Analysis of High Performance Low Power Broadband Powerline Channel using S-Parameter

Mukesh Kumar Varma[1], Dr. Zainual Abdin Jaffery[2], Dr. Ibraheem Nasiruddin[3]

Electrical Engineering Dept, FET,Jamia Millia Islamia, New Delhi, India

ABSTRACT-Broadband power line communication has been achievingsignificant interest over the last few years for high speed data communication. This paper presents the characterization and modeling of a proposed high performance low power broadband powerline channel models, using s-parameter. In this work we describe some important properties and, main features, mathematical derivation of the transfer function of the power line channel. The channel frequency response of the proposed model is carried out on MATLAB to explore the validity of the powerline channel transfer function, in the frequency series of 1-30MHz. This paper also reports the important applications of the broadband powerline communication technology as a solution for the next generation access network.

KEY WORDS-*Channel modeling,S-parameter, Transfer function.*

1. INTRODUCTION

Present electrical power systems exist everywhere and it covershuge geographical area in the country. However, there are many uneven geographical conditions it reaches about to every house. With the reform process of electricity enterprises search, new markets for finding new business prospects. The Utilities has been increasing interest in the use of the power-line network for broadband communication. The Broadband Power Line Communication (BPLC) is acknowledged as one of the technology in the research world that utilizing existing wireline networks as a medium for transmission of information, which is proficient of providing data transfer and the frequencies to provide communication services. Basically, the power line is built for delivery of electrical power at low frequencies (50-60 Hz), however, it can be used simultaneously as a communication medium at high frequencies (1-30MHz)[1-4]. Since the BPLC technology uses the prevailing power cable structure for data communication purposes, thus this technology provides a convenient and cost-effective solution for data transmission. [5]

Unlike the additional wire built telecommunications networks, the electrical supply network does not have well demarcated physical or electrical characteristics. Also unlike the other wired communication means such as the unshielded twisted pair and coaxial cables, power lines existing an enormouslystrictsituation for the high-frequency data communication signals. The three important channel parameters, that is noise, impedance, and attenuation, are extremelymutable with time, frequency, and location [1].Attenuation is the drip in the signal power when communicating from one place toanother. It can be produced by the communicationroute length, obstacles in the signal route,and multipath effects. Any objects, which block the line of sight signal from thetransmitter to the receiver, can sourceof attenuation. In order to overcome these difficulties, many techniques have been proposed in the literature for the channel modeling. However, a commonlyrecognized channel model has not been established yet. Here we proposed a new high performance low power channel analysis, which is based on the s-parameter for radial structure of the low voltage electrical networks.

The channel modelling methodologiesavailable in literature are the top-down approachand the bottom-up approach. These two methodologies are summarised and analysed in this paper.The first is discussed to as bottom-up methodology. The bottom-up methodology exploits the transmission line theory to calculate the channel response amongst the transmitter and the receiver. It confirmssolidnetworks with the reality since it uses all the topological information, but it is relatively computationally costly if applied to real PLC networks. Bottom-up models have been reported in [5] and [6]. The top down methodology and uses data from measurements [6]. In the top-down approach model, the powerline channel described as if it were predominately affected by multipath effects. According to the top-down methodology, the channel response is acquired by fitting a definite parametric function with measured data.

This paper is organized as follows. In section 2, we start with the description of system architecture of the broadband powerline communication system based on types of low voltage networks configuration common in India. Section 3 is devoted to the algorithm for the proposed powerline channel model. Section 4, describes the channel performance and effectiveness of the proposed channel model. Concluding remarks are drawn in section 5.

2. BROADBAND POWERLINE COMMUNICATIONS SYSTEM ARCHITECTURE

Broadband Power Line Communications is a communications technology that utilize the existing infrastructure (electricity cables), it very attractive as for in house and industryusers.The applications for broadband powerline communications systems fall into two generaltypes, In-house Broadband powerline communication,and outdoor access network. In the electrical distribution network, Low Voltage lines, with voltages in the range from 220 to 440 V, are connected to the medium voltage lines via secondary transformer substations. The Low Voltage lines lead directly or over street cabinets to the end customers' premises.Figure-1 shows a typical structure used as powerline communication access network from customer's location to high voltage substation [10].

