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Abstract	Timing precision in OFDM
Purpose	Resolving ambiguity in PHY layer OFDM
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Timing precision in OFDM

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1 Statement of the problem

There is a major ambiguity in section 8.3.12 of the standard relating to timing precision at the SS. There are two different interpretations of the text. This contribution presents the impact of this for different architecture and situations, and proposes a compromise solution

2 Justification

2.1 Different interpretations

The text in 8.3.12 requires the SS to be synchronized and locked to the BS:
"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."

It appears there are 2 very different interpretations of this text:
- the first understanding is that frequency and timing clocks at the SS should have the same relative precision. Therefore the 2% subcarrier spacing applies to carrier frequency precision, and the timing precision can be derived using a simple ratio calculation.
- the second understanding is that frequency and timing clocks at the SS should have the same absolute precision

Specifically, let us provide numbers:

Absolute precision
The value of 2% subcarrier spacing corresponds to:
312.5 Hz @3.5 MHz
625 Hz @7 MHz
900 Hz @10MHz

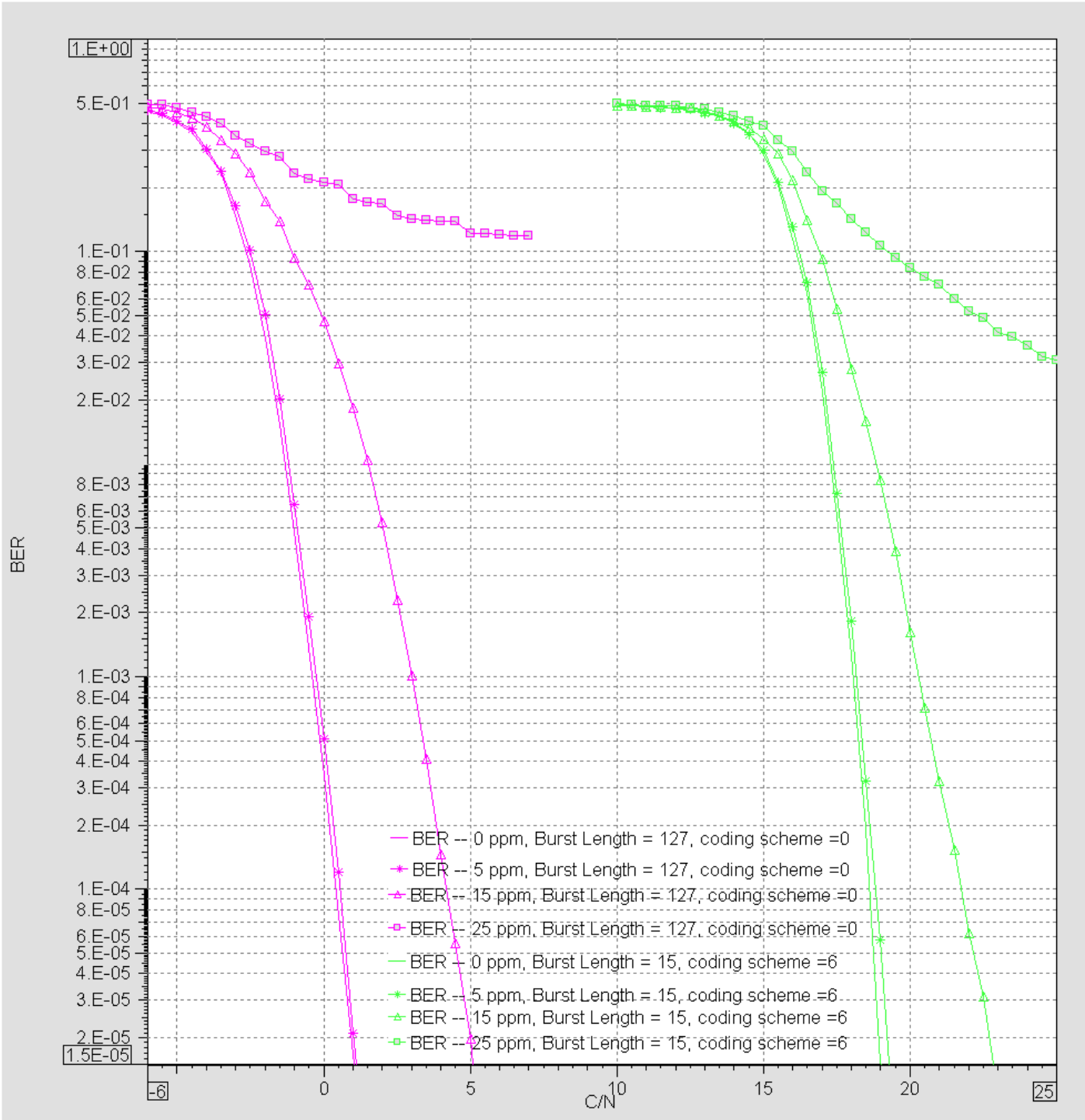
Relative precision
The relative precision implied by 2% subcarrier spacing related to carrier frequency is:
0.09 ppm @3.5 MHz, 3.5 GHz
0.18 ppm @7 MHz, 3.5 GHz
0.15 ppm @10 MHz, 5.8 GHz

2.2 Performance impact

As the SS is locked to the BS, the BS should not be tracking timing in the UL. Therefore it will be sensitive to a timing drift, that translates into a phase rotation. This phase rotation appears gradually during a burst, and therefore its effect is stronger for long bursts.

The following graph shows performance in BPSK 1/2 (coding scheme 0) and 64QAM 3/4 (coding scheme 6), for a burst of approximately 1500 bytes. This simulation has been conducted with an ideal transmitter

and receiver, introducing the timing frequency offset as only impairment. 4 values of relative timing offset (offset of the SS vs the BS) have been simulated : 0 ppm, 5 ppm, 15 ppm and 25 ppm.



These graphs show an acceptable degradation in both modulations with 5 ppm. At 15 ppm, the performance degradation is important. Specifically, the degradation brought by this impairment alone (not taking into account channel estimation and other impairments) makes it impossible to reach levels of performance as specified in 8.3.11.1, table 266 of 802.16-2004. At 25 ppm, transmission is impossible.

2.3 Analysis

As the above performance shows, it is possible that a BS that has made the assumption that the SS was perfectly locked still be able to demodulate an SS that is in fact not perfectly locked with for instance a 5

ppm offset. We therefore suggest as a compromise solution to differentiate in the text the requirement on the carrier frequency and timing frequency, and adopt 5 ppm as a requirement for the timing frequency precision.

3 Specific text changes

Add section 8.3.12, page 70

Modify 2nd paragraph:

“At the SS, both the transmitted center frequency and the ~~symbol~~ sampling clock frequency shall be synchronized and locked to the BS with a tolerance of maximum 2% of the subcarrier spacing for the transmit center frequency, and 5 ppm for the sampling clock frequency”