

A Survey of BPL Technology and Feasibility of Its Application in Iran (Gilan Province)

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Abstract: Recently Broadband over power lines (BPL) has received much attention in communication technology and this is due to economically of sending high data rate services by re-use of power line cables. As data transfer via power lines to final consumer is one of the growing technologies, this study discusses the modeling and optimization of data transfer via power transfer lines and feasibility and adaptation of using this technology in Gilan are investigated. Finally, a model is evaluated for power lines by selection of a cable in selected area (Gilan province) as high speed transfer media and by investigation of the effect of different loads on channel feature, simulation and transfer function between various areas of network are considered. Simulation is done by ABCD transfer matrix and channel frequency response is achieved. This model is useful in description of frequency response of lines of this network and application in design of data transfer system.

Keywords: High Speed Data Transfer, Power Lines, BPL, Channel Simulation

1. Introduction

Data transfer technology via power lines to final consumer is one of the growing technologies in most advanced countries in the world. Many developing countries have studied on using this technique in power network level and some of them have installed it (Mirjalili et al., 2005). One of the most important features of these systems is lack of needing new network for data exchange and using existing electric network. Due to some advantages as lack of loss of time and cost to make new telecommunication channel, this technology can be a good strategy in the market of services with broadband (Antoniali, et al, 2013). As the major part of an electric network is weak pressure, this technology is one of the best methods from geographical coverage. Low speed data transfer from power lines is not a new technology and it has been used for a long time in electricity network management (Canete, etal, 2011). In recent years, with the progress of technology, high speed data transfer via power lines is possible. Today, based on the increasing development of internet and IT applications in various countries, it is attempted to provide connection to internet and high speed data transfer in each area of city and village. Thus, the selection of a good telecommunication environment to connect users to

information source is importance in terms of various parameters as easy development of telecommunication network, required costs to develop telecommunication network, development of coverage of this network and bit rate to each user via this network.

Today, power network has received much attention for high speed and high frequency data transfer, BPL¹. It seems that this method is a good rival for high speed communication systems namely ADSL². This technology applies ready structure of power network and can have access to all areas with power lines and high speed service is provided. This feature leads to attraction of this technology in the world and many projects are dedicated to it. This study attempts to investigate BPL network and its performance on power network and required equipment of this system.

2. Empirical Review of Literature

In the study of Azadedel et al., (2003), methods of recognition and performance of channel in frequency to 30MH is considered and by math differential methods, channel is simulated in various modes. To improve energy

1 Broadband Power line

2 Asymmetric Digital subscriber Line

transfer lines, optimization methods are analyzed.

Also, Abasi Moghadam *et al.*, (2006) in a study investigated telecommunication parameters of power lines and the effect of minimizing the parameters on transfer data. Attenuation of transfer lines and multi-path phenomenon and Noise are adverse effects in the study and channel model is studied by considering Gaussian noise and channel transfer function is investigated.

Asadzade *et al.*, (2008) in a study evaluated the problems and limitations of telecommunication in distribution networks and referred to the methods of achieving frequency response of power lines and investigated different noises in power lines. Also, the effect of pulse noises is presented.

Babic (2001) in the study investigated the frequency fading in transmission line. It is explained that continuous change of loads and impedance mismatch creates echoes in transfer line. Based on branches and connections, extra paths can be investigated and the result is a multi-path propagation with selective fading of frequency.

Gebhardt(2003) investigated reference channels and the properties of various channels based on various data and measures and pioneer companies in this regard and different frequency bands to be used in data transfer are introduced.

Arthur (2004) investigated the price and speed of BPL technology and competition of this technology with ADSL. The benefits of this technology are value of investigation and investment of this technology. The general structure of BPL network was investigated and three main parts as access network, Modem and repeater were introduced.

In a paper with the aim of simulation of a BPL network, to simulate the network, it is required to determine the network structure. The connection between energy and house provider is done via main panel (SP). It was shown that there were some junction boxes in the network and each of them were connected directly to main panel. Any power line starting from junction box ends to a socket. There are two different connections between sockets and junction box. The start and bus connection. In star connection, each socket is connected directly to a junction box. A socket can end to impedance with various values or it can be open circuit. In this study, channel simulation is done via bottom up and it introduces some samples of channel and produced networks (Marrocco *et al.*, 2012).

3. Study Purpose

In this study, selection of an output feeder from electricity post in Gilan province and feasibility of implementation of BPL technology on feeder is considered.

4. Study Method

The study method is theoretical and based on valid books, articles and researches as applied to introduced BPL technology, then feasibility of this technology on an output feeder of post in Pasdaran region of Anzali is investigated and then simulation is performed in MATLAB.

4.1. The Methods of Modeling Power Lines

There are various methods to model power lines. Two common methods of top-down and bottom –up methods are used in most of papers. Top-down method presents a parametric model as its parameters can be achieved via result of tests and measurements. Modeling of BPL channels to this method is almost difficult as parameter values are regulated according to the results in tests and as there is different wiring method in various areas, we should measure it in various places (Meng *et al.*, 2002). Thus, second method is used in which by transfer line and ABCD matrix, transfer function is achieved.

4.2. Determining Channel Transfer Function

For modeling the channel by transfer matrices, each part of line is modeled as bipolar (Figure1). Then, the relationship between currents and input and output voltages of bipolar network in frequency field by ABCD transfer matrix is shown by equation (1):

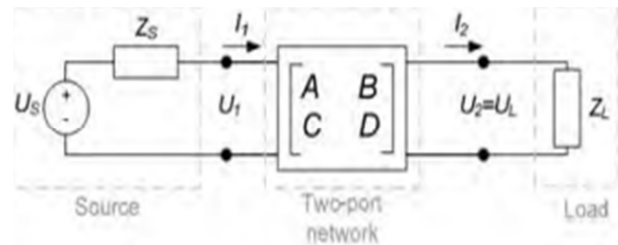


Figure 1. Equivalent bipolar network.

$$\begin{bmatrix} U_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} U_2 \\ I_2 \end{bmatrix} = A \begin{bmatrix} U_2 \\ I_2 \end{bmatrix} \quad (1)$$

ABCD values are mixed functions of frequency and define the electric features of bipolar network. In a two-wire line, these parameters are discussed based on impedance Z_c and propagation constant γ as:

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} \cosh(\gamma l) & Z_0 \sinh(\gamma l) \\ \frac{1}{Z_0} \sinh(\gamma l) & \cosh(\gamma l) \end{bmatrix} \quad (2)$$

ABCD parameters calculate two important quantities: Transfer function as the ratio of load voltage to network input impedance source voltage:

$$H = \frac{U_L}{U_s} = \frac{Z_c}{A.Z_c + B + C.Z_c.Z_s + D.Z_s} \quad (3)$$

$$Z_m = \frac{A.Z_L + B}{C.Z_L + D} \quad (4)$$

To investigate the simulation results and precision of this method, simple network of Figure (2) is used and transfer function between transmitter and sender is calculated. In this model, middle branch of circuit is open.

