



# **Performance Analysis of Power Line Channel Using Digital Modulation Techniques**

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**ABSTRACT:** Power Line Communication has been considered as a good candidate for “the last mile” solution and for home networking. However Power line is worse than other wired transmission medium due to its noise. This paper introduces power line channel modelling and to realize reliable data communication over PLC. This paper carries the first Power line Channel properties and noise behaviour. This paper discusses required techniques and basic knowledge in power line communication. Hence, information on how the concept of digital modulation scheme are introduced, how data will transmit through power line.

**KEYWORDS:** Power Line Channel, Digital Modulation Techniques, BER

## **I. INTRODUCTION**

Power line Communication Carries a data on conductor that is also used simultaneously for AC electric power transmission or electric power distribution to consumers. It is also called power line carrier [1]. The PLC technology (Power Line Communication) uses a Power Line for data communication. PLC Technology takes profit from the advantage of not requiring any additional wiring. Power lines were originally devised to transmit electric power from a small number of sources to a large number of sinks in the frequency range 50-60Hz [2].

The main advantage of PLC is the use of an existing infrastructure. The PLC communication takes place over the same lines that deliver electricity. This technique involves injecting a high frequency over AC carrier onto the power line and modulating this carrier with data originating from the remote meter or central station. Power line carrier techniques are used successfully and cost effectively for short distances [1].

## **II. RELATED WORK**

The basic principle of power line communications (PLC) is to use the existing electrical power line networks for telecommunication purposes. Over the years, power line networks have served as a medium of transmission and distribution of electricity signals. Until recently, communication over power lines was restricted to low-speed functions such as remote metering and operations management that serve the needs of power supply utilities. This limited scope of power line functions changed recently, on account of the tremendous demand for high-speed broadband multimedia communications.

A survey of the literature surrounding PLC is provided in this chapter. Undoubtedly, knowledge of the structure and properties of power line networks is essential for the examination and development of new PLC techniques and products. The historical development and the current advances in the PLC technology are outlined. Details about the contending modulation techniques and channel modelling methods are also provided. This chapter serves as a knowledge basis that will be used in later sections of the dissertation to investigate existing techniques and develop new ones to serve the aim of enhancing the performance of PLC systems.



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In [2] author analysed asynchronous noise in PLC system Using OFDM (Orthogonal Frequency Division Multiplexing). In this paper, the OFDM sub carriers are modulated using BPSK, 4-QAM and 16-PSK. OFDM performance analysis, for PLC system and under different sub-carriers modulation, has been carried out. In [3] author analysed and simulates the noise model in power line communication systems. They have discussed various aspects of PLC in this paper. It can save infrastructure cost such as installation of fibre optic cables and can reach to rural areas since the power line infrastructure is already present. Then the nature of PLC as a communication environment was analysed. In [4] author presents the study of the UWB (Ultra Wideband) transmission characteristics over household power line in a very high frequency band, from 50 MHz to 550MHz. The characteristics of indoor power line channels are examined for its use in UWB Communication in both measurements and software simulations. Firstly, broadband channel characteristics are measured in both frequency and time domain, followed by system level simulation of BER performance versus Eb/N0.

### III. PROPOSED ALGORITHM (POWER LINE CHANNEL)

#### A. Power line Transfer Function

Power line network, whose original design is not intended for data communication, shares some similarity to other wired networks, such as Ethernet and telephone local loop. Modelling the power line channel is tough task since its nature is unpredictable nature with frequency, time of day, geographic location and rural environment. The main parameters, taken into account are the impedance, attenuation and noise. Absolute impedance of the power distribution system up to 30 MHz has been carefully studied in several countries. A component model can be expressed by F matrix shown in equation [9].

$$\begin{bmatrix} V1 \\ I1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V2 \\ I2 \end{bmatrix} \dots\dots\dots (1)$$

Where A, B, C, D are the coefficient of F matrix. V1, I1 are input Voltage and input current. V2, I2 are output voltage and output current. All the coefficients are uniquely defined from an equivalent circuit model and coefficients can be mentioned as the model parameters of the component model by using two port models all the parameters can be calculated by the equation from [9].

$$A = \cosh(\gamma l) \dots\dots\dots (2)$$

$$B = Z \cdot \sinh(\gamma l) \dots\dots\dots (3)$$

$$C = \frac{\sinh(\gamma l)}{Z} \dots\dots\dots (4)$$

$$D = \cosh(\gamma l) \dots\dots\dots (5)$$

And the transfer function can be given as,

$$H = \frac{R1}{A.R1+B+C.R1.Rs+D.Rs} \dots\dots\dots (6)$$

Where  $\gamma$  is propagation constant of the power line. Rs, R1 are source and load resistance of the power line and 1 is the number of concentrating node in the transmission or reception side.

