전력선 통신을 위한 저압 배전 시스템의 임피던스 연구

(Study on Characteristic Impedance in LV Distribution System for PLC)

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Abstract

In this paper, the investigation of characteristic impedance on low voltage distribution system is described. The residential area of LV distribution systems is researched for the modeling. At frequency range from 1MHz to 30Mhz, the input characteristic impedances of low-voltage distribution network are obtained with experiments. The low-voltage distribution system based on the model is built at the laboratory building. S parameters are measured by performing experiments. Finally, the characteristic impedances are reported

1. Introduction

As the IT industry growth, communication systems improve rapidly and it is applied to other industry in the world. The power system is not exceptional. For utility demands, the high speed communication systems provide AMR(Automatic Metering Reading), DAS(Distribution Automation System), etc., with less expense. For customer demands, home automation security, internet, etc., are offered at low cost [1], [2]. For these reasons, PLC(power line communication) is one of the most accomplished communication system.

There are many advantages of PLC. High or middle-voltage power supply networks can be utilized to connect a longer distance to avert building an extra infrastructure. Low-voltage supply networks are available worldwide in a very large number of households.

However, there are difficulties to be a high speed communication. The power system is not designed for communications. Accordingly, the transmission characteristics of power line channels are not favorable for data transfer. Definitely, studies for the transmission characteristics are necessary to understand PLC. In advance, LV distribution system must be investigated at transmission frequency band. Charles in [3] performs on the experimental investigation of influence of high frequency signal attenuation on the load in the house and the building. In the aim to analyze a distribution network in high frequency range some methods are carried out [4], [5]. However, above these papers do not investigate the characteristic impedance of low-voltage distribution systems with an experiment or a simulation. Young-Jin in [6] finds the average characteristic impedance of low-voltage distribution networks but it is limited to only home network.

The main contents of this paper consist of three parts and the each part is summarized as follows. Section 2.1 defines the basic concept of PLC. The Classification of low-voltage distribution system is reported. Finally, the model of LV distribution system is described. In section 2.2 and 2.3, the experimental tests of low-voltage distribution system are performed with Network Analyzer 8712ES. The condition of test is in detail. Consequently, the characteristic impedances of low-voltage distribution system are found.

In this paper, at frequency range from 1MHz to 30MHz, the characteristic impedances are investigated by performing the test based on the model of low-voltage distribution system between the pole transformer and a consumer.

2. Modeling of LV Distribution System

2.1. Distribution Network

Low-voltage supply networks directly connect the end customers in a very large number of households worldwide. In the residential area, the number of the customer is depends on a capacity of pole transformers. Also, there are different types of transformer connection. Those affect the configuration of low-voltage distribution networks greatly. Fig.1 shows typical low-voltage distribution networks in Korea. The low-voltage distribution network is tree system. From the general low-voltage distribution network, only one customer is chosen and the configuration is described in detail.

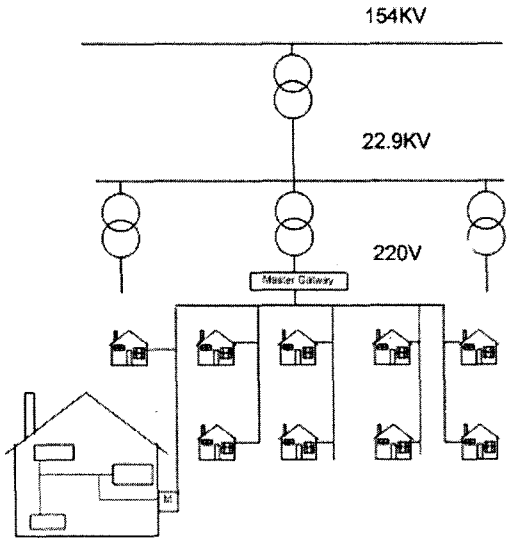


Fig. 1. General Distribution System

2.2.Configuration of LV Distribution System

PLC access network can be realized to include a whole low-voltage power supply network or to include only a part of a supply network. To reduce the number of users per PLC system and the network length, it is possible to divide the low-voltage network into several parts [7]. The basic unit of communication is shown in Fig.2 The elements of low-voltage distribution networks are reported in Fig.2.

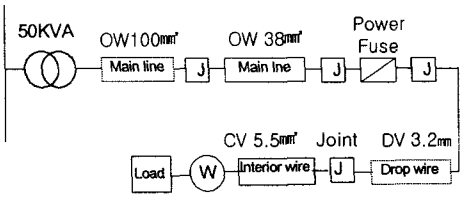


Fig. 2. Model of Distribution Sysem

At the pole transformer, the $100\,mm^2$ diameter wire is used to be connected. The wire length is 2m. The 38 mm^2 diameter wire is 100m length. There is the power fuse between the main wire and the drop wire. The Drop wire is 15m length. The interior wire is 10m length of CV5.5mm^2. The watt-hour meter is also connected to low-voltage distribution line.

2.3.Equipment Set and Test Condition

In this thesis, at frequency range from 1MHz to 30MHz, the S parameters are measured with Network Analyzer 8712ES from the pole transformer and the what-hour meter which is located at an entrance of the house. Fig.3 shows the test of condition and configuration. For the test, the low-voltage distribution is built at the laboratory building.

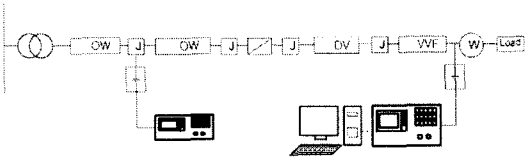


Fig. 3. Test Bad

We perform the test with various loads. The table.1 shows the different connection of loads. The loads are all household goods.

