allowance

where

* Reference Thermal Noise Density Level = Boltzman Constant + 10\*log(Reference Noise Temperature) with Boltzman Constant = -138.6 dB(mW/(K\*MHz)) and Reference Noise Temperature = 290 K (degrees Kelvin);
* Noise Figure = 3 dB for the base station and 6 dB for the CPE;
* Effective Channel Bandwidth = 10 log (Signal Bandwidth (MHz) ) with Signal Bandwidth values as in 1444HTable 201);
* Required Signal-to-Noise Ratio = the Reference Normalized SNR as shown in 1445HTable 228 for a BER performance of 2x10-4 where the values include 1.1 dB, 1.3 dB, 1.5 dB, and 1.7 dB decoder implementation margins for QPSK, 16-QAM, 64-QAM, and 256-QAM modulations respectively;
* Receiver Implementation Margin = 1.9 dB and 2.1 dB for BS and CPE respectively, accounting for the coupling loss, pre-amplification filter loss, assuming that a low-noise pre-amplifier is located at the antenna;
* Interference Allowance = 1 dB for either BS or CPE to cover for the impact of local interference at the receiver.

The base station and CPE minimum receiver sensitivity for the three channel bandwidths shall at least meet the values given in 1446HTable 231.

1. — Minimum receiver sensitivity requirement for QPSK rate: 1/2 at BER= 2\*10-4

|  |  |  |  |
| --- | --- | --- | --- |
| **TV channel bandwidth (MHz)** | **6** | **7** | **8** |
| Base station receiver sensitivity (dBm) | -94.5 | -93.8 | -93.2 |
| CPE receiver sensitivity (dBm) | -91.3 | -90.6 | -90.0 |

*[End of proposed text.]*

1. The multipath channel used for the calculations is defined on 6 paths as follows: excess delay: -3, 0, 2, 4, 7 and 11 μsec; relative amplitude: -6, 0, -7, -22, -16 and -20 dB; the phase for each path is random. The delay, amplitude and phase are assumed to be constant over the period of one symbol. [↑](#footnote-ref-1)