#### B. Power line model

The power line model is required to simulate PLC communications. The power line model applies the methods used to model electricity distribution networks. The chain parameter matrices describing the relation between input and output voltage and current of two-port network can be applied for the modeling the transfer function of power line channel [10].

Modeling power line as cascaded elementary two-port network enables working with elementary networks, two-ports, which can be described by cascade parameters. Cascade solution offers the possibility of choosing a certain degree of

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complexity and precision of the line being modeled. It is also possible to define individual blocks as macro models describing a data channel [10].

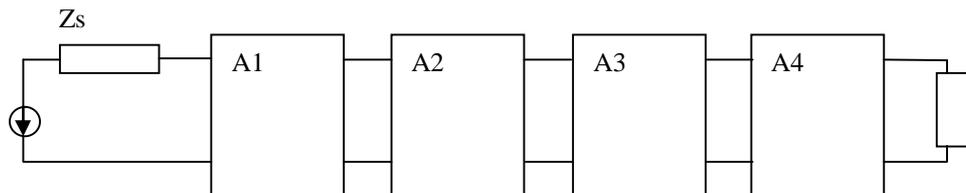


Fig1. Cascade Power Line

Each part of the line is described by a separate cascade matrix  $A_1$  to  $A_4$ . Internal series impedance  $Z_s$  of signal source  $V_s$  and parallel impedance of load  $Z_L$  can also be described by cascade parameters and included in the resultant transfer function. The power line model with noise model is shown in fig 2. The particular noise has been created by Simulink block's help [10].

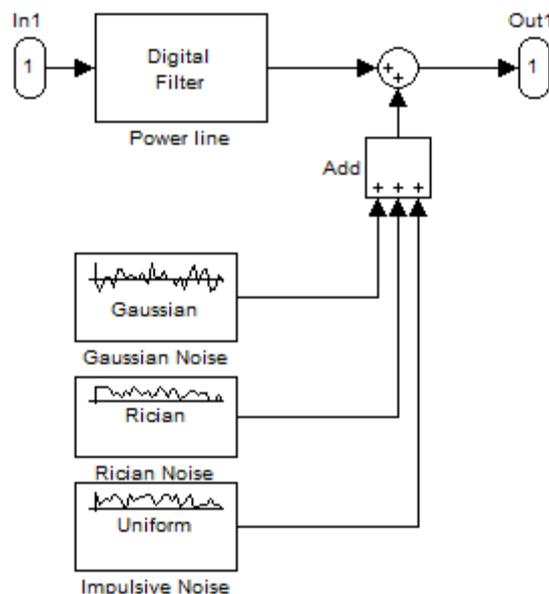


Fig2. Power Line Model

## C. Power line channel conditions

The main problem associated with PLC is Channel noise. The Channel noise is mainly non-white in nature. There are various types of noise that need to be taken into consideration while designing a PLC system. They are listed as follows [2].

1. Background Noise: Mainly low power noise that vary slowly over time.
2. Narrowband Noise: Mainly Confined to a narrow portion of the Channel. Depends on atmospheric conditions.
3. Periodic Impulsive Noise: Mainly caused by switching power supplies and also due to supplies synchronous with the main cycle.
4. Asynchronous Noise: Mainly caused due to switching transients. The noise is the most severe in nature.

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## IV. SIMULATION RESULTS

The Simulink model has been made from using power line channel as medium to transmit digital data using digital modulation techniques in MATLAB using simPower tool. The simulation studies the performance of the power line system according to the BER it is calculated by SNR vs. Eb/N0 reading. Here proposed system is basic digital modulation system using different modulation techniques like BPSK, QPSK, 8-PSK, 4-QAM, and 8-QAM. In comparing performance of three PSK based transmission under same channel (PLC) Condition, three BER plots are generated for each channel conditions. In theoretical probability of error for M-PSK is calculated by:

$$P_E(M) = \frac{1}{M} \operatorname{erfc} \left( \sqrt{\frac{E_b}{N_0}} \sin \left( \frac{\pi}{M} \right) \right)$$

