2004-11-04 IEEE C802.16e-04/469

Project	IEEE 802.16 Broadband Wireless Access Working Group <a href="http://ieee802.org/16">http://ieee802.org/16</a> >
Title	Ambiguity in PHY layer §8.3 OFDM frequency and timing requirements
Date Submitted	2004-11-04
Source(s)	Juergen Otterbach Joerg Schaepperle Roland Muenzner Torsten Fahldieck Alcatel SEL AG  Voice: +49-711-821-32255 Fax: +49-711-821-32453 Juergen.Otterbach@alcatel.de
Re:	802.16e D5 September 2004
Abstract	Correction of inconsistencies for 802.16e D5 PHY §8.3 OFDM
Purpose	Resolving ambiguity in PHY layer §8.3 OFDM
Notice	This document has been prepared to assist IEEE 802.16. 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 802.16.
Patent Policy and Procedures	The contributor is familiar with the IEEE 802.16 Patent Policy and Procedures <a href="http://ieee802.org/16/ipr/patents/policy.html">http://ieee802.org/16/ipr/patents/policy.html</a> , 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 <a href="mailto:chair@wirelessman.org">mailto:chair@wirelessman.org</a> 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 802.16 Working Group. The Chair will disclose this notification via the IEEE 802.16 web site <a href="http://ieee802.org/16/ipr/patents/notices">http://ieee802.org/16/ipr/patents/notices</a> .

2004-11-04 IEEE C802.16e-04/469

## Ambiguity in PHY layer §8.3 OFDM frequency and timing requirements

Juergen Otterbach / Joerg Schaepperle / Roland Muenzner / Torsten Fahldieck Alcatel SEL AG

## 1 Statement of the problem

In section 8.3.12 "Frequency and timing requirements" of IEEE802.16-2004 it is stated that the symbol clock frequency of the subscriber station (SS) "shall be synchronized **and** locked to the BS with a tolerance of maximum 2% of the subcarrier spacing". The wording here is ambiguous.

The subcarrier spacing is defined as follows:

$$\Delta f = F_s / N_{FFT}$$
 with 
$$F_S = floor(n*BW/8000)*8000$$
 
$$F_s = \text{sampling frequency}, \ n = \text{sampling factor} = \frac{8}{7}, \ \text{BW} = \text{nominal channel bandwidth}$$
 and  $N_{FFT} = \text{number of FFT points}$ 

In the case of BW = 10 MHz,  $N_{FFT}$  = 256, a subcarrier spacing of

$$\Delta f = floor(n*BW/8000)*8000 \div N_{FFT} = 44.625KHz$$

results. Two percent of this value corresponds to 892.5 Hz.

According to this tolerance the SS is allowed to transmit OFDM symbols with differences in duration as shown in Figure 1 with a Cyclic Prefix (CP) time of 1/4 of the "useful" symbol time assumed. The symbol time extension by the CP is 256/4 = 64 samples. The whole symbol is equivalent to 320 samples that correspond to symbol time  $T_s = 28.011\mu$ sec nominal.

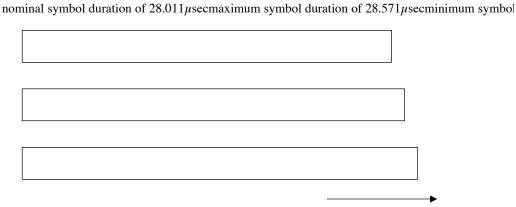


Figure 1: Possible differences in OFDM symbol duration

In a view of the Base Station receiver a nominal symbol duration of  $28.011\mu$ sec is expected. An UL OFDM symbol with maximum symbol duration of  $28.571\mu$ sec is 6.4 samples longer than the expected nominal symbol duration of  $28.011\mu$ sec. A detection of the short preamble using time domain correlator principles would fail.

Moreover the term "locked" is ambiguous, making it unclear whether the term "synchronized" applies to the synchronization of the SS to the BS or to the synchronization between the symbol clock frequency and the center frequency at the SS.

## 2 Proposed solution

2004-11-04 IEEE C802.16e-04/469

The above ambiguity could be solved by explicitly stating that the accuracy of the symbol clock frequency at the SS is guaranteed by its locking to center frequency at the SS, thereby exploiting the fact that through the requirement, that the symbol clock frequency and the center frequency are derived from a single reference at the BS, they have a fixed and predefined ratio.

## 3 Specific text changes

[Change the second paragraph in §8.3.12 as follows:]

8.3.12 Frequency and timing requirements

At the SS, both the transmitted center frequency and the symbol clock frequency shall be synchronized and locked to the BS with a tolerance of maximum 2% of the subcarrier spacing. Additionally the symbol clock frequency at the SS shall be locked to the center frequency at the SS which guarantees a tolerance for the symbol clock frequency at the SS of maximum 2% of the subcarrier spacing divided by the center frequency.