Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**DL Preamble Boosting**
Date Submitted	**2005-05-04**
Source(s)	Joerg Schaepperle Alcatel SEL AG Joerg.Schaepperle@alcatel.de
Re:	Informational document on DL preamble boosting
Abstract	Clarification of the effects of DL preamble boosting on EVM and SNR
Purpose	Support comment #150 of letter ballot 17a on IEEE 802.16-2004/Cor1_D2
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 <http://ieee802.org/16/ipr/patents/policy.html>, 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 <mailto:chair@wirelessman.org> 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 <http://ieee802.org/16/ipr/patents/notices>.

DL Preamble Boosting

Joerg Schaepperle
Alcatel Research & Innovation

Problem

Preamble boosting seems to be optimized for data signals with a peak-to-average-power ratio of >8 dB. In this case the peaks of the optimized preamble are comparable with the peaks of the not optimized data signal. If the PAPR of the data signal can be reduced to 7 dB or below by using PAPR reduction techniques, the peak values of the preamble are higher than the peak values of the optimized data signal and increase the required power amplifier back-off. If preamble peaks are clipped, the EVM of the optimized preamble signals increases rapidly with decreasing clipping level. The advantage of preamble boosting with respect to preamble SNR is very limited and vanishes if the system is interference limited as it will be in most of the cases.

Background

According to current standard, preamble subcarriers are boosted by 9 B (factor $2\sqrt{2}$) Since only every 3[rd] subcarrier is used, the mean power of the preamble is 9 dB – 4.77 dB = 4.23 dB above the mean power of the data signal. Pilot boosting by about 2.5 dB (factor 4/3) reduces this difference by $10\log\left(\frac{\left(\frac{4}{3}\right)^2+6}{7}\right)\text{dB} = 0.45\,\text{dB}$

Assuming a data signal with 8 …9 dB peak-to-average ratio, the peak values of data and preamble are nearly balanced. But if the data signal is clipped to a value acceptable with respect to EVM caused by clipping, the peak values of the data signal are below the peak values of the preamble. Clipping to a PAPR of about 7 dB seems to be possible with a data EVM below 34 dB. The unbalance is increased if PAPR reduction methods like subcarrier reservation are used. The power levels of the preamble and data signals with different PAPR reduction methods are illustrated in Figure 1. Preamble PAPR varies between 3.9 and 4.5 dB depending on FFT size.

Although preamble SNR increases with preamble boosting there seems to be no significant performance gain.

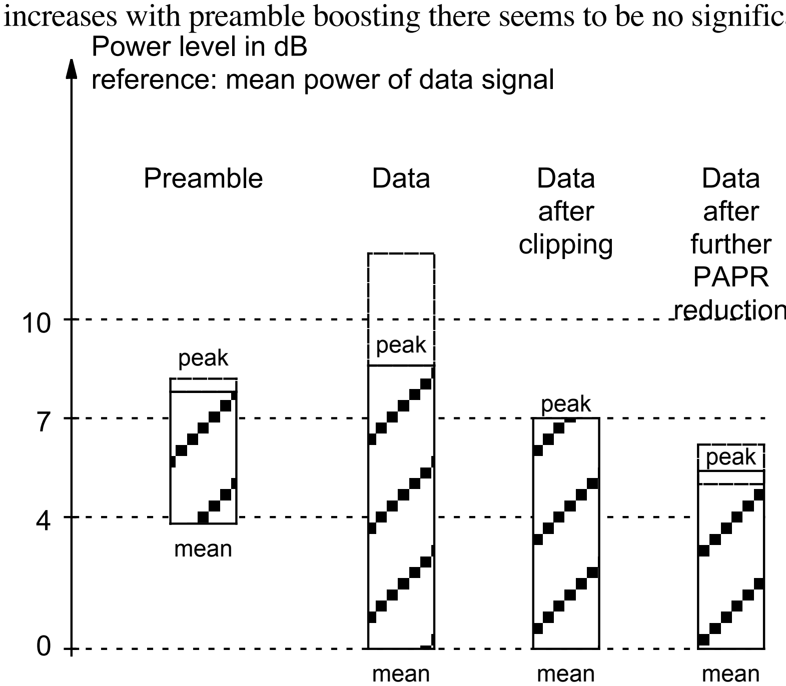

Figure 1: Peak and mean power levels of the preamble and the data signal with and without PAPR reduction

Figure 2 shows the EVM values for the preamble and the data signal caused by amplitude limitation (hard clipping) as functions of the achieved data PAPR. For PAPR ratios below 7 dB the preamble EVM is worse than the data EVM and prevents further PAPR reduction. At 7 dB PAR the preamble has no better EVM than the data signal. This means that there is no gain due to preamble boosting, when amplitude limitation is taken into account. Reducing preamble boosting would reduce preamble EVM without relevant loss in preamble SNR.
When using further PAPR reduction methods, the green curve for the data signal EVM will be shifted to the left, while the curves for the preamble remain the same, because they are already optimized with respect to PAPR.

