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Channel Characterization for Broadband Power Line Communication System

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Abstract

Broadband over power line grid called Broadband Power Line (BPL) communication that provides internet access over any ordinary power line. A laptop or any other computing device can be plugged into any power outlet (by use of BPL modem) in building to get access to high speed internet. The main advantage of use of BPL system over power line is to utilize the existing infrastructure of power line networks. This means great savings in wiring (cost-effective) and providing internet to customers in rural area where cannot receive cable modem or any other internet services. However, power-line systems are not designed for transferring data signal. In this paper different issue facing channel properties of BPL system will be discussed. There are some factors influencing transfer function of BPL system. The main focus of this study is to assess the effects of varying the branch's length. The success of this research would be a great forward step towards implementation of BPL system. The Integrated Development Environment (IDE) used in this study is MATLAB.

Key words: Broadband Power Line communication (BPL), Power Line (PL), Transfer Function (TF), Medium Voltage (MV), Digital Subscriber Line (DSL)

1. Introduction

In today's world, providing high data communication services can be in two ways; wireless and wired. Considering the wired option, there are currently two approaches for providing a broadband service; through telephone line by use of Digital Subscriber Line (DSL) and through coaxial cable by means of the cable modem. Broadband Power Line Communication system (BPL) is a third wire-line option that uses electric utility power line grid. The main advantage of BPL system is that there is no need for new wirings or major infrastructure deployment which means a great reduction in time and cost when providing broadband service (Amirshahi & Kavehrad, 2007).

Although some elementary of transmission models for PLC system were available for many years, but there were no any serious attempts for BPL channel modeling until recently.

This paper begins with channel characteristics of power line system. Some of the available channel models are discussed. The multipath channel model is also recognized as a suitable approach for power line channel (Omega, 2011). In the followings, factors influencing transfer function of BPL system i.e. effects of varying the branch's length will be reflected.

2.Channel Characteristics

The choice of the communication method must take the transmission channel into consideration. In addition systems requirements should be met. The power line channel is characterized by its transfer function. This function operates between the transmitter point and receiver point as well as the interference that receiver faces (Chaouche Et al. 2010). An existing power line grid is not designed for high speed data transmission, therefore the power line channel is a harsh and noisy medium for fast data transmission. There are many factors affecting this such as length of the transmission from receiver to transmitter, types of loads, line branching, number and type of branches, length of each branch and type of the power line equipment connected (such as capacitor and transformer). An Orthogonal Frequency Division Multiplexing (OFDM) is the most reasonable and suitable modulation technique for power line channels (Lowery & Armstrong, 2006).

3. Channel Models

The idea of using the power grid system for communication is not firsthand at all. For many years power provider companies have been using their network for low data transmission such as control, management and supervision of power plant and distribution facility operation (Kitayama & Abe, 2008).
It is essential to have detail knowledge of power line channel in order to develop BPL system. There are a few available power line channel models such as Zimmermann and Dosteret model, Philipps model, Anatory et al. model and multipath model. A multipath model proposed by Philpps and Zimmermann is known as the best and suitable approach for describing the transmission behavior of the PL channels. The echo model describes the impulse response of the PL channel of N Dirac pulses representing the superposition of signals from N different paths (Anatory & Theethayi, 2011). In below the complex channel transfer function (CTF) is given:

$$H(f)=\sum_{i=1}^{N} pi \;\; e^{-j2\pi f \tau i} \qquad (1)$$

In equation (1) pi represents the product of reflection transmission factors for each echo path and is normally called the complex factor and τi is the delay parameter. This approach is well suited describing indoor channels due to allowing the realistic reproduction of notches of the PL channel. The multipath approach proposed by Zimmermann is a universal and is more useful model to describe the low pass characteristics of PL channel. As it can be seen in equation (2) this model is combine of echo model with an additional attenuation factor. In this equation N is the different path signal which is individually characterized by a weighting factor g_i and the length di. a_0, a_1 and K are frequency dependent attenuation and can be obtained from magnitude of the frequency response.

$$H(f)=\sum_{i=1}^{N} g_i \; e^{-(a_0+a_1 f^k)d_i} . e^{-j2\pi f \frac{d_i}{v_p}} \qquad (2)$$

As it can be seen this model consists of two exponential functions; first one attenuation and the second one echo model with the propagation speed (v_p) included.

