Keynote: “Power line channels: frequency and time selective”

Part 2.- Part 2.- Noise statistics of indoor PLC channels. This keynote discusses the behavior of noise in indoor power line communications (PLC) channels. Some ideas to improve system performance based on the knowledge of PLC noise are also introduced.

The power-line noise at an outlet is the sum of noise waveforms produced and emitted to the lines from the appliances connected to the power-line network. In the design and the analysis of wireless communication systems, stationary additive white Gaussian noise (AWGN) is often assumed. In PLC systems, however, the statistical behavior of the man-made noise is quite different from that of the stationary AWGN.

The fact that the noise in power-lines is not AWGN is often believed to be a cause of low quality of communications. However, Gaussian is the distribution of the largest entropy, and communications under non-Gaussian noise may achieve better performance if the system is designed to adapt the noise statistics. In other words, PLC systems retain large potential for performance improvement if the behavior of the noise is clarified and taken into account in the system design.

For narrow-band indoor PLC, we have a mathematically tractable and accurate model based on experimental measurements. In this model, the noise is expressed as a Gaussian process whose instantaneous variance is a periodic time function. With this assumption and representation, the cyclostationary features of power-line noise can be described in close form formula with a small set of parameters.

In wide-band indoor PLC, we have made measurements with high speed sampling (50MHz) with long observation duration (10.4s). The measured noise is represented on a time-frequency plane, and its stochastic properties are discussed. Cyclostationary features of the noise in each frequency sub-band are confirmed. It is found that the amplitude distribution in each sub-band is different and that Gaussian noise model is not a good approximation in higher frequency bands. It must be mentioned that the noise waveforms in sub-bands have large correlations.

Thermal noise dominates noise statistics in many wireless systems, and the noise waveforms at a transmitter and a receiver are independent. In PLC systems, however, the dominant factors of noise sources are electrical appliances connected to a power-line network, and it can be expected that the noise waveforms at different outlets have correlations. In fact, we have shown that the noise waveforms taken simultaneously at two different outlets in the same power-line network are not independent, and if the outlets are connected to the same live conductors, even instantaneous voltages of noise have high correlations.

In summary of the above discussions, the noise in PLC is non-stationary in time, non-white in frequency, and even non-independent at different outlets. These peculiar features of PLC noise can be employed in designing PLC systems. For example, adaptive coding and modulation can be introduced based on the non-constant noise level in time and frequency. The knowledge of the noise level also can be employed for optimum reception of the signal. In addition, the correlations of noise waveforms in frequency and outlets give us the possibility to estimate noise behavior at different sub-bands and locations.