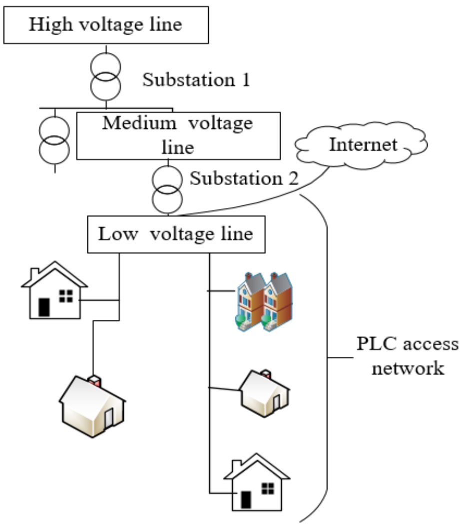


Fig.1 – system architecture of BPLC access network

3. ALGORITHM FOR THE PROPOSED POWERLINE CHANNEL

The most significant problem is channel modelling for broadband powerline communications. With the knowledge of the low power line network's topology and cable characteristics, the initialization of the algorithm starts with transmission line theory, that can be modeled as two port network by using ABCD parameter, then thisPower Line Cable Transfer Function.Thereafter s-parameters are determined.The two-port network (2PN) model of powerline is shown in figure2[11].

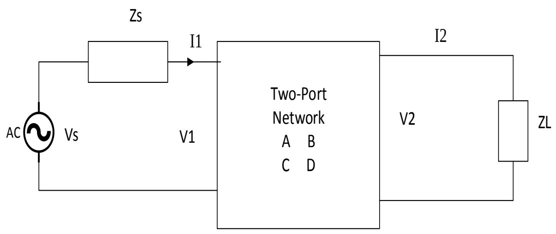


Fig.2-Two-port network model

A, B, C, D parameters are mostly the frequency reliant composite function andWhere Z_S ,Z_l ,l and γ are the source impedance, load impedance ,lenngth of line and the propagation constant respectively, are illustrate the electrical properties of the two-port network are defined as follows;

$$A = \frac{V_1}{V_2}\, |I_{2=0} \qquad -(1)$$

$$B = \frac{V_1}{I_2}\, |V_{2=0} \qquad -(2)$$

$$C = \frac{I_1}{V_2}\, |I_{2=0} \qquad -(3)$$ and

$$D = \frac{I_1}{I_2}\, |V_{2=0} \qquad -(4)$$

Considering a general domestic transmission line as communication channel, the correlation between input voltage and current can be denoted as ABCD parameters as

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ I_2 \end{bmatrix} \qquad -(5)$$

The succeeding equation of figure 2 specified the transfer function of this network. The Transfer function of the network is given by the equation

$$H(F) = \frac{V_2}{V_S} = \frac{Z_l}{A.Z_l + B + CZ_S Z_l + DZ_S} \qquad -(6)$$

And Transfer function in dB is given as

$$H(F) \text{ in dB} = 20 \log_{10} \frac{Z_l}{A.Z_l + B + CZ_S Z_l + DZ_S} \qquad -(7)$$

For the uniform two-conductor transmission line, the parameters A, B, C, D stated as

$$A = D = \cosh \gamma l \qquad (8)$$

$$B = Z_c. \sinh \gamma\, l \qquad -(9)$$ and

$$C = \frac{1}{Z_c}. \sinh \gamma\, l \qquad -(10)$$

Where Z_S ,Z_l ,l and γ are the source impedance, load impedance ,lenngth of line and the propagation constant respectively. The scattering matrix of a network module relates the incident wave $(a_1,a_2)^T$ and the reflected wave $(b_1,b_2)^T$through

$$\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = S. \begin{bmatrix} a_1 \\ a_2 \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} . \begin{bmatrix} a_1 \\ a_2 \end{bmatrix} \qquad -(11)$$

