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Title	Power per subcarrier in downlink zones and DL preamble in OFDMA
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Re:	IEEE P802.16e/D2-2004
Abstract	Currently there is variance in the symbol power between preamble, first zone (PUSC) and other zones, which causes in-efficiency in the BS power amplifier. We suggest a remedy.
Purpose	Adopt changes
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Power per subcarrier in downlink zones and DL preamble in OFDMA

Yuval Lomnitz, Uri Perlmutter, Eyal Bick, Dov Andelman

1.   Motivation

The current definitions in the standard are that preamble subcarriers are boosted by 9dB and the nominal power per tone is the same power across permutation/STC zones. The definitions of preamble boosting originate in early stages of the standard before PUSC was introduced, and are suited only for full-reuse (FUSC, or PUSC with all subchannels). However, when PUSC with partial subchannels is used (e.g. for reuse 1:3), then since the number of subcarriers in the PUSC zone is lower than in other zones, the average power of the transmitted signal used in the PUSC zone is much lower than the power in zones with full-use and of the preamble.

This means that for reuse-1:3 system, the preamble is the limiting factor on the BS power amplifier (or regulations), and power used for PUSC zone will be about 5dB lower than planned. This reduced the range of reuse 1:3 systems by an equivalent of **5dB**.

We propose to change the preamble boosting levels, and allow more flexibility in power changes (in the power per tone) between zones.
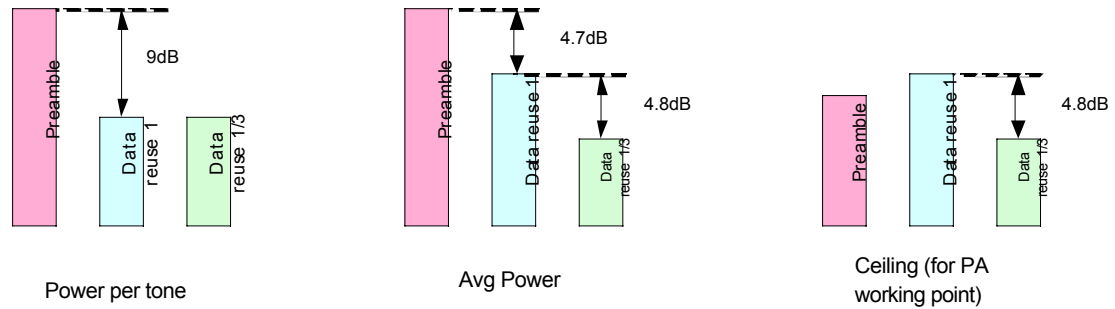
2.   Details

2.1.   Preamble boosting

In this part we deal only with the problem of the preamble boosting and how it affects the first zone immediately after the preamble. Later we'll discuss other zones.

2.1.1.   Problem description

Preamble boosting of 9dB (8) is currently defined. Since every 3rd tone is used, the overall power in the preamble is by $8/3 = 4.26$dB higher than the nominal power of full reuse symbols. Since the peak to RMS of the preamble is about 5dB, which is by at least 5dB lower than the peak to average of normal OFDMA transmission, the preamble matches an "FUSC" transmission in terms of required PA backoff.

Current situation

Preamble 9dB Data reuse 1 Data reuse 1/3

Power per tone

Preamble 4.7dB Data reuse 1 4.8dB Data reuse 1/3

Avg Power

Preamble Data reuse 1 4.8dB Data reuse 1/3

Ceiling (for PA working point)

However when using partial reuse, the power of the first zone is decreased. For reuse-1:3 the power is decreased by x3 (4.8dB). In these conditions, the BS will not be able to use full potential of it's PA, since the limiting factor is the preamble. The actual effect of the higher boosting of the preamble, is actually lowering of the power-per-subcarrier for the PUSC zone, and the range is affected by equivalent of 5dB !!

2.1.2.   Possible solutions

Solutions that were considered:

2.1.2.1.   Reducing the preamble boosting

The simplest solution is reducing the preamble boosting by 5-6dB, so that it will correctly match a reuse-1/3 system. The drawbacks of this solution are:
1. The preamble boosting will be mismatched to reuse-1 systems
2. The range of AAS systems may be affected

Regarding (1), reducing the preamble boosting doesn't have such a strong effect in reuse 1, because it only affects the channel estimation gain (only for noise-limited systems). From the calculation below (2.3), the degradation in performance for a noise limited reuse-1 system would be 0.4dB. So it seems worth it to sacrifice 0.4dB for reuse-1 in order to gain 5dB for reuse-1:3

For AAS systems, the extra range can be compensated by more complex synchronization mechanisms (taking into account preamble of several frames), but these complicate the system.