4. Effect of Branch Length

There are various challenges influencing transfer function of power line channels. The line length from transmitter to receiver, the lead impedance, branch's length, and the number of branches are some of them. The focus of this study is on the effect of varying the branch's length (BD) on power line system (Agarwal, Afzal, & Singh, 2011).

The configuration as is given in figure 1. was used to obtain the effect of varying of the branch's length. The length of transmitter to receiver (A to C point) was kept constant at 3Km. The length of the branch was varied as BD = 5m, 10m, 15m, 20m. Point D was terminated in 50Ω and Point B is at the mid-point of AC line.

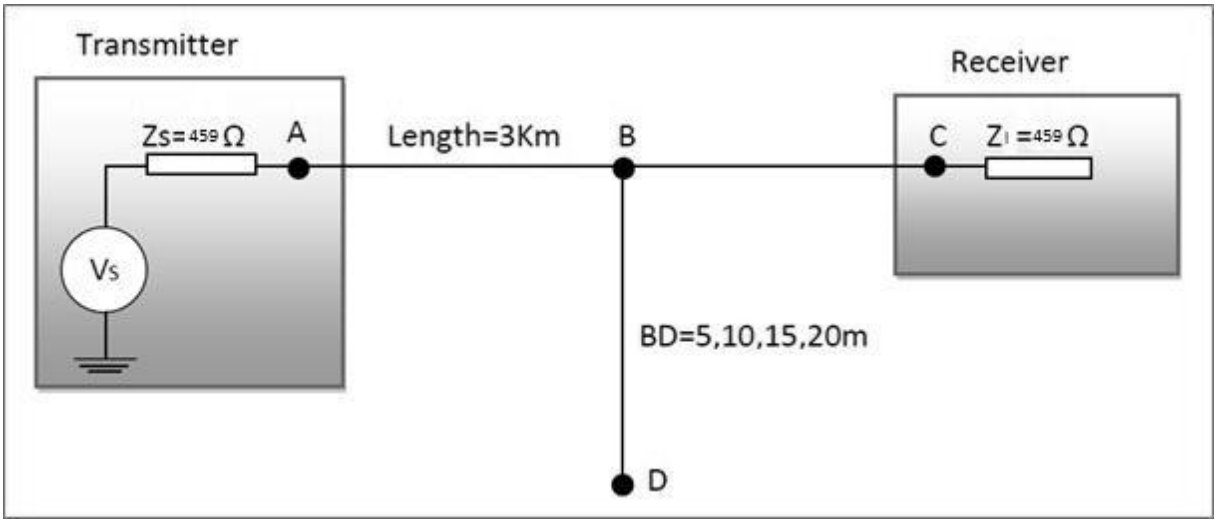

Fig. 1: Power Line MV network configuration with various lengths

Figures.2,3,4,5. illustrate the simulated results of frequency responses for different branch lines. The maximum number of path tested is N=6 with the attenuation parameters of k=05, a_0=0, a_1= $2x10^{-8}$ s/m. the parameters were determined from the measurement using Least- Square fitting algorithm.