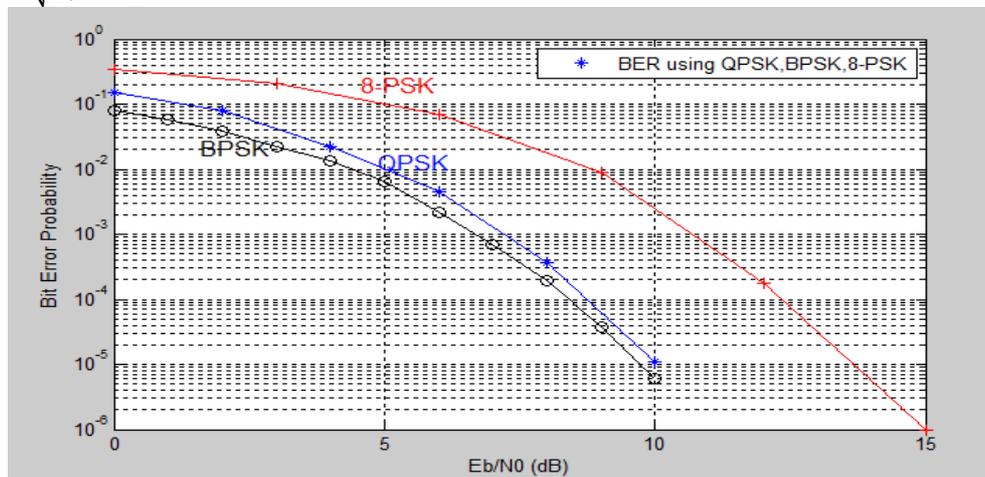


Fig3. BER for M-PSK using Power Line Channel

The mathematical analysis and simulation using SIMULINK shows that BER for all the M-ary PSK based digital modulation schemes decrease monotonically with increasing values of Eb/N0. To calculate probability of error in M-QAM (theoretical):

$$P_E(M) = \frac{2}{m} \left( 1 - \frac{1}{\sqrt{M}} \right) \operatorname{erfc} \left( \sqrt{\frac{3mE_b}{2(M-1)N_0}} \right)$$

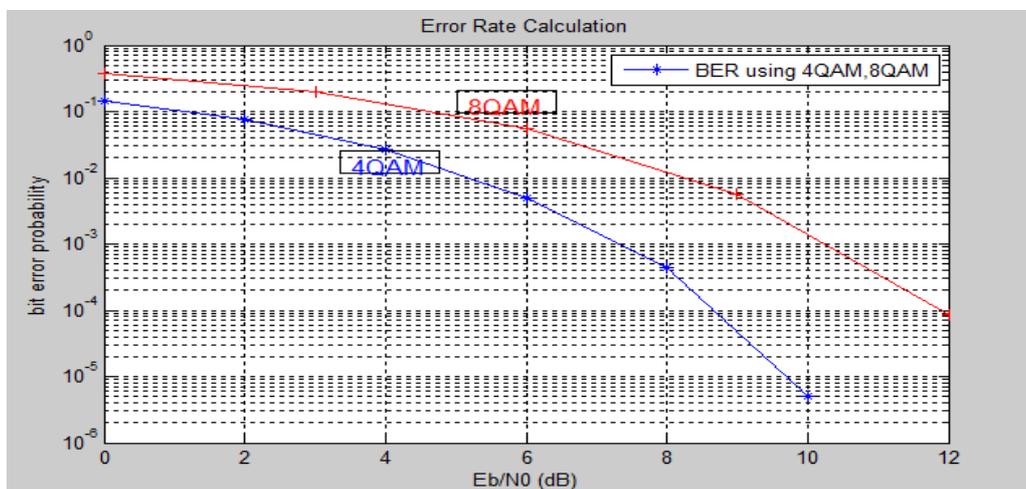


Fig4. BER for M-QAM using Power Line Channel



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## V. CONCLUSION AND FUTURE WORK

The simulation results showed that the performance of digital modulation techniques using Power line channel is better performance for the transmission of digital data. Power Line Communication is one of the technologies that have proved useful for control application. It is widely used in home automation, automotive and internet access application. The performance of digital modulation techniques is calculated from BER. BER is a parameter which gives excellent indication of the performance of digital modulation techniques for digital transmission systems. Here BER is as low as  $10^{-4}$  indicates the better performance using PLC channel. Simulation of power line in MATLAB have checked transmitting frequency over 50-60 Hz for the medium of digital transmission.

In future we can use modulation scheme and coding techniques for high speed data transmission up to 10Mbps using power line channel as a medium.

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