International Journal of Strategic Engineering
Volume 5 • Issue 1

Modeling and Analyzing Trellis-Coded Modulation on Power Line Communication Systems

Ali Hosseinpour, Skillnet, UK
Reza Montasari, Swansea University, UK*

ABSTRACT

Power line channels present a very harsh environment for high speed data transfer which degrades the data transmission. Using proper channel coding can enhance the data transmission over PLC systems. The purpose of using channel coding is to encode the information transmitted over communication channel in such a way that in the presence of other interferences and noise, the error can be detected and possibly corrected. This paper investigates the bit error rate (BER) performance of PLC systems based on orthogonal frequency division multiplexing (OFDM), in the presence of Middleton class A noise, and applying Trellis Coded Modulation (TCM)/Rectangular Quadrature Amplitude Modulation (QAM) TCM as a channel coding. Simulations are undertaken in Matlab. The obtained results illustrate that although trellis codes produce improvements in the SNR in the presence of additive white Gaussian noise (AWGN), they do not perform well with multipath power line channel and Middleton class A noise. Therefore, the Rectangular QAM TCM has been used to enhance the results.

KEYWORDS

AWGN, BER, Impulsive Noise, Middleton Class A, OFDM, PLC, Power Line Channel, Rectangular QAM TCM, TCM

INTRODUCTION

Power Line Communication (PLC) exploits an existing electrical infrastructure to provide high-speed broadband to customers with not requiring new wiring infrastructure which is a great cost saving (Hosseinpournajarkolaei et al., 2012). The development of broadband power line communication systems for providing broadband applications requires an adequate knowledge of the power line channel characteristics (Najarkolaei et al., 2012). Attenuation, various types of noise and multipath affects are some of the main factors of power line systems which need to be considered carefully in designing PLC system. Particularly, an effect of impulsive noise with a high amplitude and short durations is identified as one of the major impairment in PLC systems (Najarkolaei et al., 2015). In order to achieve reliable communication through a channel affected by noise in the communication

DOI: 10.4018/IJoSE.292443
*Corresponding Author

system, the codewords required to be different from each other conspicuously enough. This difference reduce the probability of each single symbol to be taken for another symbol.

The conversion of the message with this purpose is defined as a channel coding in digital communication system (Yang et al., 2009). However it might cause some side effects such as an increase in needed channel bandwidth, decline of data transmission rate and an increase of complexity in the encoder/decoder (Yang et al., 2009). One of the available channel coding for digital communication system is Trellis Coded Modulation (TCM) which is a combination of coding and modulation (Ng et al., 2006). It is bandwidth efficient modulation based on convolutional coding system by doubling the number of constellation points of the signal that results an increase in bit rate and keeping the symbol rate at the same (Ng et al., 2006). TCM was originally proposed for transmission over Additive White Gaussian Noise (AWGN) channels, but its later it was further developed for applications such as in mobile and wireless where it is capable of achieving a coding gain without bandwidth expansion (Ng et al., 2006).

In Mlynek et al.'s (2010) work, different types of PLC noise sources are modelled in Matlab/ Simulink, among these the background and impulsive noises are the main source of interference resulting in signal distortion. The background noise can be modelled as an AWGN and the impulsive noise is based on the Middleton Class A noise model (Bahatti et al., 2009). In Wang et al.'s (2012) work the performance of using Orthogonal Frequency Division Multiplexing (OFDM) modulation for a PLC channel is analyzed and compared with a single carrier modulation system and is found that the OFDM enhances the Bit Error Rate (BER) performance.

In Sekhararao et al.'s (2009) work, the BER performance using OFDM modulation in presence of impulsive noise is given and is shown that convolution coding with a Viterbi decoder improves the transmission performance. In Hongchun's (2012) work, a comparison between TCM and Read Salman (RS) coding for mid-voltage electric distribution line carrier communication system showed that the TCM can have a great advantages compare to other coding methods such as RS when it is fitted to the mid-voltage distribution system. Convolutional code and TCM based on OFDM for a Rician fading (Satellite) channel was considered in Anushruti's (2013) work. The BER performance comparison between these two illustrated that the TCMOFDM provides better performance compared to the convolutional ones.

This paper begins with a brief overview of the basic concept of PLC channel in section II. In section III the different types of noise in the PLC channel, mainly the Middleton Class A impulsive noise is discussed followed by quick introduction to OFDM as a multicarrier modulation technique being used in PLC systems in next section (IV). TCM and Rectangular QAM TCM as a convolutional channel coding are discussed in section V. Later on in the section VI a proposed Simulink model followed by simulation results for the OFDM PLC for TCM and Rectangular QAM TCM are given in Matlab/Simulink 2013b in section VII. Finally conclusions are given in section VIII.

PLC CHANNEL

According to Zimmermann & Dostert (2002), there are various models available for PLC channel such as the Zimmermann and Dostert's model, Philipps model and the Anatory et al. model. The multipath model proposed by Philpps and Zimmermann is a widely used model for investigating the data transmission over power lines and is given by:

$$H\left(F\right)=\sum_{i=1}^{N}g_{i}e^{-\left(a_{0}+a_{1}f^{k}\right)d_{i}}\ .e^{-j2\pi fd_{i}/v_{p}} \tag{1}$$