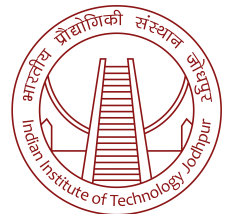


Physical Layer Security and Performance Evaluation of Power Line Communication Systems

A Thesis submitted by
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in partial fulfillment of the requirements for the award of the degree of
Doctor of Philosophy



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Conclusions and Future work

This chapter presents the final findings and conclusions of the study conducted in this thesis on PLC systems. The thesis also discusses areas that need further investigation and describes potential expansions to the existing work.

5.1 Conclusions

In this thesis, we evaluated the secrecy performance of DCSK-based PLC systems under correlated Log-normally distributed PLC wiretap channels. Utilizing the FGM Copula method, the PLS performance metrics in the form of SOP and SPSC were derived. Specifically, the FGM Copula demonstrates an accurate depiction of the correlation between the main and wiretap channels in terms of the dependence parameter. Further, in order to obtain an in-depth understanding of the performance of the PLC system, an asymptotic analysis was conducted. This analysis revealed a relationship between the secrecy coding gain and the secrecy diversity order. We also demonstrated an algorithm that maximizes secrecy while following SOP constraints. Furthermore, useful insights into the considered PLC system are revealed as follows:

- The SOP performance improved with increasing values of the average SNR of the main channel and deteriorated when the dependence between the main and wiretap channels increased. Similarly, the SPSC performance was better when transmitted power increased.
- Utilizing the algorithm, the optimal value of SNR is determined at which the secrecy throughput is maximized. It was noticed that secrecy throughput is better with a lower value of optimal SNR.
- The SOP and SPSC performance were degraded with the more arrival of the impulsive noise components into the considered PLC system. Moreover, we have compared the SOP performance of the proposed system with GCDSK, DS-DPSK, and CDMA. It was observed that the proposed system outperforms the GCDSK and CDMA for certain values of the spreading factor.

Next, we analyzed the secrecy performance of the considered PLC system in a multiple eavesdropper environment and utilized the DCSK modulation scheme by virtue of being capable of providing secure communication. The PLS performance of the considered PLC system was investigated by assuming two conditions a) when the main and eavesdropper channels were independent and b) when all the eavesdropper channels were correlated but independent of the the main channel. Further, the effect of correlation on secrecy performance is observed. It was shown that the higher correlation among eavesdropper channels helps in improving the secrecy performance of the considered PLC system. In order to comprehensively examine the secrecy performance, we formulated an optimization problem to maximize the secrecy throughput under security and reliability constraints. We have also proposed an algorithm to determine the optimal threshold value of the SNR

for a given SOP. It was found that the secrecy throughput maximizes with lower value of optimal SNR. Furthermore, we performed an asymptotic analysis of the SOP under correlated eavesdropper channels. Besides, some special cases are derived to obtain some useful insights, including asymptotic SOP analysis. Moreover, fruitful insights were obtained by analyzing the effect of various system parameters such as correlation parameter, impulsive noise occurrence probability, distance, transmitted power, number of eavesdroppers, impulsive noise index, and SNR on the considered system as follows:

- The ASC always improved with the increasing value of the average SNR of the main channel. When the number of eavesdroppers was increased, the ASC performance always decreased.
- The ASC performance of the considered system was better when the correlation among the eavesdroppers increased and ASC performance deteriorated with a higher occurrence probability of impulsive noise components and a larger value of the impulsive noise index.
- Similarly, the SOP performance was always better with an increasing value of the average SNR of the main channel. SOP performance was poor when the number of eavesdroppers increased and the arrival probability of impulsive noise increased. Further, the SOP performance was better when the correlation among the eyedropper channels increased and improved when the eavesdropper moved. farther from Alice.
- Moreover, we have compared the SOP performance of the proposed system with GCDSK, DS-DPSK, and CDMA. It was noticed that the proposed system outperforms the GCDSK and CDMA for a specific values of the spreading factor.

Further, we evaluated the performance of the considered PLC system in the presence of a random jammer, wherein, subjected to the state of the jammer, we computed the PDF of the instantaneous SJNR and the instantaneous SNR. Further, utilizing the statistical characterization of the SJNR and SNR, we derived the series-based expressions of the ASER and OP of the considered PLC system. In order to thoroughly investigate the ASER performance analysis, we performed the asymptotic analysis of the ASER. Herein, it was elucidated that the diversity order of the considered PLC system under the pulse jamming attack depends only on the shaping parameter of the main channel and is independent of the shaping parameter of the jammer channel, whereas the coding gain depends on both shaping parameters. Furthermore, some fruitful insights were exhibited by demonstrating the effect of the different system parameters through the numerical results in the following.

- The ASER performance always improved with the increasing value of the average SNR of the main channel and worsened when the value of $\mathcal{M}$ increased. Similarly, the ASER performance was also reduced when the jamming power increased.
- The ASER and OP performances deteriorated when the value of the probability of jamming increased. Besides, the OP performance decreased with a higher value of the occurring probability of impulsive noise components as well as the impulsive noise index.
- The proposed $\mathcal{M}$ -PSK modulation-based PLC system performed better than the DCSK, CDSK, and DS-DPSK modulation schemes.

5.2 Future Work

The investigations conducted in this thesis provide several avenues for future research, allowing researchers to further expand based on the insights of this study. The following are some

significant ideas for further research:

- This work investigated the PLS performance of PLC systems considering passive eavesdropping scenario. This work can be extended to analyze the PLS performance of PLC systems assuming active eavesdropping and colluding eavesdropping scenarios.
- In this work, we have focused on the performance of SISO and single-input multi-output (SIMO) PLC links. This work can be extended to evaluate the performance of MIMO PLC systems utilizing M-ary DCSK modulation scheme.
- In the future, the covert communication and spoofing can be investigated for PLC using the finite-block length communication. Besides this, non-orthogonal multiple access (NOMA) and simultaneous wireless information and power transfer (SWIPT) can be incorporated with PLC.
- Future work also includes exploring the integration of PLC with the other communications technologies such as, free space optical communication system (FSO), visible light communication (VLC) system, and unmanned aerial vehicles (UAVs).