Coded FSK and SFSK Performances Analysis under The Narrow-Band PLC Channel

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In this paper, two decision methods for the uncoded frequency shift keying (FSK) are detailed and their extension to the coded FSK using the permutation coding are proposed. The performance results of the different methods are compared under the real indoor NB PLC channel attenuation and impulse noise. The decision schemes are mainly the probability density function (PDF) based system for the Spread FSK (SFSK) and the Non-PDF-based system (select largest) for the conventional FSK (called FSK/SL). The BER performances of the different techniques prove that the coded Select Largest system achieves good performance results in the PLC constraints while having a low complexity, in comparison with SFSK system.

The narrowband PLC channel constraints considered for the performances' evaluation of the proposed techniques are based on measurements of the indoor PLC channel characteristics in the frequency band from 10 kHz to 500 kHz [1]. In this work, one measured channel, having an attenuation varying from -5 dB to -54 dB and a frequency selective behavior, is used. Its transfer function is illustrated in Fig. 1. As for the impulse noise, it is generated based on the time domain expression of damped sinusoids, which represent the form of the majority class of single pulses, as well as the stochastic model [2, 3].

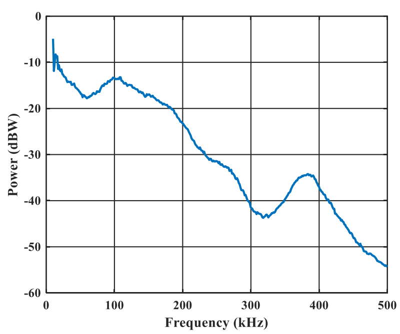

Fig. 1. Measured PLC channel transfer function.

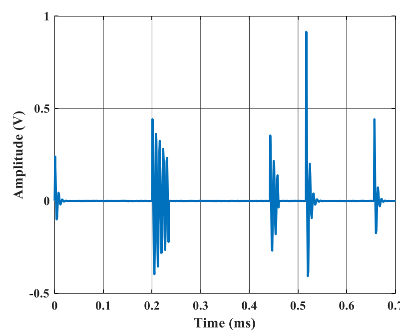

Fig. 2. Example of the generated impulse noise.

Permutation coding has the advantage of adding time and frequency diversity to the system with the possibility of low complexity decision such as the threshold-based hard decision [6, 7]. In fact, a permutation code C has |C| code words, each of length M, and the minimum Hamming distance between two codes is d_{min}. Every code word is represented by an $M \times M$ binary matrix to be used for decoding, where rows describe the output for the detector at frequency f_i, $i=1,..,M$ and columns represent the time interval T_j, $j=1,..,M$, in which it occurs. The considered systems are based on the classical non coherent binary FSK transceiver.

For the classical FSK system, the uncoded decision compares directly the output of the envelope detector and chooses the largest as the emitted bit. Similarly, for the coded system, the code word having the highest magnitude is chosen.

Concerning the SFSK receiver, it adds a specific decision unit to the classical non-coherent FSK envelope detector that estimated the channel and noise parameters to calculate the conditional probability density functions (PDF) of the received signal. For the coded SFSK system, the decoding process calculates the probability of receiving a given code word knowing the received matrix, it is based on the Maximum Aposteriori Probability (MAP) demodulator [7].

The performances of the coded and uncoded systems are first assessed in the Gaussian channel. The obtained curves are displayed in Fig. 4. The uncoded systems BER curves are conform to the theoretical curve. Besides, the coding brought a gain up to 3 dB for both methods FSK/SL and SFSK.

The systems are then tested under the channel transfer function of fig. 1 and the impulse noise effects and their performances are gathered in Fig. 3. It can be seen that all the curves have an almost constant BER for high SNR value. This error floor is caused by the omnipresence of the impulse noise and its high energy levels. Nevertheless, permutation coding is efficient in mitigating the impulse noise effect since lower error floors are achieved. For both uncoded and coded systems, SFSK achieves the best performances, with error floors equal to 7×10^{-5} and 2×10^{-6} respectively. However, even though the coded SFSK has better performances than the coded FSK/SL (C FSK/SL) performance, the latter has an interesting performance since an important gain in complexity is achieved and error floor is equal to 6×10^{-6} which is an excellent result regarding the low complexity. Besides, the difference in the performances appear from SNRs higher than 15 dB.

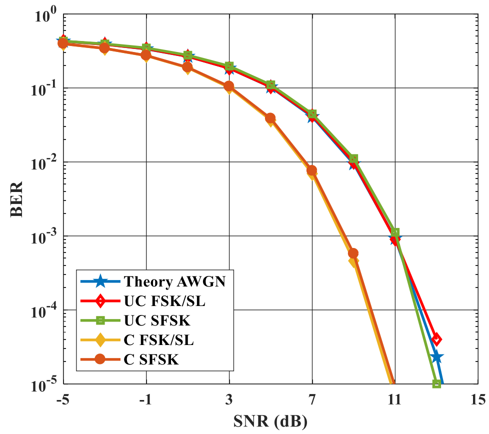

Fig. 3. BER versus SNR performances of the coded and uncoded systems in the Gaussian channel.

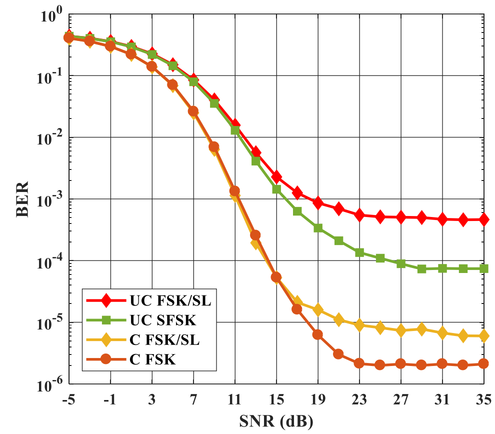

Fig. 4. BER versus SNR performances of the coded and uncoded systems in the PLC channel transfer function and impulse noise environment.

The complete description of the systems and their performances in the different combinations of impulse noise and channel effect will be presented in the full paper.

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