PERFORMANCE EVALUATION OF PLC SYSTEMS UNDER NON-GAUSSIAN ADDITIVE NOISE

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Certificate

This is to certify that the thesis entitled **"PERFORMANCE EVALUATION OF PLC SYSTEMS UNDER NON-GAUSSIAN ADDITIVE NOISE"** being submitted by **Mr. AASHISH MATHUR** to the Department of Electrical Engineering, **Indian Institute of Technology Delhi**, for the award of the degree of **Doctor of Philosophy** is the record of the bona-fide research work carried out by him under our supervision. In our opinion, the thesis has reached the standards fulfilling the requirements of the regulations relating to the degree.

The results contained in this thesis have not been submitted either in part or in full to any other university or institute for the award of any degree or diploma.

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Abstract

Power line communications (PLC) is the use of power lines for the dual purpose of power transmission and data communication. PLC has recently grabbed significant attention of researchers owing to its potential to cater to the demand for high speed access to video and data, widespread availability, and huge geographical coverage area. However, the variation in the key parameters, such as noise, channel impedance, and attenuation with time, frequency, and distance makes it difficult to model a PLC channel thereby rendering it hostile for communication.

The additive noise in PLC is broadly categorised into background noise and impulsive noise. While the background noise is modeled by the Nakagami-m distribution, the impulsive noise follows the Middleton class A distribution. Besides additive noise, PLC channel also suffers from multipath effects and impedance mismatches resulting into multiplicative noise. Various efforts have been made by the researchers to model the PLC channel. Rayleigh, Rician, and Log-Normal distributions are commonly used to model the PLC channel gain.

In literature, threshold based detectors are used to determine the value of transmitted data over a PLC link under the influence of Nakagami-m background noise which results in a suboptimal performance. In this dissertation, we derive the condition for optimal detection of binary and quaternary transmitted data in a PLC system subjected to Nakagami-m additive background noise. Numerically computable expressions for the analytical average bit error rate (BER) and symbol error rate (SER) of the considered system are derived using the copula approach. It is observed that the proposed detector significantly outperforms the existing threshold based detector.

Further, we perform a detailed performance analysis of PLC systems under the influence of Rayleigh, Rician, and Log-Normally distributed channel gains in the presence of Nakagami-m background noise. In order to gain a better understanding of the PLC systems, we investigate the BER performance of a PLC system under the combined influence of Nakagami-m background noise and Middleton class A distributed impulsive noise. It is seen that due the detrimental effect of the impulsive noise, the BER performance does not improve with the signal-to-noise ratio (SNR) once the impulsive noise starts to dominate the background noise. We also evaluate the BER and outage performance of a PLC system subjected to Rayleigh distributed channel gain in the presence of both background and impulsive noises by considering an accurate non-uniformly distributed model for the phase of the background noise.

Because of the fluctuating nature (small block fading duration) of the PLC channel, it is not possible to obtain perfect channel state information. The periodic changes in the channel transfer function make it difficult to estimate the carrier phase. Additionally, the presence of impulsive noise at the switch-overs of transfer functions increases the problem in PLC channel estimation. Thus, differential modulation schemes can be utilised to overcome this difficulty as exact channel knowledge is not required. We evaluate the performance of a PLC system assuming differential binary phase shift keying (DBPSK) modulation in the presence of both background and impulsive noises. We use a least square detector for the considered system in the presence of Nakagami-m background noise by using an accurate model for its phase. Closed-form expressions of the analytical average BER and outage probability of the considered PLC system have been derived. It is concluded that there is a 5 dB loss in SNR for DBPSK as compared to BPSK under Nakagami-m additive background noise for the considered PLC system. The detrimental effect of the impulsive noise is also observed on the BER and outage performance.

We also discuss an application of PLC systems to solve the range limitations of conventional wireless networks. There may be remote locations where wireless signals are unable to reach. Using a PLC link after a wireless link allows us to extend the network. We derive the equivalent end-to-end SNR of a dual-hop wireless-powerline mixed cooperative communication system using decode-and-forward (DF) relaying protocol. Closed-form expressions for the analytical average BER, outage probability, and the average channel capacity of the system are obtained. It is observed that the impulsive noise index and the probability of occurrence of the impulsive component of the Bernoulli-Gaussian noise of the PLC link significantly affect the performance of the considered cooperative communication system.

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Abbreviations

AWGN	Additive White Gaussian Noise
BER	Bit Error Rate
BPSK	Binary Phase Shift Keying
c.d.f.	Cumulative Distribution Function
DF	Decode-and-Forward
DBPSK	Differential Binary Phase Shift Keying
IAT	Inter Arrival Time
LLR	Log Likelihood Ratio
ML	Maximum Likelihood
p.d.f.	Probability Density Function
PLC	Power Line Communications
PSK	Phase Shift Keying
QPSK	Quadrature Phase Shift Keying
RV	Random Variable
SER	Symbol Error Rate
SNR	Signal-to-Noise Ratio