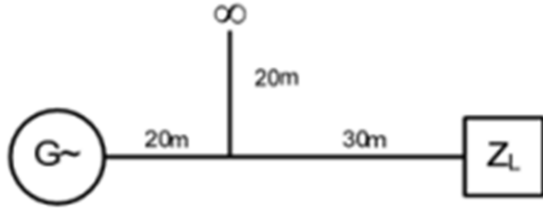


Figure 2. Simple model of a single branch network.

The effect of echoes in branch in transfer function is emerged as indentations with constant frequency distance. The first indentation is occurred if the direct and echoed waved is shifted as half of opposite wavelength and this weakens the amplitude.

4.3. The Model of Loads and Their Classification

Other communication technologies are only exposed to background noise but BPL technology is exposed to another noise as arising from electric devices connected to network. For modeling the loads in BPL network, the accepted model in different articles is a set of impedance functions as a selection in time and frequency. After measuring many electrical devices, it was shown that impedance behavior of these devices can be classified in three groups. Almost constant impedances, fixed impedances with time but selective in frequency and varied impedances with time and selective in frequency.

For the first group, fixed impedances, logical and normal values 5, 50, 150, 1000 and infinite ohms are used as indicating low impedance, Radio frequency standard, similar to Z_0 transfer line and open circuit, respectively. To model the second group in (Schikober, 1997), an equation is presented:

$$Z(\omega) = \frac{R}{1 + jQ\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right)} \quad (5)$$

Where, R is resistance in resonance frequency, ω_0 angular frequency of resonance and Q is coefficient of quality (associated with bandwidth and selection is associated to it).

The third group is divided into two groups based on their behavior in network cycle. One of the loads showing two impedance levels (stepped) over time and another the loads with mild changes with network voltage. In both groups, impedance dependence to frequency is shown in different times.³ The presence of varied time loads causes that the behavior of the network is varied with time. This behavior makes modeling difficult. Also, the design of suitable modems for such varied condition is difficult. Some tests are performed on different loads. The results show that varied behavior with time of loads is due to existing rectifier in their power source and is not associated to the main structure of circuit. This behavior is controlled by a capacitor or EMI filter. Most manufacturers consider this issue to avoid harmonic injection to network. Thus, we can be sure in most of loads, this behavior is controlled. As control of this condition is simpler than modeling

varied loads with time and design of BPL models for time varied systems, this behavior is ignored in designs and is controlled by filter.

4.4. Using Power Line as Telecommunication Channel

If we use a power line as communication channel, this line has many advantages. As power networks are the most comprehensive networks compared to any other network in country, they are available in all sockets of houses, BPL systems are less costly as they don't need any extra wire (Mork, 2005).

Later, a power line communication channel with some branches is simulated by using ABCD performance matrix in a bipolar network with MATLAB software and the effects of various capacities and different paths and their inconsistency are investigated. To investigate the performance of transfer channel from the cable applied in selective sample network, initial parameters $R=1.9884\Omega/\text{m}$, $G=0.01686\text{ns}/\text{m}$, $c=0.13394\text{nF}/\text{m}$, $L=362.81\text{nH}/\text{m}$ are selected for cable with area 16mm^2 . These values are extracted from the features of cable producers and in this simulation, the cables have various lengths and different bridged tabs and different loading conditions.

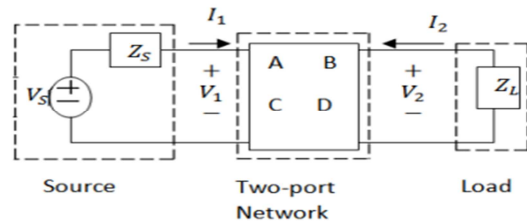


Figure 3. Bipolar circuit model of network.

ABCD matrix model indicates a bipolar circuit as suitable to calculate and achieve line transfer function. In this chapter, at first the required cable as telecommunication cable is turned into a bipolar network as shown in Figure 3, then the relationship between input current I_1 , and input voltage V_1 and output current I_2 and output voltage V_2 is achieved as:

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ I_2 \end{bmatrix} \quad (6)$$

$$V_1 = (A V_2 + B I_2) \quad (7)$$

$$I_1 = (C V_2 + D I_2) \quad (8)$$

$$V_L = I_2 Z_L \quad (9)$$

$$V_S = (C I_2 Z_L + D I_2) Z_S + (A I_2 Z_L + B I_2) \quad (10)$$

To model channel by ABCD matrix, each part of power line is considered as bipolar. After the relationship between current, input and output voltage of this bipolar network in frequency field is defined. ABCD values are mixed functions of frequency and define electric characteristics of bipolar network. These parameters are described based on Z_c characteristic impedance

and propagation constant γ as:

$$Z_{in} = \frac{(AZ_L + B)}{(CZ_L + D)} \quad (11)$$

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} \cosh(\gamma l) & z_c \sinh(\gamma l) \\ \frac{1}{z_c} \sinh(\gamma l) & \cosh(\gamma l) \end{bmatrix} \quad (12)$$

ABCD parameters compute two important values. Transfer function as ratio of load voltage to impedance source voltage of network and propagation constant and characteristic impedance are computed by following equations:

$$H = \frac{V_L}{V_s} \quad (13)$$

$$H = \frac{Z_L}{AZ_L + B + CZ_L Z_s + DZ_s} \quad (14)$$

$$\gamma = \sqrt{(R + j\omega L)(G + j\omega C)} \quad (15)$$

$$Z_c = \sqrt{\frac{(R + j\omega L)}{(G + j\omega C)}} \quad (16)$$

The power communication line is not always simple, without branch as shown in Figure 1. Normally, in distribution network, there are various bridged tabs (branches) with various cable lengths. For the entire power network with some sections, transfer function for the entire network is equal. Although ABCD matrix of system is different, determinant of ABCD matrix is defined by a chain of rules. Transfer line matrix is introduced in Equation 9.

