Training Program : Point-to-Point Radio Link Design

Course : Multipath Fading

COMPLEMENTS to Lesson 2 : Multipath Events and Impairments

Undistorted Signal Transmission

Undistorted transmission of a signal is achieved when the transmission system output is simply a copy of the transmitted signal x(t), with some time shift (τ) and an amplitude factor (K). Therefore, the received signal y(t) can be expressed as:

$$y(t) = K\, x(t - \tau)$$

Taking the Fourier Transform of this equation, with the time shift applied to the x(t) signal, we get :

$$Y(\omega) = K \exp(-j\,\omega\,\tau)\, X(\omega)$$

From this equation we see that, in the frequency domain, the requirement for the channel transfer function $H(\omega)$ is :

$$H(\omega) = Y(\omega) / X(\omega) = K \exp(-j\,\omega\,\tau)$$

Finally, the channel transfer function modulus $|H(\omega)|$ and phase $\theta(\omega)$ must be:

$$|H(\omega)| = K \qquad \theta(\omega) = -\,\omega\tau$$

This means that:

- the amplitude response of the transmission channel must be a constant for all frequencies;
- the phase response must be a linear phase with slope ($-\tau$), corresponding to a group delay τ.

The above requirements are to be satisfied within the whole bandwidth occupied by the transmitted signal.

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Field Experiments

Field experiments can be divided in two categories, depending on the final goal and use of experimental data:

a) experiments aimed to investigate multipath mechanisms and to obtain statistical data on multipath channel parameters, in order to build statistical models useful for performance predictions.

b) experiments aimed to test radio equipment, often with different receiver configurations, to check system performance in working conditions, to evaluate improvement given by multipath countermeasures, and to compare observed results with model predictions.

In the first case, experimental data generally include: Rx power level recordings, measurement of multipath channel selectivity (amplitude and group delay), fading correlation on space diversity receivers, same for frequency diversity, effect of path length on multipath activity, etc.

The second kind of field experiments is mainly addressed to correlate propagation conditions with performance results; to this goal, the Bit Error Rate (BER) is recorded together with Rx power level and (possibly) with estimates of channel selectivity; quite often, different receiver arrangements are tested, in order to compare equalized and unequalized receivers, single and diversity configurations, etc.

See References below with some examples of field experiment reports.

Po Models

The ITU-R model derives from the processing of a significant amount of Po estimates, at several frequencies (up to 37 GHz) and with various path lengths in different climatic environments.

The mathematical approach is mainly based on minimizing the standard deviation between empirical data and prediction formulas by means of curve fitting with multiple regressions.

The positive aspect is that the model is well related to observations in real links. It is stated that the overall standard deviations of error using the proposed models is of the order of 5 dB (including the contribution from year-to-year variability).

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On the other hand, a physical model underlying formula structure and parameter choice is not clearly defined, so that it appears that the proposed approach could be revised on the basis of a new experimental database, as already happened in recent years.

Useful References

[1] Barnett W.T. "Multipath Propagation at 4, 6, and 11 GHz", BSTJ, Vol. 51, n. 2, 1972

[2] Rummler W.D, “A New Selective Fading Model: Application to Propagation Data", BSTJ, Vol. 59, n. 5, 1979

[3] Rummler W.D., "Time- and Frequency-Domain representation of Multipath Fading in Line-of-Sight Microwave Links", BSTJ, Vol. 59, n. 5, 1980

[4] Moreno L. and Vicini P., "Field trial results of 140 Mb/s 16QAM digital radio under multipath propagation", IEEE GLOBECOM '83, San Diego (CA), 1983

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