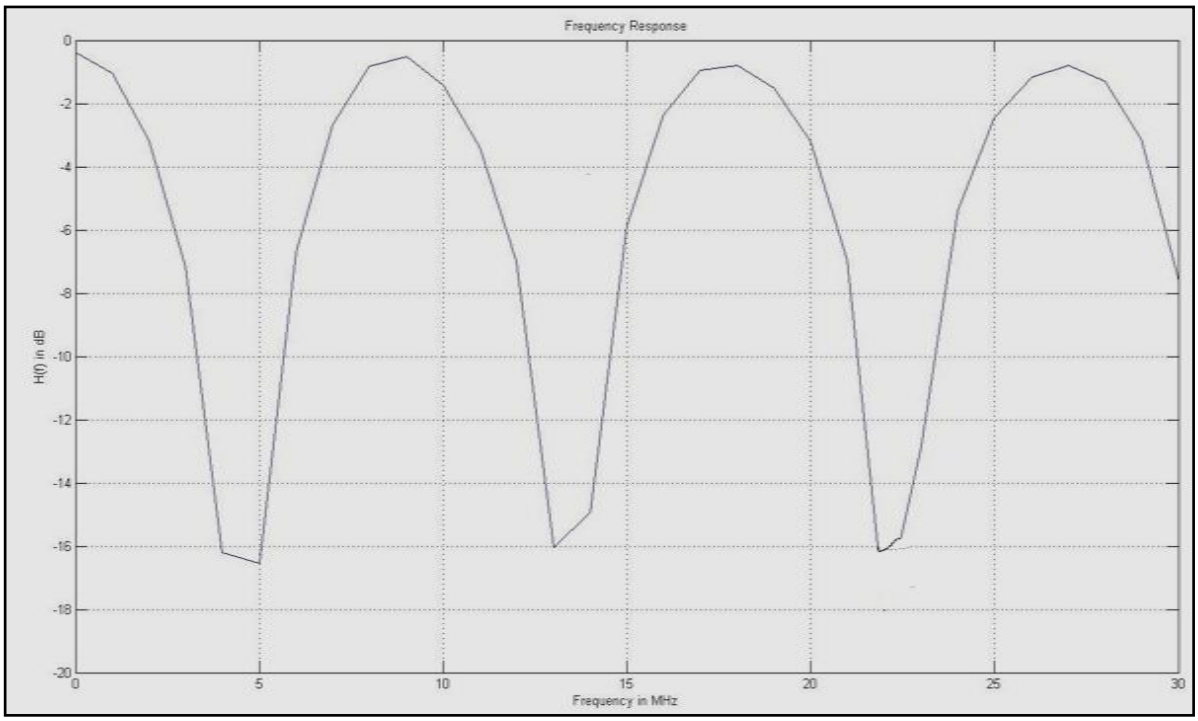

Fig. 2: Simulation result for MV of 3Km length with one branch of length 5m

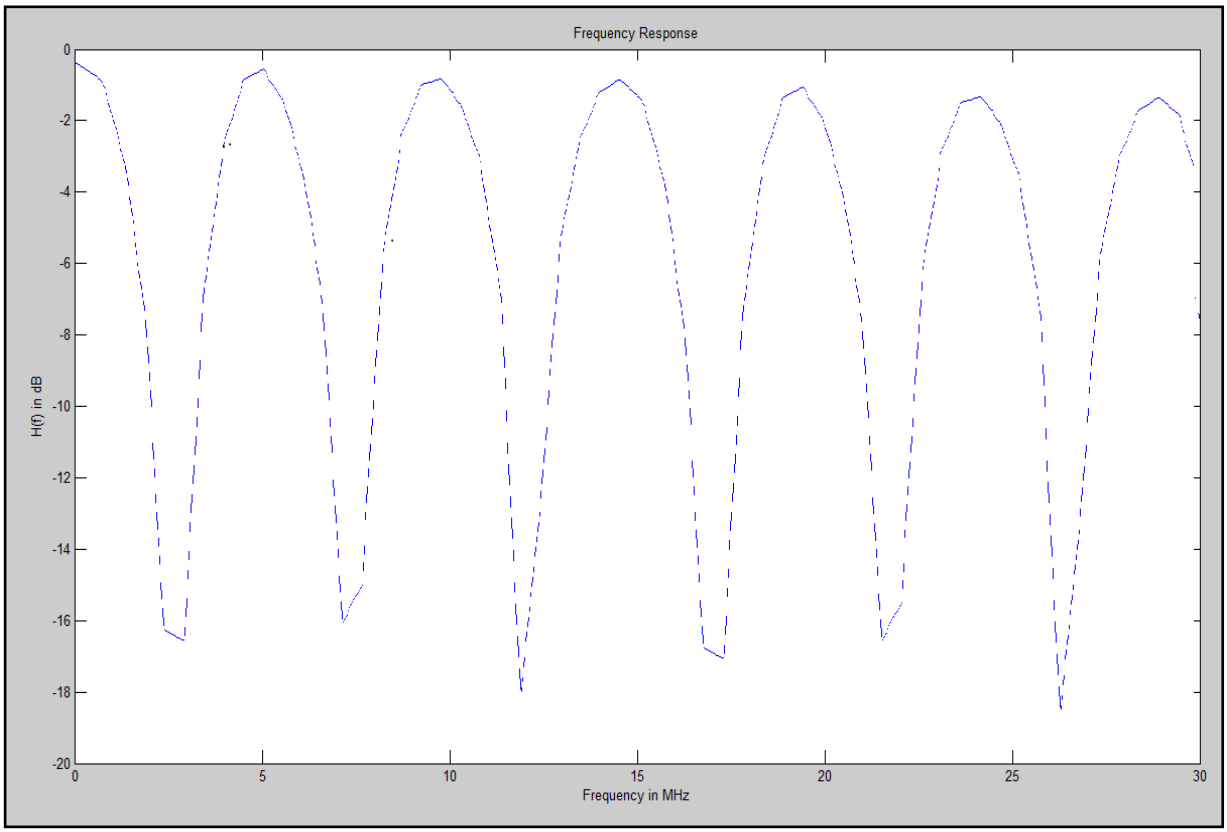

Fig. 3: Simulation result for MV of 3Km length with one branch of length 10m

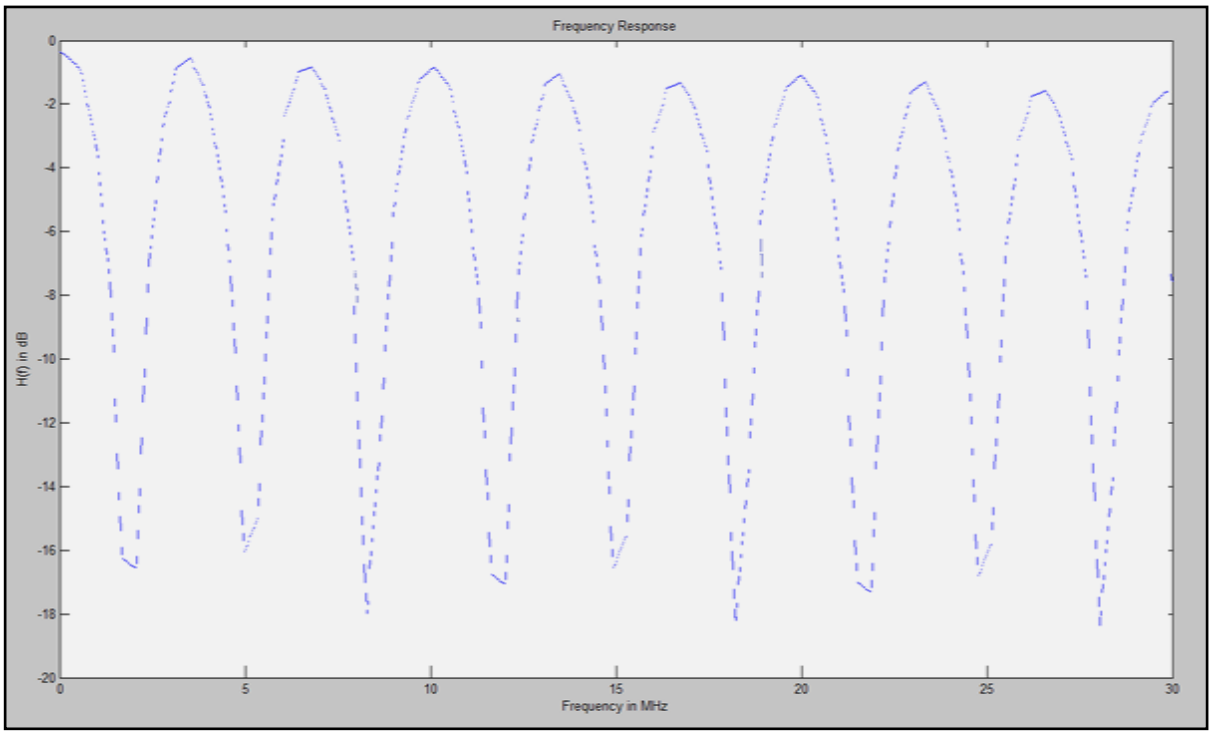

Fig. 4: Simulation result for MV of 3Km length with one branch of length 15m

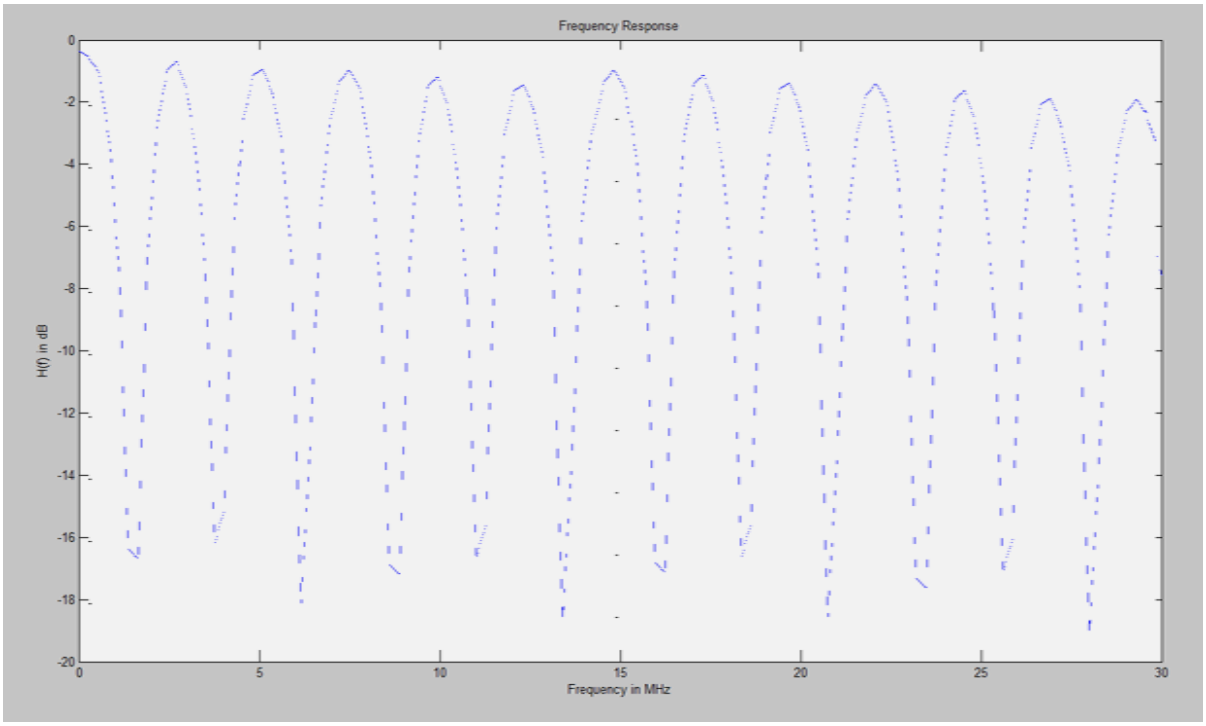

Fig. 5: Simulation result for MV of 3Km length with one branch of length 20m

The results show that the peak frequency responses and notches did not attenuate with branch length. However the position of peaks and notches are case dependent meaning

increasing the branch length results an increase in number of notches. The further work of this project would be analyzing the effect of applying number of branches, various loads connected to branches by use of MATLAB IDE on BPL system.

5. Conclusions

BPL system is an alternative way of providing high speed data transmission with advantage of using an existing infrastructure which is cost effective (there is no need for additional cabling). However BPL systems were not designed to transmit high speed data. Therefore it is very harsh and noisy medium for transmission of high speed data. A multipath channel considered as a well suited channel model for power line communication. From the simulation result, was obtained that the peaks of frequency response does not attenuate with either frequencies / branch length. However the position of the peaks and notches is case dependent (increasing the length of branch line results an increase in the number of notches).

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