ABCD matrix for series source impedance is defined with Z_s as followings:

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 1 & Z_s \\ 0 & 1 \end{bmatrix} \quad (17)$$

ABCD matrix for impedance load Z_b of parallel branch load is defined as:

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ \frac{1}{Z_b} & 1 \end{bmatrix} \quad (18)$$

Z_{eq} for bridged tab with load and Z_b impedance is as follows:

$$Z_{eq} = Z_c \frac{z_b + z_c \tanh(\gamma_{br} l_{br})}{z_c + z_b \tanh(\gamma_{br} l_{br})} \quad (19)$$

Z_c is characteristic impedance of bridged tab and L_{br} branch length and γ_{br} propagation constant for bridged tab.

(Figure 3) Bipolar model of power line with bridged tab and it is replaced with Figure 4. (Figure 5 shows a power line with

bridged tab).

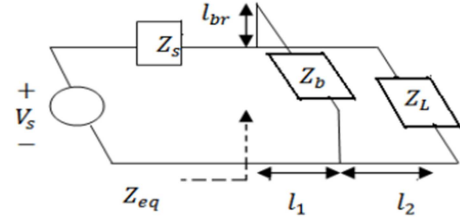


Figure 4. Power network line with connection node.

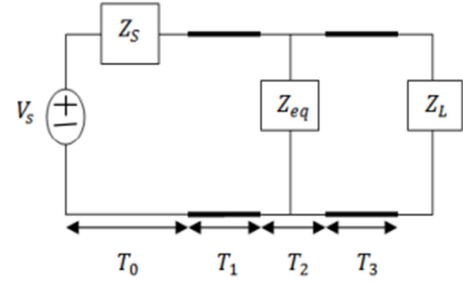


Figure 5. Substitution model.

It can be divided into four sections of T_3, T_2, T_1, T_0 . T_0 is a series sub-circuit with load. T_3, T_1 Sub -circuits are some sections of transfer line. T_2 is impedance of parallel load and each of them is computed based on the following equations:

$$T_0 = \begin{bmatrix} 1 & Z_s \\ 0 & 1 \end{bmatrix}, T_1 = \begin{bmatrix} \cosh(\gamma_1 l_1) & Z_1 \sinh(\gamma_1 l_1) \\ \frac{1}{Z_1} \sinh(\gamma_1 l_1) & \cosh(\gamma_1 l_1) \end{bmatrix}$$

$$T_3 = \begin{bmatrix} \cosh(\gamma_2 l_2) & Z_2 \sinh(\gamma_2 l_2) \\ \frac{1}{Z_2} \sinh(\gamma_2 l_2) & \cosh(\gamma_2 l_2) \end{bmatrix}$$

$$T_5 = \begin{bmatrix} \cosh(\gamma_3 l_3) & Z_3 \sinh(\gamma_3 l_3) \\ \frac{1}{Z_3} \sinh(\gamma_3 l_3) & \cosh(\gamma_3 l_3) \end{bmatrix}$$

$$T_2 = \begin{bmatrix} 1 & 0 \\ \frac{1}{Z_{eq1}} & 1 \end{bmatrix} \quad T_4 = \begin{bmatrix} 1 & 0 \\ \frac{1}{Z_{eq2}} & 1 \end{bmatrix}$$

$$T_6 = \begin{bmatrix} 1 & 0 \\ \frac{1}{Z_{eq3}} & 1 \end{bmatrix} \quad T_8 = \begin{bmatrix} 1 & 0 \\ \frac{1}{Z_{eq4}} & 1 \end{bmatrix}$$

Finally, to compute the channel with a bridged tab, we have

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \prod_{i=0}^3 T_i = T_0 T_1 T_2 T_3.$$

By this equation, we can easily computed $\begin{bmatrix} A & B \\ C & D \end{bmatrix}$ matrix

for a channel with n bridged tabs. Thus, we have:

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \prod_{i=0}^{2n+1} T_i$$

Thus, Z_n, \dots, Z_2, Z_1 are impedances and $\gamma_n, \dots, \gamma_2, \gamma_1$ propagation constant of power line between branches and $Z_{eqn}, \dots, Z_{eq2}, Z_{eq1}$ are impedance of eq for parallel branches as with the numbers of bridged tabs 1, 2 or 3n bridged tab, by achieving values of ABCD matrix elements, the performance of transfer line is easily achieved.

By increasing the number of bridged tabs, ABCD matrix volume is increased but the calculations are not complex to find the matrix of transfer line. Thus,

$$\begin{aligned} p_1 &= \cosh(\gamma_1 l_1), q_1 = Z_c \sinh(\gamma_1 l_1), r_1 = \frac{1}{Z_c} \sinh(\gamma_1 l_1), \\ s_1 &= \cosh(\gamma_1 l_1), p_2 = \cosh(\gamma_2 l_2), q_2 = Z_c \sinh(\gamma_2 l_2), \\ r_2 &= \frac{1}{Z_c} \sinh(\gamma_2 l_2), s_2 = \cosh(\gamma_2 l_2) \\ n &= 1, 2, 3, \dots, 10 \quad p_{11} = \cosh(\gamma_{11} l_{11}), q_{11} = Z_c \sinh(\gamma_{11} l_{11}), \\ r_{11} &= \frac{1}{Z_c} \sinh(\gamma_{11} l_{11}), s_{11} = \cosh(\gamma_{11} l_{11}) \end{aligned}$$

Equivalent impedance for a branch is achieved of the following equation:

$$Z_{eq1} = Z_c \frac{Z_{b1} + Z_c \tanh(\gamma_{br1} l_{br1})}{Z_c + Z_{b1} \tanh(\gamma_{br1} l_{br1})}$$

Also, equivalent impedance for 10 branches is obtained by following equation.

$$Z_{eq10} = Z_c \frac{Z_{b10} + Z_c \tanh(\gamma_{br10} l_{br10})}{Z_c + Z_{b10} \tanh(\gamma_{br10} l_{br10})}$$