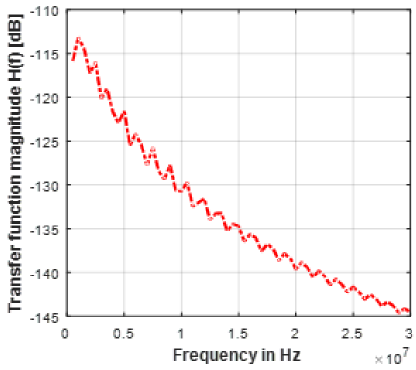
Where a_1, $b_1$are incident and reflected voltage at port-1, and a_2, $b_2$are incident and reflected voltage at port-2. The conversion

$$\begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} = \begin{bmatrix} \frac{B - Z_n\,(D - A + CZ_n)}{B + Z_n\,(D + A + CZ_n)} & \frac{2Z_n\,(AD - BC)}{B + Z_n\,(D + A + CZ_n)} \\ \frac{2Z_n}{B + Z_n\,(D + A + CZ_n)} & \frac{B - Z_n\,(A - D + CZ_n)}{B + Z_n\,(D + A + CZ_n)} \end{bmatrix} \qquad -(12)$$

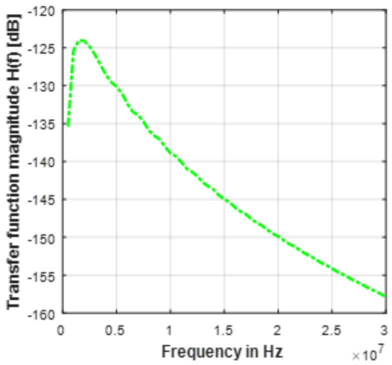
So, the s-parameters are created by the considered ABCD parameters of specified network. The advantages of s-parameter matrix are, the preciseestimation of the end to end transfer function also accurate demonstration of attenuation discontinuities at the branching points.the channel performance is evaluated in the next section.

4. CHANNEL PERFORMANCE

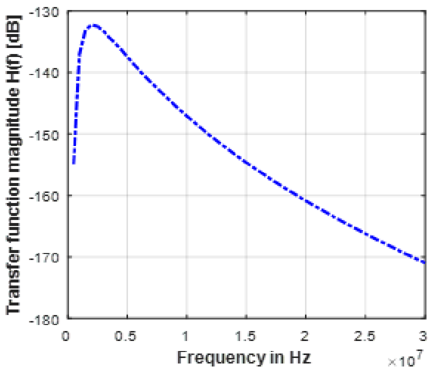
In this part, different topology was chosen, for analysis. In This paper we will consider a copper core conductor with PVC insulation, that is normally used for house wiring. The powerline configuration of figure 2, For our system we use the wiring cable of the copper conductor of radius 4 mm, the spacing between the conductor is 0.15 meter of length l=100 meter. we consider the case –1, the length of the line varies from 50 m to 200 m load impedance and source impedance, is 50 ohms, the transfer function response result for 30 MHz frequency shown in figure 3 below. The results show that as in increase in the length of the line of the channel as some conclusions, increase in the attenuation.



