Attenuation Measurement of Laboratory-Based PLC Implementation

Intan Sari Areni, Elyas Palantei, Ansar Suyuti, Adnan, Weni Sri Yusnita, Heni Susanti

***Abstract*—Power Line Communication (PLC) is commonly known as an attractive and an alternative potential communication technology suitable for data communication by using power electrical wiring. In this paper, laboratory-based PLC system has been developed at the Department of Electrical Engineering, Universitas Hasanuddin. An experimental assessment is performed by setting the transmitted signal into several values of frequency variations. The experimental testing also considers the variations of the distance between transmitter and receiver. The whole system performance is measured and the power line attenuation is recorded. The numerical evaluations to verify the attenuation property throughout PLC network is carried by altering the size of NYM cable; the distance between transmitter and the receiver; and the frequency. A series of experiments verifies that the variability of -3.1 dB until – 4 dB attenuation existed within the constructed PLC system.**

***Index Terms*—Power Line Communication (PLC), Attenuation, NYM cable, PLC network, PLC throughput.**

I. Introduction

Data communications over a power electrical wiring are an alternative of communication systems which has been widely received as the interested area to be researched and to be developed currently. One of the critical problems in data communication is the use of cables in large quantities that can disrupt the aesthetic side. Therefore, the use of low voltage electricity network as an alternative communication media is a smart option due to no requirement of additional communication wires. Furthermore, it would be the preferred medium for providing broadband connection to rural areas where telephone and cable connections may not exist. Installation of electrical wiring existed in office buildings, housing and campuses becomes one of the advantages of PLC technology implementation. The existing problems of PLC technology such as attenuation, noise, distortion, and multipath on power lines are mostly caused by the electrical equipment connected to the power line [1].

Determination of the power lines characteristics is the first necessary step to be known before the implementation of PLC technology. In this case, one of the most influence parameters is attenuation. In Ref. [2], Liu et al. has discussed the influence of the cable type on the attenuation level generated at the measuring points along the propagation paths. The resulted attenuation is relatively different for each frequency. Meanwhile, in [3], Mulangu, et.al. has also outlined the importance of the attenuation phenomena by reviewing the effect of power line mismatching on the nodes throughout PLC network. There is an interesting comparison results between the measurement and simulation on this study [3]. Furthermore, Wei Cai, et.al. [4] has proposed PLC channel modeling method based on information nodes. The results show that the distance from the transmitter to the receiver has less influence on the frequency characteristics of amplitude, but the length of the PLC branch channel will affect the amount of peak attenuation [4].

Due to the many effects of attenuation on PLC network, the effect of damping on the power lines within the laboratory room will be investigated in this paper. The paper presents laboratory testing, such as the measurement and the simulation results.

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II. Power Line Communication

Power Line Communication (PLC) is a communication system that sends data over electrical transmission cable. Hence the electric network serves not only as a conductor of the electric power but also as a medium for communication. The use of UTP cable is exchanged with an electric cable.

PLC system can be classified into Broad-Band (BB) PLC and Narrow-Band (NB) PLC. The BB-PLC uses a frequency band from 2 MHz to 30 MHz in Japan, which is called High Frequency (HF) band, and the high data communication rate up to 200 Mbps is commercially available. However, the usage of HF band causes a serious problem, which is unintentionally radiated PLC signals interfered with the existing radio services. It is called Electro-Magnetic Compatibility (EMC) problem. Because of that, the BB-PLC is not permitted for outdoor application in Japan [5]. The NB-PLC uses a band from 10 kHz to 450 kHz, so that the EMC problem does not exist, but the available rate is low (up to 100 kbps). The promising applications in NB-PLC are Automatic Meter Reading (AMR) [1], Advanced Metering Infrastructure (AMI) [6], and the smart meter, because the NB-PLC is permitted for both indoor and outdoor applications.

BB-PLC becomes an alternative to Wi-Fi suitable for utilization at home and building applications due to the same advantages, such as no additional wiring and quick deployment. BB-PLC will perform better when a Wi-Fi system suffered from wall attenuation. However, this technology has also some technical shortcomings such as the low level of network security and the attenuation, and the noise due to the existence of a variety of electrical equipment in power grids [7].