Also,

$$A_1 = p_2 \left((p_1 + r_1 Z_s) + \left(\frac{q_1 + s_1 Z_s}{Z_{eq1}} \right) \right) + r_2 (q_1 + s_1 Z_s)$$

$$B_1 = q_2 \left((p_1 + r_1 Z_s) + \left(\frac{q_1 + s_1 Z_s}{Z_{eq1}} \right) \right) + s_2 (q_1 + s_1 Z_s)$$

$$C_1 = p_2 \left(r_1 + \frac{s_1}{Z_{eq1}} \right) + s_1 r_2, D_1 = q_2 \left(r_1 + \frac{s_1}{Z_{eq1}} \right) + s_1 s_2$$

$$A_2 = p_3 \left(A_1 + \frac{B_1}{Z_{eq2}} \right) + r_3 B_1 + \frac{1}{Z_{eq3}} q_3 \left(A_1 + \frac{B_1}{Z_{eq2}} \right) + s_3 B_1$$

$$B_2 = q_3 \left(A_1 + \frac{B_1}{Z_{eq2}} \right) + s_3 B_1,$$

$$C_2 = p_3 \left(C_1 + \frac{D_1}{Z_{eq2}} \right) + r_3 D_1 + \frac{1}{Z_{eq3}} q_3 \left(C_1 + \frac{D_1}{Z_{eq2}} \right) + s_3 D_1,$$

$$D_2 = q_3 \left(C_1 + \frac{D_1}{Z_{eq2}} \right) + s_3 D_1$$

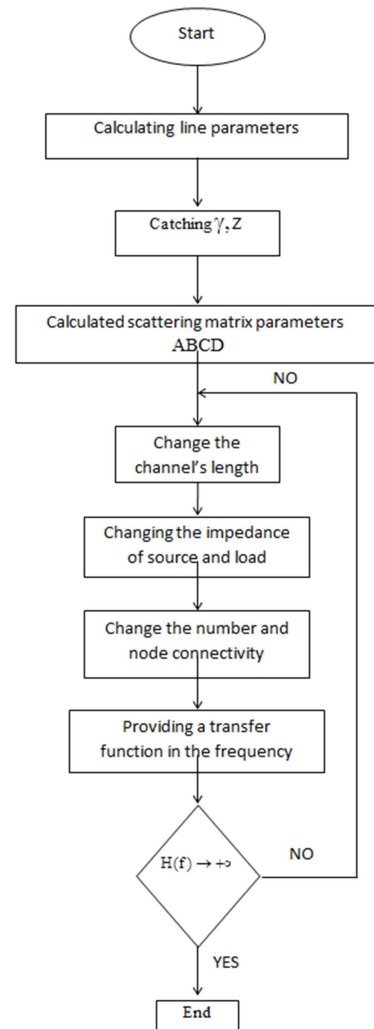
Also, we can achieve A9, B9, C9, D9 by this method.

$$A=(P11A9+r11B9), B=(q11A9+s11B9)$$

$$C=(P11C9+r11D9), D=(q11C9+s11D9)$$

The calculation results via modeling power network to telecommunication channel by different cable sizes and different connection nodes and loading different conditions are shown.

Also programming has been shown in the following flowchart.



5. Simulation and Results

Simulation of charts

The results of simulation are shown by modeling telecommunication channels of power system of region under

various conditions (length of line, bridged tab, loading conditions). Cable parameters are as $R = 1.9884\Omega / m$, $G = 0.01686nS / m$, $C = 0.13394nF / m$ and $L = 362.81nH / m$. Simulation of this method is performed by MATLAB software. The transfer function chart under different conditions is ranging 0 to 35 MHz in various conditions in bandwidth. The following figure shows a part of power network with bridged tab.

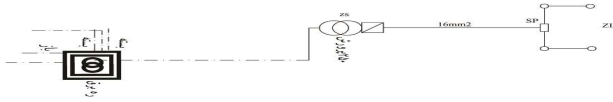


Figure 6. Output feeder of post to consumer.



Figure 7. A part of selective power network with branches of channel.

5.1. Power System Model with Cable Length and Impedance of Varied Source and Fixed Load Impedance

Charts 1, 2 are shown based on load impedance 50Ω and the change of line length from 1 to 2m and source impedance from 0 to 40m. As shown, by increase of impedance, transfer function source is reduced rapidly and power in output is reduced with the increase of impedance.

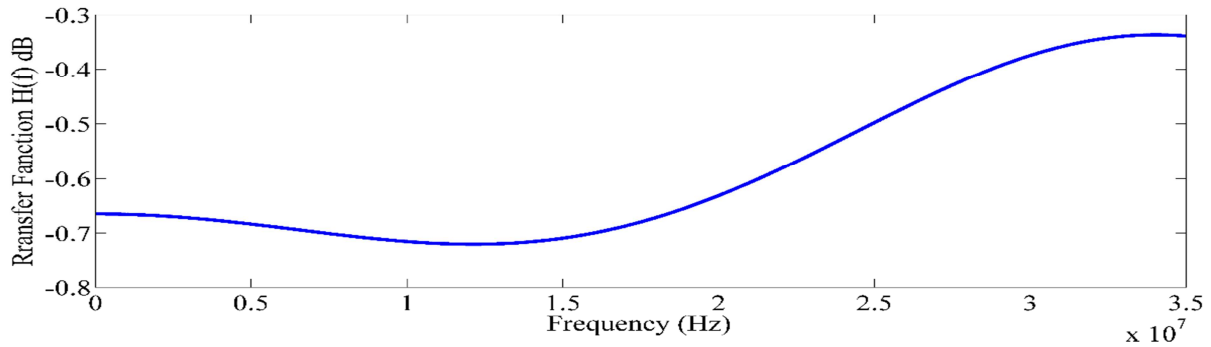


Chart 1. Transfer function with cable length 2m, $Z_s = 0\Omega$, $Z_L = 50\Omega$.

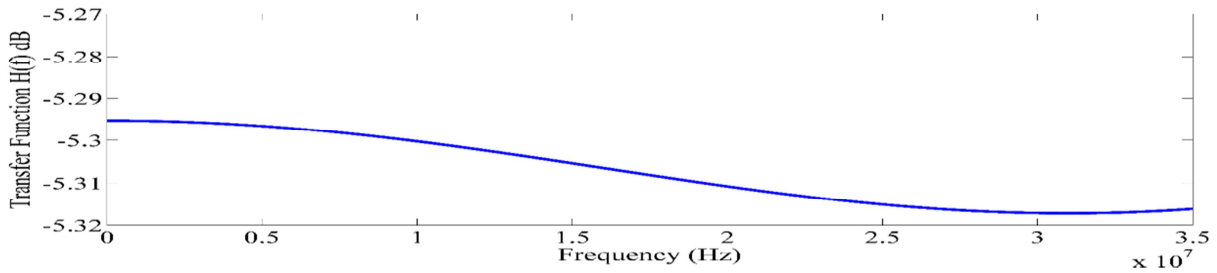


Chart 2. Transfer function with cable length 1m, $Z_s = 40\Omega$ and $Z_L = 50\Omega$.

