Project	**IEEE 802.16 Broadband Wireless Access Working Group**
Title	**Degradation Limit on Receiver Sensitivity**
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Re:	Call for contributions on receiver sensitivity degradation limit of Broadband Wireless Access radios in meeting #4, Hawaii. This is a revision to the previously submitted document 802.16cc-99/30.
Abstract	Taking into consideration the internal and external factors contributing to increase in noise floor, limits on receiver sensitivity degradation are proposed and the noise level associated with these levels are calculated.
Purpose	It is proposed that 802.16.2 (Coexistence Task Group) adopt the limits proposed in this document as the recommended limits on receiver sensitivity degradation within the Recommended Practices Document.
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Degradation Limit on Receiver Sensitivity

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Introduction

Receiver sensitivity determines the minimum detectable signal and is a key factor in any link design. However, as the level of receiver noise floor increases, the sensitivity degrades. This, in turn, causes loss of cell coverage and revenues. The factors contributing to the increase in noise power divide into two groups, internal and external. The Internal factors include, but are not limited to, the noise generated by various components within the receiver. The external factors include, but are not limited to, intra- or inter-network co- and adjacent-channel interference.

Internal noise is dominated by thermal noise generated within the receiver and is formulated through introduction of noise factor (linear) or noise figure (dB).

Intermodulation and harmonic distortion is another source of internal noise. Nonlinear devices such as amplifiers create harmonics that raise the noise floor. The input level of the received signal(s), as well as the equivalent *n*th order Intercept Point (IP_n) of the receiver, determine the level of the harmonics. The effects of non-linearity of mixers and amplifiers are, therefore, captured by the concept of intermodulation.

Ambient thermal noise, *kTB*, is the major external noise into the receiver and its level directly affects the calculation of the receiver sensitivity. Addition of any noise power of any origin to this level increases the noise floor of the receiver. Other external noise sources are external intermodulation (either generated in transmitters or in passive components such as antennas and connectors) and co- or adjacent-channel interference from other cells/sectors within the network or across the network boundary.

Limit on Sensitivity Degradation

Any noise power additional to thermal noise contributes to sensitivity degradation. Degradation of receiver sensitivity reduces maximum range and degrades availability on the fixed-length link.

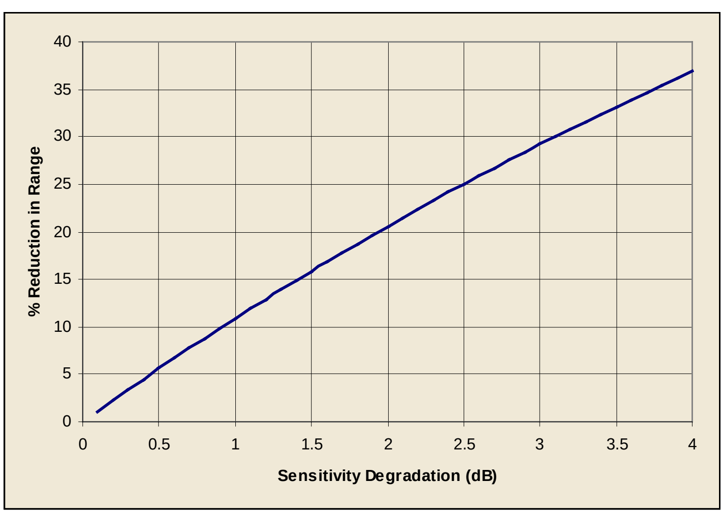

Figure 1. Range reduction due to RX threshold degradation

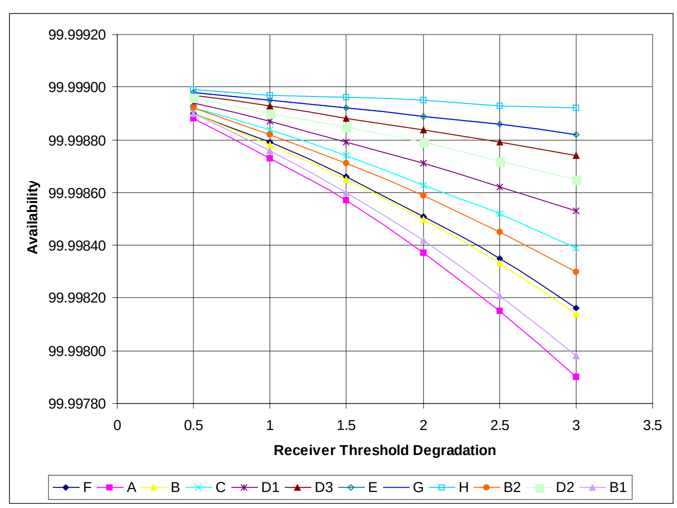

Figure 2. Availability versus RX threshold degradation

Figure 1 and 2 depict the effects of RX threshold degradation on range and availability, respectively. Typical QPSK data has been used on a 0.7 mile link with target availability of 99.999% in the case of figure 2.

If ΣI is the total noise power added to the thermal noise, consisting of co-channel and adjacent channel interference as well as all the intermodulation power within the passband of the receiver, then [1],

$$\frac{S_2}{S_1} = 1 + \frac{\sum I}{kTBF_T}.$$ Equation 1

F_T= Total equivalent noise factor of the receiver

S_1 = Sensitivity with thermal noise

S_2 = Sensitivity with thermal noise and additional noise power.

$$\Sigma I = P_{\text{i-co}} + P_{\text{i-adj.}} + P_{\text{IM}} + P_{\text{coex.}}$$ Equation 2

$P_{\text{i-co}}$ and $P_{\text{i-adj.}}$ are the internal co- and adjacent channel interference power of the BWA network. P_{IM} is the total intermodulation noise power in the receiver band and $P_{\text{coex.}}$ is the total interference power from coexisting BWA networks.

Self-protection

Recommended Text:

It is recommended that the total effect of noise of any source additional to thermal noise at the receiver input (ΣI) and noise factor of the receiver, F_T, degrades the receiver sensitivity not more than **3 dB** at any point in time. Therefore, for any given receiver with a given F_T, the maximum total interference power allowed into the receiver should be less than or equal to

$$\left(\sum I\right)_{\max} \le kTBF_T.$$ Equation 3

The interference power, however, could be controlled with filters and other control mechanisms in the radio. It is recommended that the receiver should monitor the rise in noise floor and the control mechanisms, such as variable attenuators, kick in at the receiver sensitivity degradation level of **3 dB**.

Coexistence

Recommended Text:

In order to reduce the contribution of coexistence in the overall ΣI, appearing as $P_{\text{coex.}}$, it is recommended that the effect of any BWA network on any other coexisting BWA networks should not degrade the receiver sensitivity of the coexisting BWA networks more than **1 dB**.

This is equivalent to

$$P_{coex.} = 0.26kTBF_T.$$ Equation 4

Therefore, if the interference power of a BWA network at the receiver of any coexisting BWA network exceeds the value in Equation 4, the coordination process, as discussed in section ___ of this document, needs to be triggered.

References

[1] Arefi, R., Etemad, K., “Effect of Intermodulation Noise & Distortion on Performance of Broadband radios”, Proceedings, 6th Annual WCA Technical Symposium, November 15-16, Dallas, 1999.