The most commonly used model in modeling the PLC channel characteristics is the transfer function $H(f)$ proposed by Philipps and Zimmermann-Dostert [8,9]. In [8], Philipps proposed an echo model and series resonant circuit models. Zimmermann-Dostert model [9] was determined by the attenuation factor of the transmitted signal. Both methods only proposed network configuration without branching. Therefore, Anatory-Theethayi has proposed a new model by considering the branching factor, the connection and the amount of branching at a node as shown in Fig.1 [10].

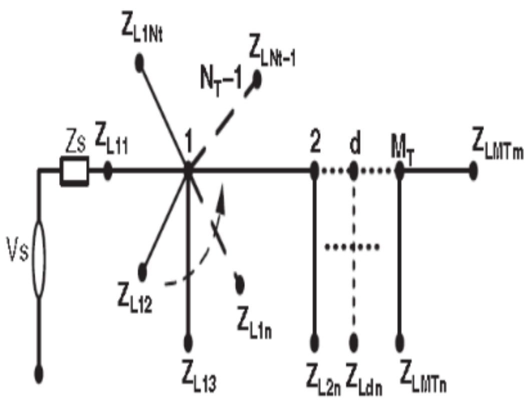
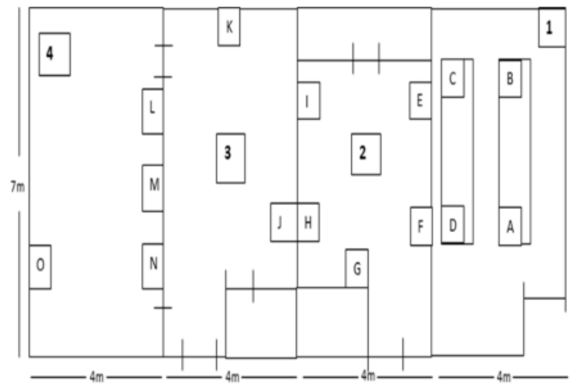


Fig. 1. The proposed model of Anatory-Theethayi [10]

III. Proposed Scheme

This study aims to determine the feasibility of the use of PLC technology in laboratory-based data communications. The Modem PLC used is AV500 Gigabit Powerline Adapter TL-PA511. Measurements carried out in our laboratory to analyze the effects of attenuation when transmitting data over electrical wiring. The site map of measurement is shown in Figure 2. The room measurements numbered from 1 to 4 which is called Radio and Microwave Telecommunication Laboratory, Telkomnet, IKA Telkom 1 and IKA Telkom 2, respectively.

The calculation of attenuation level is based on the voltage value of each outlet acted as a transmitter (Tx) and a receiver (Rx), respectively. In addition, the attenuation is simulated by using some variations of the cable length, namely: 3x1.5 mm^2, 2x2.5 mm^2 and 3x2.5 mm^2 based on the existing cable in laboratory with the frequency range of 50-300 kHz.



A;B;C;D;E;F;G;H;I;J;K;L;M;N;O : electrical outlets

Fig. 2. Site map of the measurement

IV. Results and Discussion

The type of cable installed inside the laboratory is NYM 2x2.5 mm^2 and 3x2.5 mm^2 with a resistance value of 7.41 Ohm/km. Attenuation levels through the measurement are influenced by the cable resistance per unit length of the transmission media. The results of this study in the form of measurement data and simulation of attenuation by using PLC technology are shown in Figure 3 to Figure 8. In Fig. 3, the attenuation values obtained from all rooms are around 0.32 dB - 4 dB. The attenuation values between the rooms are ranged from - 3.1 dB 0.87 dB as shown in Fig. 4.

Attenuation simulation results are shown in Fig. 5 to Fig. 8. The parameters that influence the simulation results are the NYM cable size, the distance measurement and the simulation frequency of 50-300 kHz.