5.2. The Power System Model with Varied Load Impedance and Cable Length and Fixed Source Impedance

Charts 3, 4 by assuming cable length and source impedance as constant in 2 m, 50Ω , load impedance is changed and the results are shown in these two charts. By increase of the impedance of load from 60 to 80, transfer function is increased gradually and they are inclined to weakening in both cases.

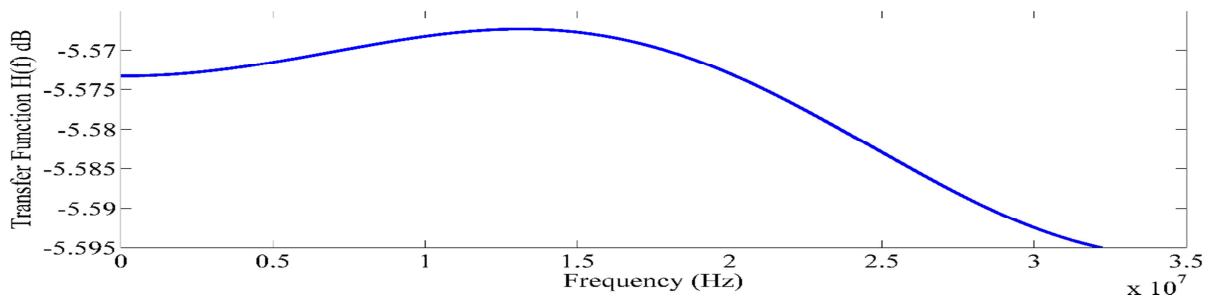


Chart 3. Transfer function with cable length 2m, $Z_s = 50\Omega$, $Z_L = 60\Omega$.

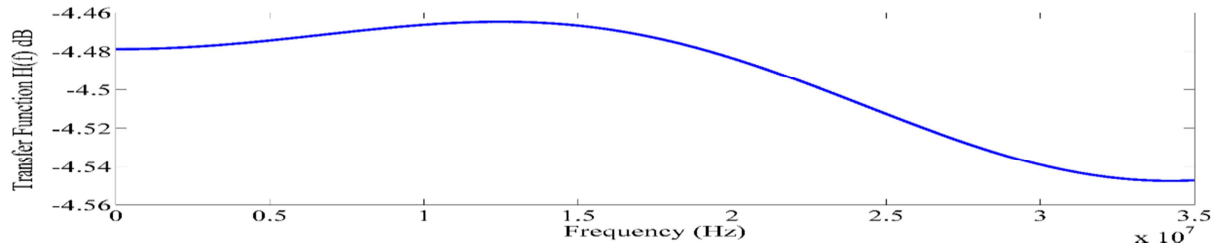


Chart 4. Transfer function with cable length 2m, $Z_s = 50\Omega$, $Z_L = 80\Omega$.

5.3. The Power System Model with Varied Cable Length and Impedance of Constant Source Load

In charts 5, 6, 7, the mentioned cable length is changed from 0.1m to 4m. Impedance of source is 30Ω and impedance of load 50Ω in three cases and only the cable length is changed. The size of channel transfer function is reduced by frequency increase. By its continuous increase, transfer function is reduced.

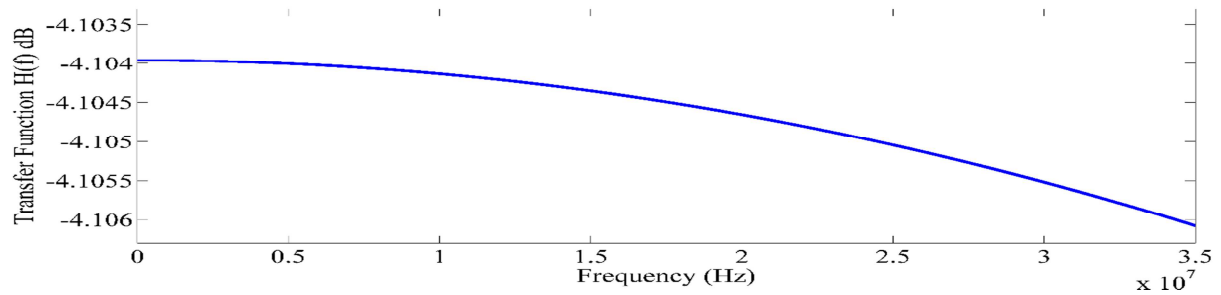


Chart 5. Transfer function with cable length 0.1m, $Z_s = 30\Omega$, $Z_L = 50\Omega$.

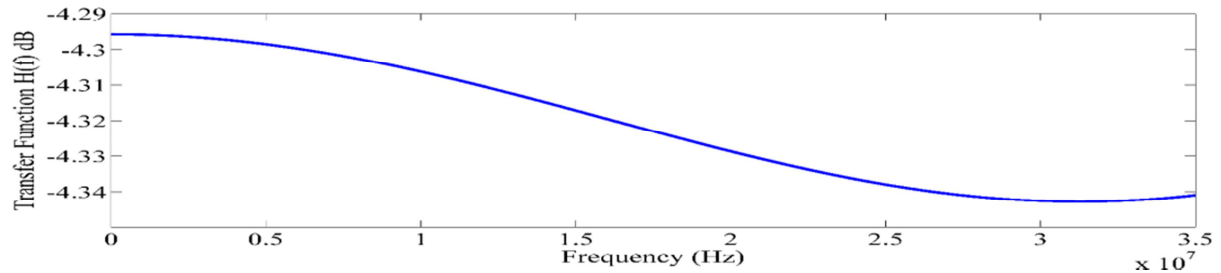


Chart 6. Transfer function with cable length 1m, $Z_s = 30\Omega$, $Z_L = 50\Omega$.