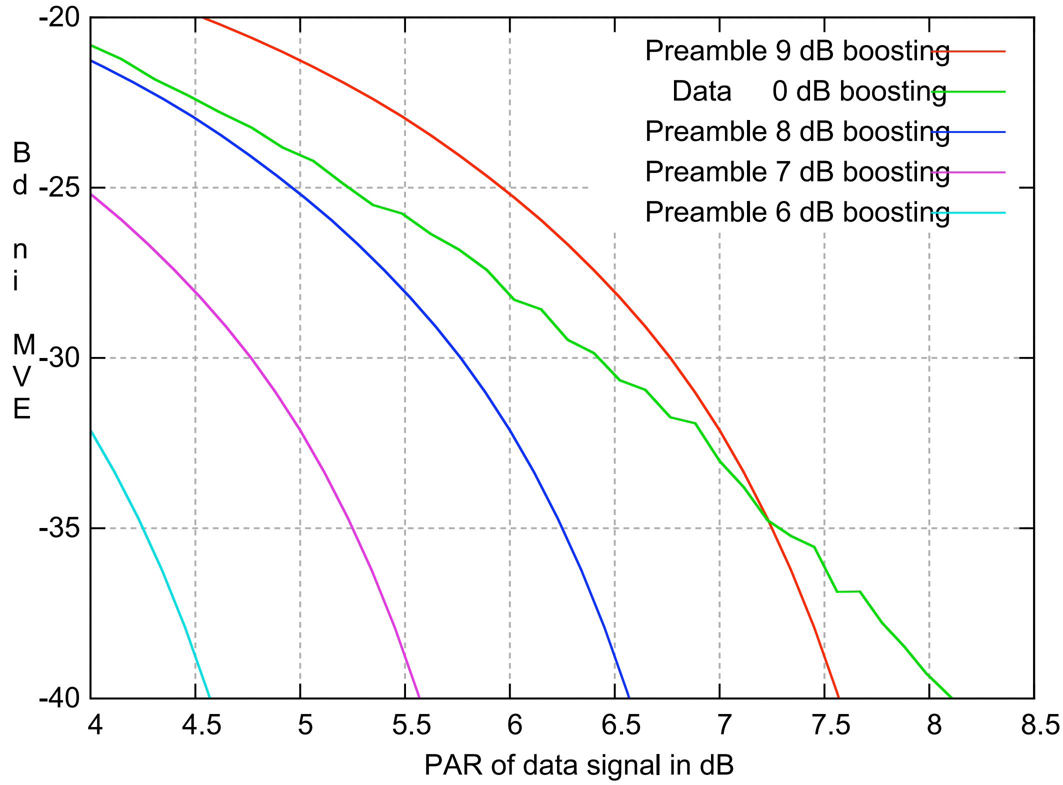

Figure 2: EVM for preamble and data signal caused by nonlinear clipping (amplitude limitation) in or before the power amplifier

In Figure 3 the preamble EVM due to noise at the transmitter and due to clipping at the peak levels of data signals with different PAPRs is shown as a function of the preamble boosting factor. Preamble EVM is calculated on the used preamble subcarriers only. Assuming that with simple clipping methods a data PAPR of 7 dB is achieved (data SNR > 30 dB), the optimum preamble boosting (minimum EVM) would be 8 dB (opposed to 9 dB in the current standard). Assuming that the data PAPR can be further reduced to 6 or 5 dB using reserved subcarriers, the optimum preamble boosting would be 7 or 6 dB respectively.

Similar values are obtained, if a noise power of 26 dB below the mean data signal power is assumed at the receiver. See Figure 4.