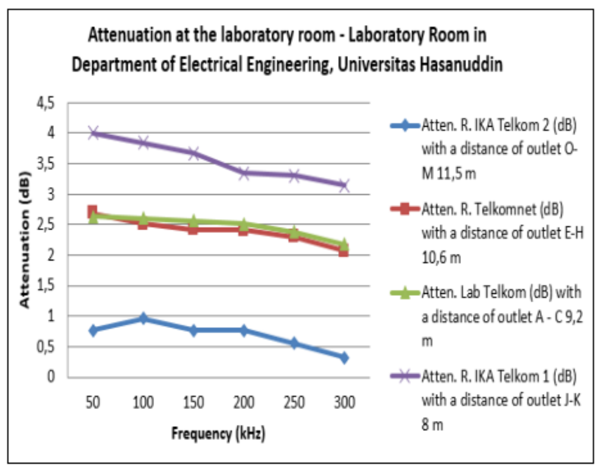


Fig. 3. A comparison of the measured results in each room.

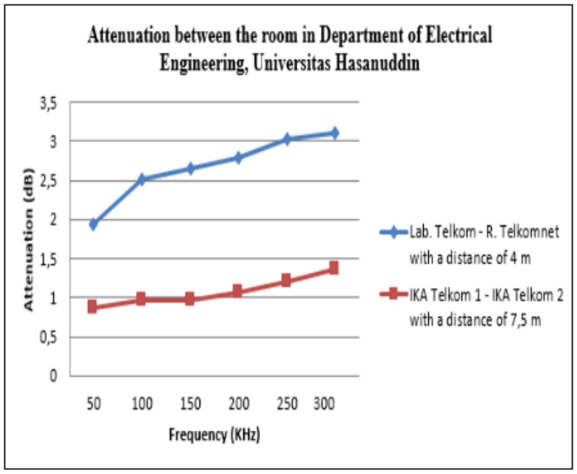


Fig. 4. Comparison of measured results between the rooms

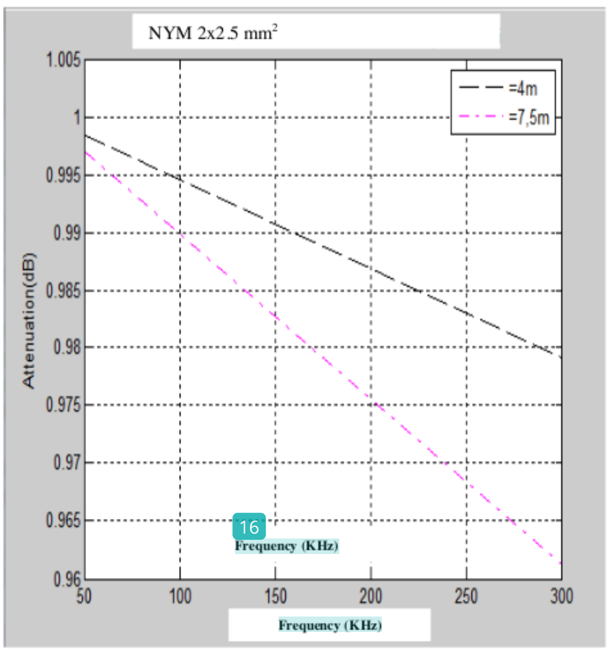


Fig. 5. The simulation results for NYM size of 2x2.5mm^2 with the distance of 4m and 7.5m

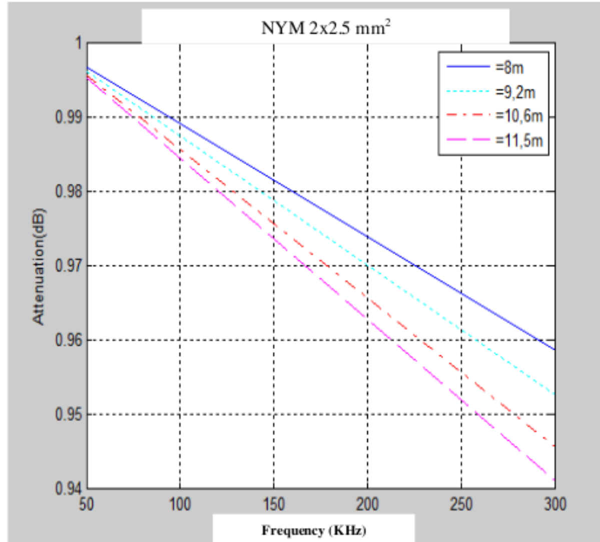


Fig. 6 The simulation results for NYM size of 2x2.5 mm^2 with the distance of 8m, 9.2m, 10.6m and 11.5m.