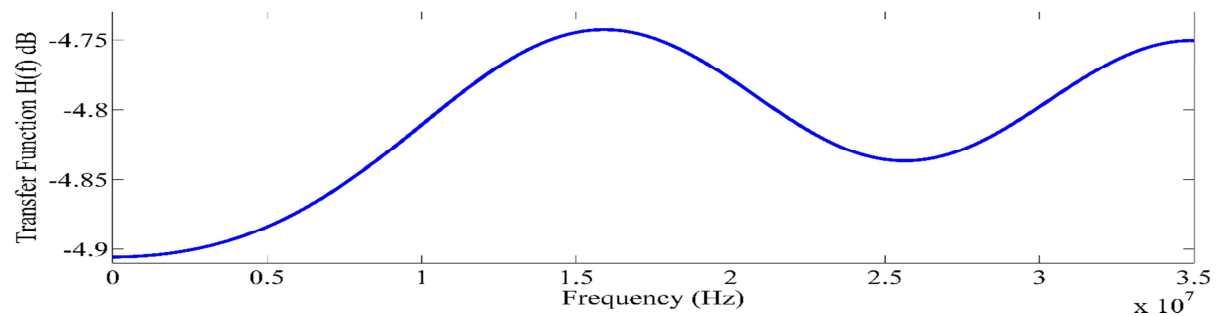


Chart 7. Transfer function with cable length 4m, $Z_s = 30\Omega$ and $Z_L = 50\Omega$.

5.4. Using a Bridge Tab and the Effect of Changing Line Length and Bridge Tab on Transfer Function

In charts 8, 9, 10, by considering Z_b , Z_s , Z_L as constant in $30 + 50j\Omega$, 30Ω and 50Ω , the effect of cable length change (in 2m, 4m, 10m, respectively) and bridged tab length (from 1m to 2m) can be evaluated. As shown, transfer function is increased with increase of cable length and compared to without bridged tab, this increased can increase attenuation.

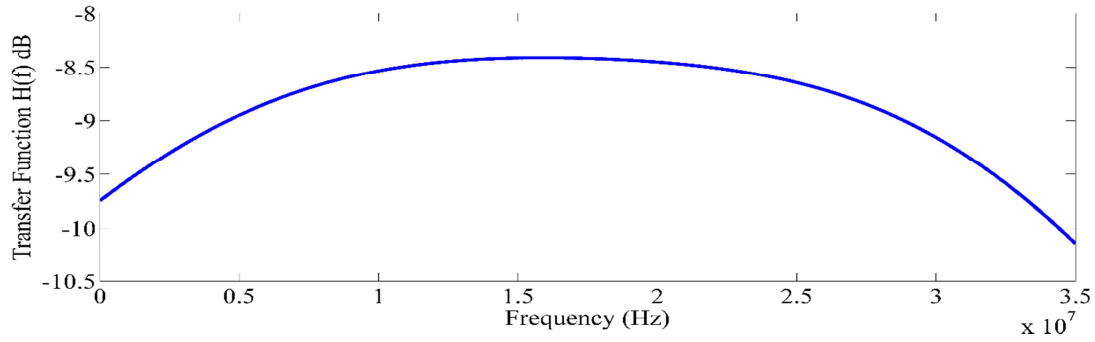


Chart 8. Transfer function with cable length 2m, $Z_s = 30\Omega$, $Z_L = 50\Omega$, $l_{br} = 1m$, $Z_b = 30 + 50j$.

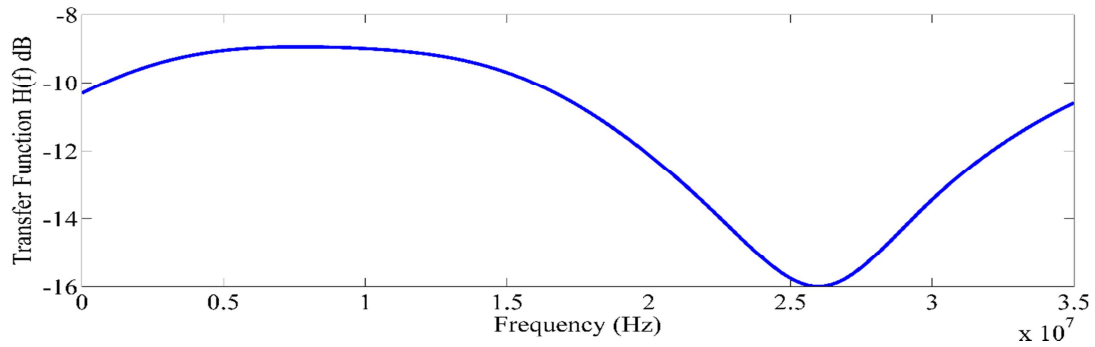


Chart 9. Transfer function with cable length 4m $Z_s = 30\Omega$, $Z_L = 50\Omega$, $l_{br} = 2m$, $Z_b = 30 + 50j$.

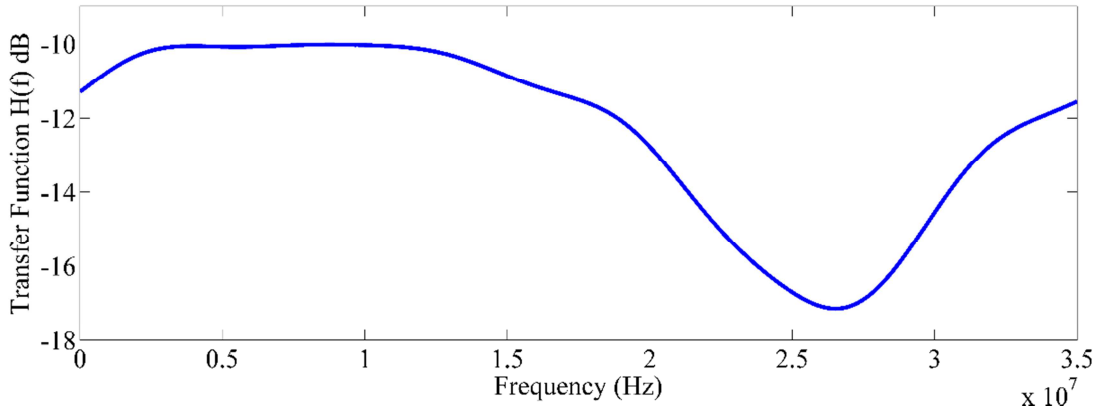


Chart 10. Transfer function with cable length 10m, $Z_s = 30\Omega$, $Z_L = 50\Omega$, $l_{br} = 2m$, $Z_b = 30 + 50j$.