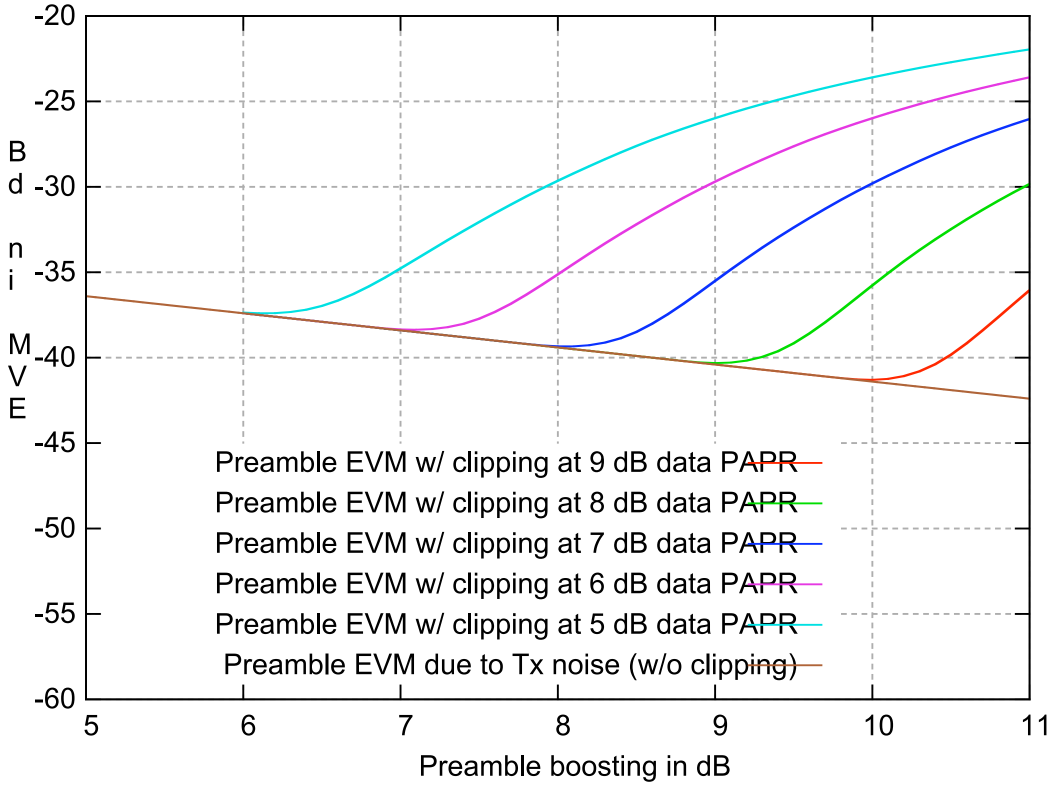

Figure 3: Preamble EVM due to noise and clipping with transmitter noise 31.4 dB below the mean power of the data signal

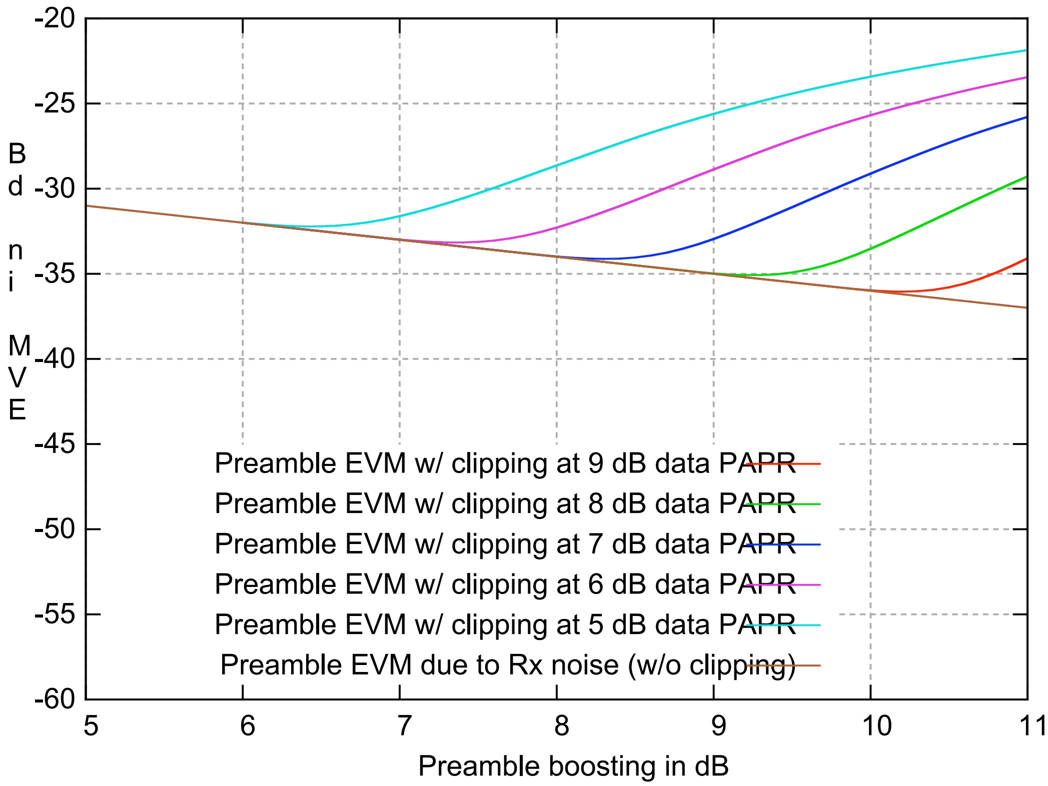

Figure 4: Preamble EVM due to noise and clipping with receiver noise 26 dB below the mean power of the data signal

Another problem is that, when using peak-to-average ratio reduction techniques for the data signal, preamble EVM and data EVM may be different. The standard currently only gives an EVM limit for the complete signal which is averaged over preamble and data. In the presence of amplitude limitation, the preamble EVM may be worse than the specified limit. This may be a problem for interoperability.

Furthermore, if the averaging time for measuring the peak of the transmitted power according to FCC regulation is in the order of magnitude of a symbol, high preamble boosting will limit transmitted power of the data signal.

Solution 1:

Keep current preamble boosting and introduce an additional requirement for preamble EVM in order to guarantee interoperability. This will require a power amplifier with higher peak power.

Solution 2:

Reduce preamble boosting by 1 … 3 dB. An additional requirement for the preamble EVM will not be required, if preamble peaks are always below data peaks. Potential problems with regulation due to higher peak power can be avoided. Preamble SNR seems to be sufficient also with reduced boosting.

Proposed Solution

Reduce preamble boosting by 3 dB.