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Effect of multipath amplification in chaotic communications

Yu.V. Andreyev*, A.S. Dmitriev, A.V. Kletsov

Institute of Radio Engineering and Electronics of RAS, Mokhovaya st., 11-7, Moscow, 125009, Russia
* Electronic Address: yuwa@cplire.ru

Here we discuss an effect of multipath amplification that was found in ultrawideband wireless communication systems with chaotic carrier. This effect is pronounced in multipath environment represented by indoor residence, office or industrial space, warehouse, etc. Under certain conditions nultipath environment can function as a sort of a "lens" or a "set of mirrors" that collects the tranmitter energy, that would have been lost in the case of free space, to the receiving point.

This effect was found in direct chaotic communication systems, in which information is encoded with chaotic radio pulses. Since the autocorrelation function of chaotic signal decays rapidly, the beams at the receiver input that have come from different directions with different delays appear practically uncorrelated, hence the are summed by power not by amplitude. Thus, unlike narrowband signals, there is no fading in such a system and summation of chaotic signals always increases the signal level at the input.

Inter-symbol interference is eliminated in this system by means of guard intervals between the pulses. However, the duration of radio pulses and guard intervals must be chosen with care so as to provide necessary transmission rate and energy efficiency.

A special issue of such a system is receiver, because the effect of multipath amplification depends on the receiver type. For example, correlation receiver is ineffective here, because (1) it's difficult (if ever possible) to have in the receiver a copy of chaotic signal of transmitter, and (2) correlation receiver effectively receives the energy of only one beam whereas the other beams are perceived as interference signal that decreases signal-to-noise ratio. Analysis shows that the optimal receiver for direct chaotic system in multipath environment is incoherent receiver, i.e. envelope detector (a simple receiver with quadratic detector and low-pass filter). It can be regarded as "rake" receiver for chaotic signals, because it collects the energy of all the beams coming to its input.

Thus, the conditions for multipath amplification effect are: use of chaotic signals; noncoherent receiver; certain relation between the durations of radio pulse, guard interval and multipath channel delay spread.

Multipath amplification effect gives 5-15 dB energy efficiency gain (depending on the channel), thus increasing correspondingly the signal-to-noise ratio at the receievr input, which extends the system operation range by factor of 2-6 for the same transmitter power.