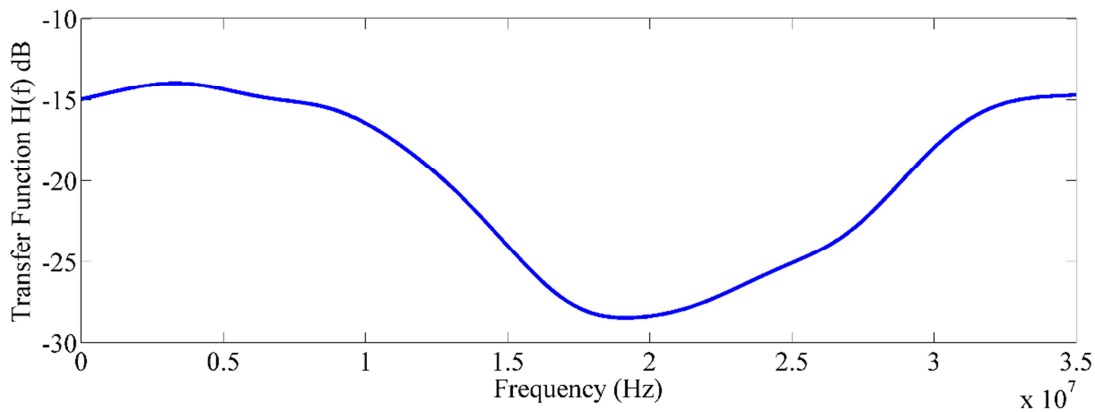


Chart 11. Transfer function with cable length 10m, $Z_s = 30\Omega$, $Z_L = 50\Omega$ and three bridged tables with the length of $l_{br} = 2m$, $Z_b = 30 + 50j\Omega$, 100Ω , 150Ω .

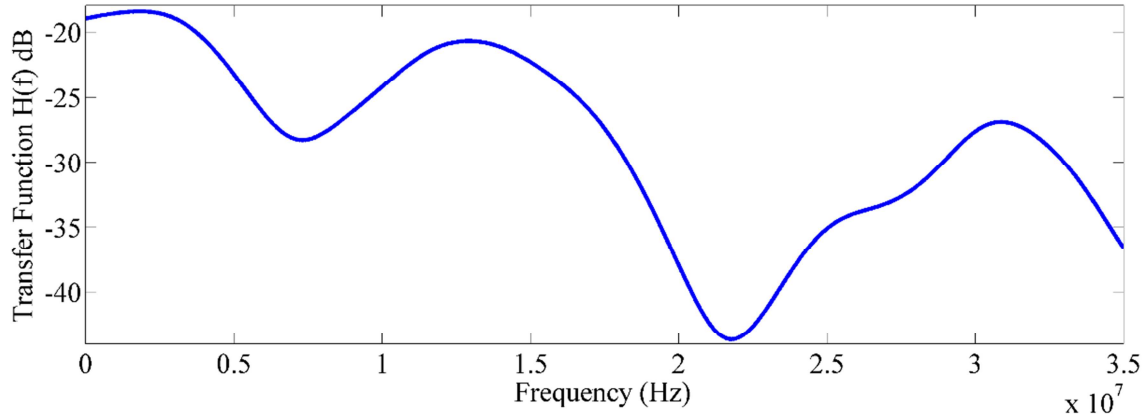


Chart 12. Transfer function with cable length 10,m $Z_s = 30\Omega$, $Z_L = 50\Omega$ and 5 bridged tabs with lengths $l_{br} = 2m, 5m, 1m, 2m, 5m$, $Z_b = 30 + 50j\Omega, 100\Omega, 150\Omega, 100 + 50j\Omega, 200\Omega$.

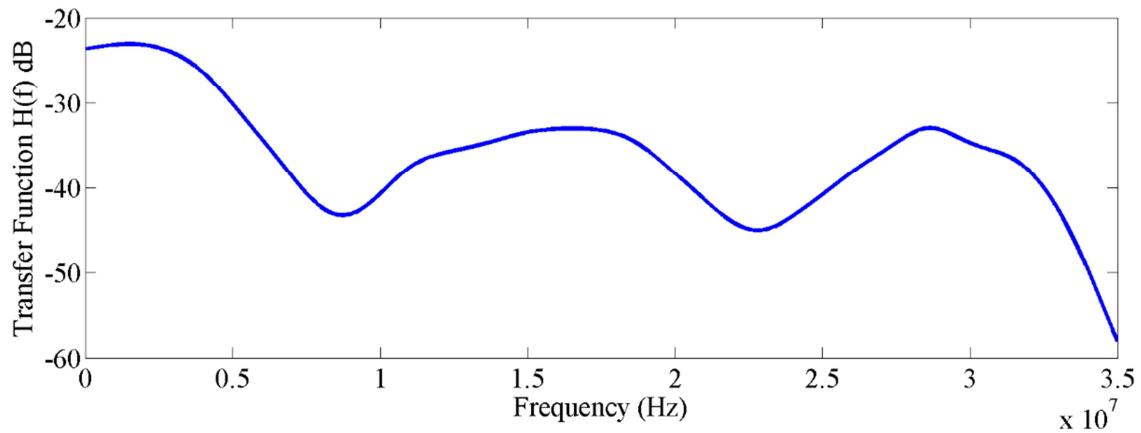


Chart 13. Transfer function with cable length 12m, $Z_s = 30\Omega$, $Z_L = 50\Omega$ and 7 bridged tabs with length $l_{br} = 2m, 5m, 3m, 5m, 1m, 3m, 5m$ and $Z_b = 30 + 50j\Omega, 100\Omega, 150\Omega, 100 + 50j\Omega, 200\Omega, 100 + 50j, 150$.

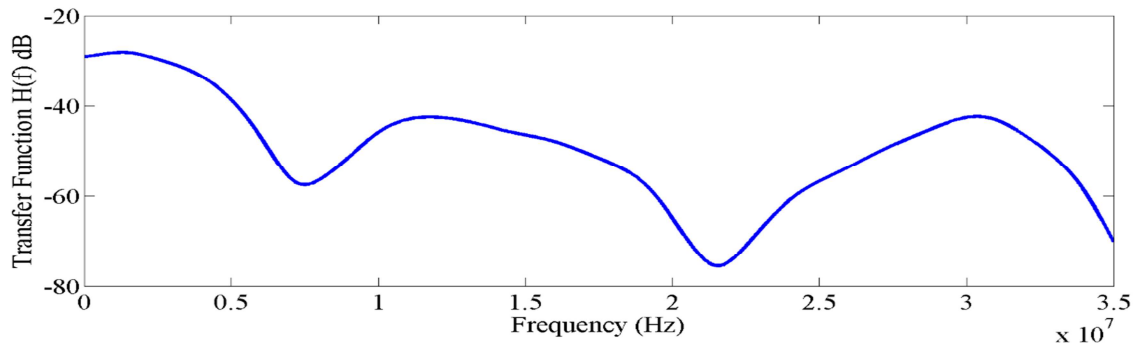


Chart 14. Transfer function with cable length 22m, $Z_s = 30\Omega$, $Z_L = 50\Omega$ and 10 bridged tabs with lengths $l_{br} = 2m, 5m, 1m, 2m, 1m, 3m, 2m, 5m, 5m, 5m$, $Z_b = 30 + 50j\Omega, 100\Omega, 150\Omega, 100 + 50j\Omega, 100\Omega, 100 + 50j\Omega, 150\Omega, 200\Omega, 100 + 50j\Omega, 450\Omega$.

