Uplink diversity gain

This is a summary of some of information contained in [1].

At a typical three-sectored cellular base station, each sector usually provides diversity reception of two receiving antennas separated by 10 ft. The reduction in required uplink signal power is called the diversity gain. The gain (G in dB) with partial correlation is approximately related to the gain G_0 with no correlation by [2-10]

$$G = G_0 + 10 \cdot \log_{10} \sqrt{1 - \rho_e}$$

Equation 1

where ρ_e is the envelope correlation coefficient. This equation is a rephrasing of [2-10, Eqs. (5.2-24) and (5.2-26)], wherein ρ^2 corresponds to ρ_e and these relationships are valid for all practical values of outage probability (i.e. a few percent or smaller) and ρ_e (i.e. $\rho_e <= 0.9$). The specific value of G_0 depends on the type of modulation, type of diversity and specified outage probability, but it can be assumed to be several decibels or more in any practical system.

The quantity ρ_e has been modelled by assuming a Gaussian angle-of-arrival spectrum for uplink multipath rays [3-11]. Since the angular spread of this spectrum is small for typical base stations, ρ_e becomes

$$\rho_e = \exp\left[-2\pi\sigma\left(D/\lambda\right)\cos\alpha^2\right]$$

Equation 2

where D is the antenna separation, λ is the wavelength, σ is the standard deviation (in radians) of the angle of arrival spectrum, and α is the angle of the direction toward the mobile with respect to the normal to the line between the diversity antennas.

Recently, the lack of knowledge about σ in [3-11] and [4-12] has been addressed by an analysis [5-13] of published measurements of Rhee and Zysman [6-14] at 821 MHz, using the Gaussian model from Equation 2. This analysis led to a quantification of σ by the following empirical formula:

$$\sigma(d) = 0.0312 d^{-0.43} \text{ rad}$$

Equation 3

where d is the base-to-mobile distance in miles. This formula is expected to be approximately valid in the range 1-10 miles. Over this range $\rho_e <= 0.9$ in both bands, and so Equation 1 is valid.

Man-made noise

Man-made noise density in dB above kT_0 is reported in [7-15] versus frequency for both urban and suburban environments. A good functional fit to the suburban result is

$$10\log_{10}\left(\frac{P_{mm}}{kT_0}\right) = 24 - 23.1 \cdot \log\left(\frac{f}{100}\right)$$

Equation 4

where *f* is in MHz. The result shown in [5-13] for urban environments is 16 dB greater at all *f*, but this appears to be an extreme worst-case result. It is assumed here instead that the urban man-made noise density is 8 dB higher than in Equation 4, i.e. 24 is replaced by 32.

The above results apply to the downlink, where the receiver at ground level is surrounded by the various sources of man-made noise, and that the noise densities are 2 dB lower at the other end, i.e. at the base-station antenna [8-16]. This noise density is reduced because part of the base-station antenna patterns is not receiving man-mad noise. Man-made nose in rural environments is expected to be much weaker than in urban or suburban environments (very conservatively a zero in both bands and in both directions).

References

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Version history

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