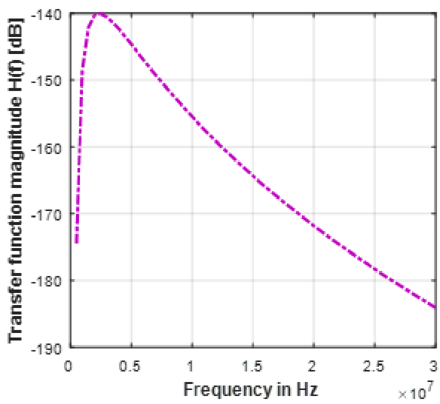
(A)



(B)



(C)



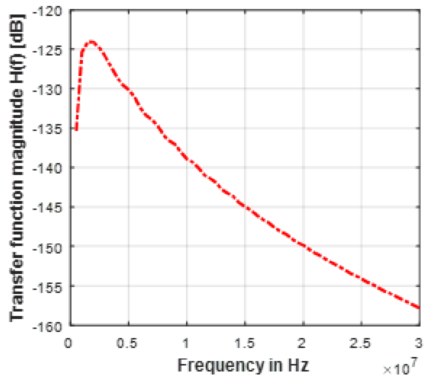
(D)

Figure 3-(A), (B),(C) and (D) for case 1

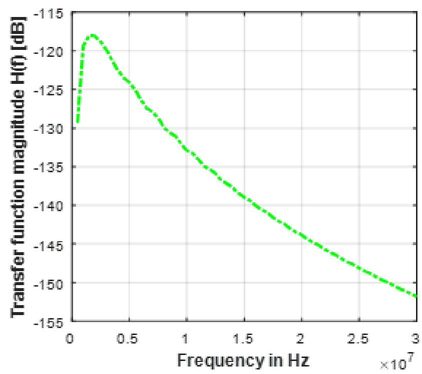
(A) For Zl=Zs= 50 ohms and Line length 50 m (B) For Zl=Zs= 50 ohms and Line length 100 m

(C) For Zl=Zs= 50 ohms and Line length 150 m (D) For Zl=Zs= 50 ohms and Line length 200 m

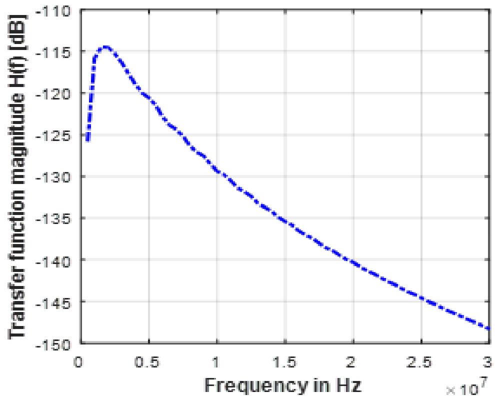
For case, 2-The connected load is varied in a realistic scenario. The load variation effects on the transfer function can help to develop the quality channel model. When load impedance varies from 50 ohms to 200 ohms, source impedance is 50 ohms, and line length is 100 m is shown in figure 4 below.



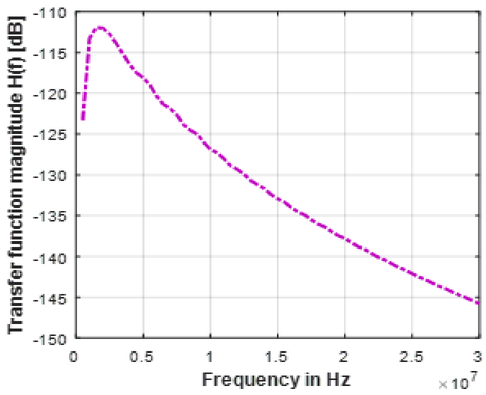
(a)



(b)



(c)



(d)

Figure 4-(a),(b),(c) and (d) for case2

(a) For Zl=Zs= 50 ohms and Line length 100 m (b) For Zl=100,Zs= 50 ohms and Line length 100 m

(c) For Zl=150, Zs= 50 ohms and Line length 100 m (d) For Zl=200,Zs= 50 ohms and Line length 100 m

5. CONCLUSION

The main contributions of the paper are offering study on progress in BPLC technology. The article deals with low power system architecture of the BPLC communicationsystem model. The model of power lines is modelledwith the information of the low power line network's topology and cable characteristics.The goal of this study is to describe broadband powerline communication (BPLC) networks characteristics for the broadcast through electrical power networks.

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