5.5. Transfer Line with Different Bridged Tabs

In charts 11-14, by considering line parameters as constant, effect of bridged tabs, length of bridged tables and their load as constant are investigated. As shown in the results, one of the general features in each case is that size of transfer function has natural fluctuation and it is increased sometimes

and also it is reduced. In all the models, load impedance and source are constant. The length of cable and bridged tab length and number of bridged tabs are varied. As shown, channel transfer function is descending by the increase of number of bridged tabs (size of transfer function is reduced). The bridged tabs act as interfering sources in data sending and due to echo can make the destructive effects of bridged tabs as more.

Thus, if we have many bridged tabs, they have big length and this eliminates the signal to be sent on power channel.

6. Conclusion

In this study, feasibility of using data transfer technology on power lines in Gilan province is evaluated in terms of network structure. BPL is a new technology to present high speed service via power lines. This technology has many advantages and it is famous in the entire world. One of the most important reasons is isolation of technology in the past years, features of transfer channel (electricity distribution network) and it has many problems. Electricity network of Iran is similar to Europe electricity network. This, technology can be used in Iran on condition that it is developed in this country. The advantages of this technology caused that it is turned into one of the best technologies to have access to internet. The following main items are used.

- Using existing infrastructures (current electricity network) with high coverage compared to other technologies.
- Rapid, easy and modular development and installation
- Rapid and easy installation of house tools
- Capital cost and similar operation xDLS and less than cable services

Finally, by selection of a sample of power channel and selection of various values of source impedance and connected loads to channel and considering various numbers of connection nodes, transfer function of selective channel in frequency are achieved and the effects of channel length and impedance changes of load and source and the effects of number of connection nodes and their length in transfer function were evaluated. The implementation of data transfer projects on power lines in Gilan is possible but high attenuation and presence of many deep fallings in specific frequencies are the problems as observed in BPL channels in simulation results. Therefore, selection of a good band for data transfer is important. Thus, achieving frequency response between various points of network by considering a good model for behaviors of line and loads connected to network in BPL frequency band can be necessary to design suitable modems and efficient networks.

Later, a selective power network with definite cable and some bridged tabs (connection node) are selected. Then, by ABCD matrix, it is modeled by a bipolar network. The results of simulation and charts show that entire selective power network is evaluated by modeling equivalent circuit and finding channel transfer function from power line topology. The final result showed that by increasing the number of bridged tabs and the increased length, power line is weakened to send data. The effect of echoes in branch is emerged as transfer function as indentations with constant frequency distance. The first indentation is occurred if the direct and echoed wave is shifted as half of the opposite wavelength and this reduces amplitude. Based on the researches in this chapter, we can say BPL channel is designed well.

Recommendations

Based on the evaluations, it is proposed that based on capacities of technology, its practical implementation is performed in Gilan province and simulation is defined for all different types of conductors in Province to define the behavior of all conductors applied in electricity lines. The fading of correction techniques and error detection in data transfer channels was investigated to show which of error correction codes (Hamming, BCH, etc.) is good in error correction.

References

- [1] Azadedel, Ramezanali; Majid Nader, Mohammad Rezayi. 2003. Modeling and optimization of data transfer in house networks. 18th international conference of power. Tehran. Tavanir Company. Energy research center.
- [2] Asadzade, Vahid; Saeed, Pouyafar, Seyed Mohammad Taghi Bathayi. 2008. Problems and limitations of BPL systems as telecommunication ground in electricity distribution networks. 23th International conference of power. Tehran. Tavanir company. Energy research.
- [3] Abbasimoghadam, Dariush; Zohre, Moades, Mehdi Nasiri Sarvi. 2006. Telecommunication parameters of power distribution lines and minimizing the effects of parameters on data transfer. 11th conference of electricity distribution networks. Mahmoudabad.
- [4] Mirjalili, Qasem; Ali Mohammadi, Abolfazl Asadi. 2005. The evaluation of modulation methods in high speed sending of data on electricity distribution networks of low pressure. 13th conference of electricity engineering of Iran. Zanzan. Zanzan University.
- [5] Antoniali, M. and. Tonello, A. M. Senior Member, IEEE "Measurement and Characterization of Load Impedances in HomePower Line Grids" Submitted on February 2013. Revised on May10, 2013 and on June 22, 2013. Accepted on June 26, 2013.
- [6] Arthur, D. Little, "White Paper on Power Line Communications", Oct 2004.
- [7] Babic, M. Hagenau, M. Dostert, K. Bausch, J. "open plc European Research Alliance", "Theoretical postulation of PLC channel model" EC/IST FP6 Project No 507667, 2001
- [8] Canete, F. Cortés, J. Díez, L. and Entrambasaguas, J. "A channel model proposal for indoor power line communications," in IEEE Communications Magazine, January 2011.
- [9] Gebhardt, M. Weinmann, F. Dostert, K. "Physical and Regulatory Constraints for Communication over the Power Supply Grid", IEEE Communications Magazine, May 2003, vol.19, pp.84-90.
- [10] Mork, B. A. "Power Line Carrier Communications System Modeling ", International Conference on Power Systems Transients (IPST'05) in Montreal, Canada on June 19-23, Paper No. IPST05 - 247, 2005.
- [11] Marrocco, G. Statovci, D. Trautmann, S. "A PLC Broadband Channel Simulator for Indoor Communications", April 2012.

- [12] Meng, H. Chen, S. Guan, Y. L. Law, C.L. So, P. L. Gunawan, E.and.Lie, T. T. "ATransmission Line Model for High-Frequency Power Line Communication Channel", 2002 IEEE.
- [13] Schickuber, S. "Control using power line:Aeuropeanview",Computing& Control Eng. Jour, pp. 180-184.,Aug 1997.