Rician K-Factor Statistics for Broadband Fixed Wireless Access Accurate Channel Modeling

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Broadband fixed wireless access (BFWA) networks operating at frequencies above 10GHz have recently evolved and matured to the degree of being standardized by various international institutes. Indicative is the release of the IEEE 802.16 WirelessMAN and the ETSI BRAN HIPERACCESS standards for systems occupying the 10-66GHz frequency range. A major concern when designing BFWA networks at frequencies above 10GHz is the existence of clear line-of-sight (LOS) path between the base station and subscriber stations. Rain attenuation is the dominant factor limiting the system reliability and cell coverage (ITU-R Rec., P.1410-2, 2003). In addition to severe attenuation, rain introduces a short-term stochastic behavior to the received signal. This suggests that, even if clear LOS exists, a reasonable amount of multipath propagation is possible, which may also result from scattering from adjacent buildings and vegetation, as well. Therefore, the fading channel of a BFWA link can be modeled as Rician with strong K-factor.

The Rician distribution of the received signal amplitude in a BFWA system was also suggested in (Xu et al., *IEEE JSAC*, 18 (3), pp.310-321, Mar.2000) where the Rician K-factor (in dB) was expressed as a function of the rain rate R (mm/hr). The results provided there were based on empirical data obtained from a measurement campaign at 38GHz in Blacksburg, VA and so, are frequency, climate and site specific. The proposed analysis here, however, is based on general assumptions about rain process, takes into account the predictions of ITU-R rainmaps (ITU-R Rec. P.837-4, 2003) and so, can be applied in global scale to any case of BFWA system and depict the effect of rain attenuation on the wideband multipath behavior of a BFWA channel. We particularly provide an analytical model calculating the cumulative distribution function (CDF) of the Rician K-factor which is defined as the ratio of the average received power on the direct LOS path (*coherent power*) to the average received power via the diffused multipaths (*incoherent power*). According to the Central Limit Theorem, for sufficiently large number of multipaths, the sum of the randomly received multipath components can be approximated by a complex Gaussian random variable, and so, the overall received signal can be expressed as the sum of the direct LOS component plus one complex Gaussian diffused one. We assume that both components propagate through the same rainfall medium and along the same path lengths and so, at the receiver, the difference between the rain induced attenuations on each represents the so-called differential rain attenuation (DRA) (Panagopoulos and Kanellopoulos, *IEEE Trans. Antennas Prop.*, 52 (9), pp.2514-2517, Sep.2003). Taking the above considerations into account, one can express the Rician K-factor (in dB) in terms of DRA. The nominal value of Rician K-factor under clear sky conditions is also necessary to be defined.

The proposed model has been tested numerically and the impact of crucial operational and geometrical parameters such as operating frequency, receive antenna beamwidth and climatic conditions is presented. Some significant conclusions have been drawn such as that as the operating frequency increases, or as the subscriber antenna beamwidth increases, or as the rain climatic conditions become more severe, the coherent power decreases, the incoherent multipath power increases and the Rician K-factor decreases, correspondingly. To sum up, an analytical propagation prediction model for the Rician K-factor distribution in a rain fading channel has been derived, which can be applied in global scale and may be very helpful during BFWA networks modeling, design and specification.