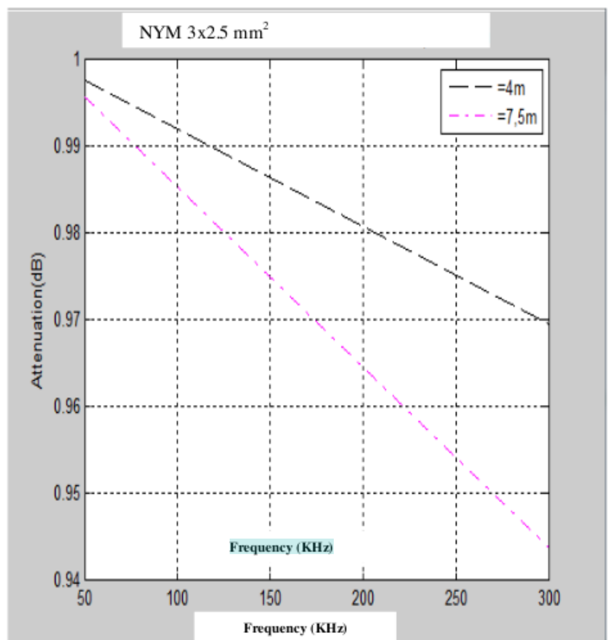


Fig. 7 The simulation results for NYM size of 3x2.5 mm^2 with the distance of 4m and 7.5m

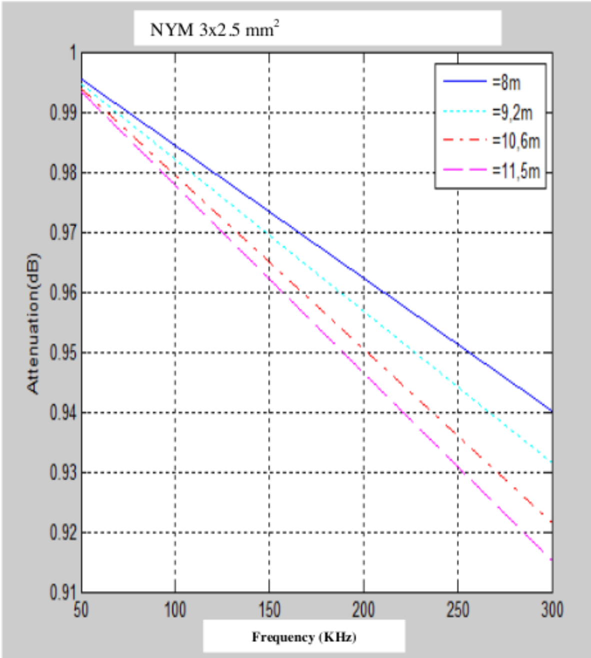


Fig. 8. The simulation results for NYM size of 3x2.5 mm^2 with the distance of 8m, 9.2m, 10.6m, and 11.5m

The measured and numerical simulated results have been recorded and plotted in Figs. 3, 4, 5, 6, 7 and 8. It is clearly shown that the attenuation values on the measurement at each location are greater than 1 dB. While on the simulation results, the value of attenuation is less than 1 dB. Attenuation at the time of measurement greater than the simulation results because these results are influenced by the presence of electrical loads.

V. Conclusion

The feasibility of laboratory-based PLC technology implementation based on attenuation value was studied in the paper. The results showed that the PLC technology can be used as an alternative telecommunication infrastructure suitable for data communication. The attenuation variations on the range of -3.1 dB - 4 dB during the measurements generated in each room and in between the rooms. The results were affected by the cable type, the distance and the frequency. For future work, the characteristics of PLC channel in the laboratory by using noise and throughput as measurement parameters are required.

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