IEEE P802.22
Wireless RANs

|  |
| --- |
| BER Simulation Comparing Upstream Subcarrier Interleaving Schemes |
| Date: 2011-05-12 |
| Author(s): |
| Name | Company | Address | Phone | email |
| Gerald Chouinard | CRC Canada | Ottawa, Canada | 613-998-2500 | Gerald.chouinard@crc.ca |
| Jason Li | WiLAN Inc. | Ottawa, Canada | 613-668-7074 | jli@wilan.com |

Abstract

This document presents Matlab simulation results on the BER performance for all PHY coding rate, modulation and bit interleaving (BI) scheme combinations, on the upstream using the old subcarrier interleaving (SI) scheme {1624,4,2,3}, the new scheme {1512,2,5,5}, on the downstream using the old subcarrier interleaving scheme {1440,40,2,2}. The simulation results show that the new upstream subcarrier interleaving scheme performs better than the old scheme. Moreover, we found that two bit interleaving schemes (K=1056 and K=2112) are incorrect.

**Notice:** This document has been prepared to assist IEEE 802.22. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.

**Release:** The contributor grants a free, irrevocable license to the IEEE to incorporate material contained in this contribution, and any modifications thereof, in the creation of an IEEE Standards publication; to copyright in the IEEE’s name any IEEE Standards publication even though it may include portions of this contribution; and at the IEEE’s sole discretion to permit others to reproduce in whole or in part the resulting IEEE Standards publication. The contributor also acknowledges and accepts that this contribution may be made public by IEEE 802.22.

**Patent Policy and Procedures:** The contributor is familiar with the IEEE 802 Patent Policy and Procedures

<[**http://standards.ieee.org/guides/bylaws/sb-bylaws.pdf**](http://standards.ieee.org/guides/bylaws/sb-bylaws.pdf)>, including the statement "IEEE standards may include the known use of patent(s), including patent applications, provided the IEEE receives assurance from the patent holder or applicant with respect to patents essential for compliance with both mandatory and optional portions of the standard." Early disclosure to the Working Group of patent information that might be relevant to the standard is essential to reduce the possibility for delays in the development process and increase the likelihood that the draft publication will be approved for publication. Please notify the Chair <**Wendong Hu**> as early as possible, in written or electronic form, if patented technology (or technology under patent application) might be incorporated into a draft standard being developed within the IEEE 802.22 Working Group. **If you have questions, contact the IEEE Patent Committee Administrator at <****patcom@ieee.org****>**.

**1. Simulation setup**

The simulation follows P802.22/D1.0. The simulation parameters are as follows:

* guard period: 1/4
* Modulation: QPSK, 16QAM, 64QAM
* FEC coding rate: 1/2, 2/3, 3/ 4, 5/6
* Bit interleaving scheme: all schemes listed in P802.22/D1.0 Table 204.
* Subcarrier interleaving schemes:
	+ Upstream {1512,2,5,5} (new scheme)
	+ Upstream {1624,4,2,3} (old scheme)
	+ Downstream {1440,40,2,2} (old scheme)
* C/N: chosen at values within practical operation range for each specific modulation + FEC combination
* Channel-B
* Carrier frequency offset: 0
* Perfect time synchronization
* Perfect channel estimation and equalization

**2. Simulation results:**

The following shows that BER simulation results for QPSK 1/2, with C/N = 7.0dB.

SI scheme {1440,40,2,2} {1512,2,5,5} {1624,4,2,3}

 (Old DS) (new US) (old US)