2.1.2.2.   Flexible preamble boosting

Leaving preamble boosting flexible means that the preamble cannot be used for channel estimation of the first symbols, because their gain is unknown. This causes a large degradation in performance (reducing channel estimation gain from ~10-14dB (depending on preamble boosting) to ~6.5dB (PUSC pilots only) => loss of 0.7dB at SNR=0dB).

2.1.2.3.   The proposed solution

The proposed solution is aimed to solve the problem for reuse 1:3 systems without affecting reuse 1 or AAS systems. The solution is to have 2 values of preamble boosting:
1. 9dB for full-reuse or AAS systems

2.   3dB for partial reuse and non AAS systems

The preamble gain will be indicated in the map and will be constant for any system. The SS will try to synchronize assuming a certain value for the preamble boosting. A mismatch in this value will not prevent reception of the DL-map since the map is coded in QPSK. After receiving a map, the SS will know the boosting value from the map. This value is guranteed to remain constant. The reason not to place this value in the FCH is that the FCH is not protected by an error detection mechanism (CRC).

2.2.   Power differences between zones

Power differences also exist between zones, from several reasons:
1.   Using partial reuse as opposed to full reuse
2.   Using part of the subchannels by simply allocating less than the maximum subchannels
3.   Varying the power by boosting

Currently, if a partial-use zone and full-use zone exist in the same frame, then the power of the full-use zone will be higher, thus creating the limiting factor on the PA power.

We suggest to enable the BS to determine the power level per zone, under a power constraint, required to enable proper AGC at the SS (see text changes).

2.3.   Calculation of degradation of reuse-1 system due to reduction of preamble boosting

The frequency-domain gain from the preamble is ~5dB, so with boosting of 9dB the channel estimation gain would be ~14dB. Together with the PUSC pilots (which have gain of ~4dB from frequency domain + 2.5dB boosting = 6.5dB), the SNR of channel estimator would be 14.7dB, causing implementation loss of 0.3dB (@SNR=0dB). On the other hand, if we reduce the preamble boosting to 3dB, the gain from the preamble is 5+3=8dB, combined with PUSC pilots is 10.3dB, and the implementation loss would be 0.7dB, so the degradation is 0.4dB.

3.   Changes summary

3.1.   Note for the editor

For clarity, the changes below are written as changes to the document 802.16-2004. Please apply the relevant changes to 802.16-2004-Cor1/D1 by copying these changes to the correct locations.

3.2.   Preamble boosting

8.4.5.1 DL-MAP PHY Synchronization Field

[make the following change in table 275]

Table 275—OFDMA PHY Synchronization Field

Syntax	Size	Notes
PHY_synchronization_field() {		
Frame duration code	87 bits	
Preamble boosting	1 bit	0 – boosting of 9dB, 1 – boosting of 3dB
Frame number	24 bits	
}		

[add the following text at the end of the section]

Preamble boosting
Indicates the level of boosting in the preamble (see 8.4.9.4.3.1). This value should be constant over frames and across the system. The SS should be able to decode the map without knowing this value since it is QPSK encoded.

8.4.5.2 Frame duration codes
[make the following change in the last line of table 274]

9-~~255~~ 127	*Reserved*

8.4.9.4.3.1 Preambles/midambles pilot modulation
[Change the subsection as follows (additions marked in blue text)]
The pilots in the downlink preamble shall follow the instructions in 8.4.6.1.1, and shall be modulated according to the following formula:

$$\text{Re}\{PreamblePilotsModulated\} = PreambleBoost \cdot 2 \cdot \left(\frac{1}{2} - w_k\right)$$

$$\text{Im}\{PreamblePilotsModulated\} = 0$$

Where PreambleBoost equals $2 \cdot \sqrt{2}$ if Preamble boosting is set to 0, and $\sqrt{2}$ if Preamble boosting is set to 1 (see 8.4.5.1).

3.3.   Zone boosting

8.4.4.2 PMP frame structure
[Add the following text at the end of the section under Figure 219]
Downlink zones except for the first zone may be boosted by multiplying the power per subcarrier by a constant factor. The same boosting shall apply to all symbols within the zone. However, the average power in any downlink symbol may not exceed the average power of the preamble by more than 4dB. Average power for a symbol is defined as a sum of squares of the gains (nominal power on linear scale, as resulting from boosting) of all active subcarriers in this symbol divided by N_fft.