Modulation QPSK QPSK QPSK

code Rate 1/2 1/2 1/2

C/N 7.0 7.0 7.0

iteration 200 200 200

BI size 48 1.1e-006 2.8e-006 2.8e-006

BI size 96 1.3e-006 4.3e-006 4.0e-006

BI size 144 8.4e-007 1.9e-006 2.9e-006

BI size 192 1.9e-006 3.8e-006 4.5e-006

BI size 240 1.5e-006 5.2e-006 4.6e-006

BI size 288 5.1e-006 4.1e-006 3.8e-006

BI size 336 2.1e-006 1.0e-005 2.4e-005

BI size 384 1.4e-005 3.6e-006 3.9e-006

BI size 432 1.7e-006 6.5e-006 5.1e-006

BI size 480 6.0e-007 8.2e-006 2.2e-005

BI size 528 6.0e-007 3.7e-006 3.4e-006

BI size 576 1.7e-006 5.2e-006 3.2e-006

BI size 672 1.8e-006 3.0e-006 4.8e-006

BI size 720 1.8e-006 4.1e-006 2.3e-006

BI size 768 2.3e-006 6.4e-006 2.6e-006

BI size 836 8.9e-007 2.2e-006 2.8e-006

BI size 864 2.4e-006 1.3e-005 1.6e-005

BI size 960 6.1e-006 5.6e-006 3.9e-006

BI size 1008 1.7e-005 4.7e-006 3.5e-006

BI size 1056 5.0e-001 5.0e-001 5.0e-001

BI size 1152 2.3e-006 3.1e-006 3.2e-006

BI size 1248 1.8e-006 4.3e-006 5.1e-006

BI size 1344 2.7e-006 4.8e-006 2.7e-006

BI size 1440 1.7e-003 2.8e-006 4.2e-006

BI size 1536 5.3e-006 3.6e-006 3.6e-006

BI size 1632 8.7e-007 7.3e-006 3.2e-006

BI size 1680 2.0e-006 4.4e-006 3.2e-006

BI size 1728 4.2e-006 5.9e-006 3.7e-006

BI size 1824 1.9e-006 5.6e-006 1.9e-005

BI size 1920 9.1e-007 5.8e-006 1.8e-005

BI size 2016 1.5e-006 5.8e-006 1.6e-005

BI size 2112 5.0e-001 5.0e-001 5.0e-001

BI size 2208 2.6e-006 2.9e-006 5.0e-006

BI size 2304 1.3e-006 5.6e-006 1.7e-005

The above results show that for bit interleaving scheme K=1056 and 2112, BER=0.5. We found that these two interleaving schemes have overlapping indices in the permuting pattern.

The following are figures showing all simulation results. The two incorrect bit interleaving schemes are not included in the figures. In each figure, bit interleaving index 1 to 32 correspond to the bit interleaving schemes listed in Table 204 in P802.22/D1.0 excluding the schemes for K=1057 and 2112.



Figure 1: BER vs. BI scheme for QPSK 1/2, C/N = 7.0 dB



Figure 2: BER vs. BI scheme for QPSK 2/3, C/N = 10.5 dB



Figure 3: BER vs. BI scheme for QPSK 3/4, C/N = 12.5 dB



Figure 4: BER vs. BI scheme for QPSK 5/6, C/N = 15.5 dB



Figure 5: BER vs. BI scheme for 16QAM 1/2, C/N = 12.0 dB



Figure 6: BER vs. BI scheme for 16QAM 2/3, C/N = 15.5 dB



Figure 7: BER vs. BI scheme for 16QAM 3/4, C/N = 20.0 dB



Figure 8: BER vs. BI scheme for 16QAM 5/6, C/N = 23.0 dB



Figure 9: BER vs. BI scheme for 64QAM 1/2, C/N = 17.0 dB



Figure 10: BER vs. BI scheme for 64QAM 2/3, C/N = 20.5 dB



Figure 11: BER vs. BI scheme for 64QAM 3/4, C/N = 24.0 dB



Figure 12: BER vs. BI scheme for 64QAM 5/6, C/N = 26.5 dB

**3. Conclusions**

The simulation results show that in general, the new upstream subcarrier interleaving scheme {1512,2,5,5} performes better than the old scheme {1624,4,2,3}.

Some bit interleaving schemes have less satisfactory performances on the upstream or downstream. However, these bit interleaving schemes may perform good on the other stream.

We suggest that further investigations should be conducted to find alternative schemes for bit interleaving block sizes K=1056 and 2112, and keep the other bit interleaving schemes.

**Reference**

[1] 802.22 draft standard, P802.22/D1.0.