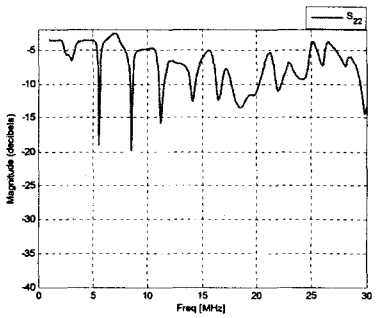
Table 1. Test of Load difference

Test	Load
1	empty
2	A
3	A+B
4	A+B+C

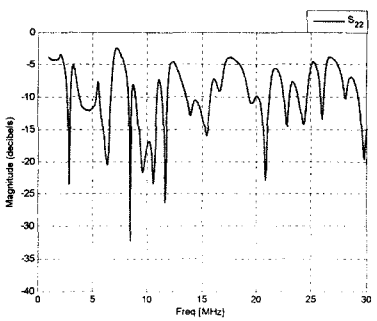
The first test is that S parameters are measured with no load. The second test is that the parameters are measured with load type A which is a hitter, the third test is with load type A and B. B is a refrigerator. The last test is that the parameters are found with A, B, and C type all connected.

2.4.Results of Test

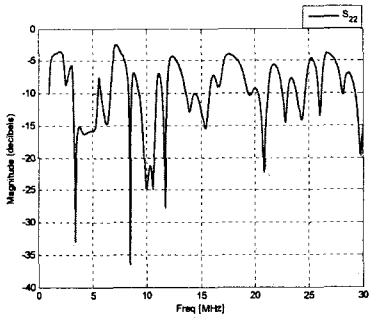
From the tests, All S parameters are measured with Network Analyzer.



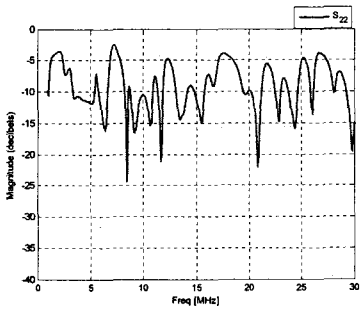
(a)



(b)



(c)



(d)

Fig. 4. S_{22}parameters from the test

In Fig.4, (a) is $S_{22}$with on load, (b) is wiith load A, (c) is with load A and B, (d) is with A, B, and C loads. As the results of test, S_{22} is largely affected by the loads especially frequency range at 1MHz ~15MHz.

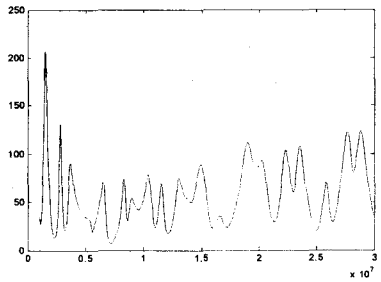


Fig. 5. Impedance from test results

In Fig.5, the characteristic impedances are obtained from frequency range 1MHz to 30MHz. Fig.5 shows the impedance with various frequencies. Fig.9 shows calculation the condition of full load and From the results, the impedance is fluctuated by load variation.

3. Conclusion

For PLC, the characteristic impedance in a distribution system is one of the most important matters. From the point of view for communication, the attenuation characteristic of the HF signals is greatly caused by impedance mismatch. Therefore this paper investigates the characteristic impedance in order to analyze the attenuation characteristic of HF signals in the low voltage distribution system. For evaluation of the characteristic impedance, the modeling of the low voltage distribution system is proposed. For modeling, the general distribution system is researched. The components and line structure are accurately described. Moreover, on the low-voltage distribution system model, the experimental tests are performed.

The important results of this paper are summarized as follows:

1) For PLC, the modeling of low voltage distribution system is described in the section between the pole transformer and the consumer. In the residential area, the typical Korean low voltage distribution system is applied to the modeling.

2) The experimental set-up of the low-voltage distribution system model is built atthe laboratory building yard. S parameters and reflection coefficients are examined by using network analyzer. From the results of test, the characteristic impedance of the model is found
It is expected that the low voltage distribution system model could be used as a primary model to analyze more diverse and complex distribution system. In addition, the obtained characteristic impedance of the system from the tests is essential information for improving the channel condition. It is worthwhile to provide the characteristic impedance of broad-band in the distribution system for the better PLC channel condition.

Acknowledgements

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Reference

[1] Klaus Doster, "RF-Models of the electrical power distribution Grid," International Symposium Power line Communication and its application, pp. 549-557, March.1988.
[2] Atrhur R. Bergen, Vijay Vittal, "Power Systems Analysis," Prentice-Hall, Inc, 2nd ed., 2000, pp292~322
[3] Charles J. Kim, Mohamed F Chouikha, "Attenuation Characteristics of High Rate Home-Networking PLC signals," IEEE Trans. On power delivery, Vol. 17, No4, pp.945-950, Octorber2002
[4] Masaoki Tanaka, "Transmission Characteristics of a Power Line Used for Data Communication at High frequencies," IEEE Trans on consumer Electronics. Vol.35, No.1, pp.37-42, February 1989.
[5] H.Meng, S. Chen, Y. L. Guan, C.L. Law, P.L.So, E.Gunawan, T.T.Lie "Modeling of Transfer Characteristics for the Broadband Power Line Communication Channel," IEEE Trans. On power delivery, Vol. 19, No.3, pp.1057-1064,July2004
[6] Young-Jin Park, Kwan-Ho Kim, "Investigation and Measurement of indoor low voltage powerline impedance for high data rate powerline Communications," Korea Electrotechnology Research Institute, Vol. 41, No.8,pp93-98August2004
[7] Halid Hrasnica, Abdelfatteh Haidine, Ralf Lehnert ,"BroadBand Powerline Communications," John Wiley&Sons, Ltd,., 2004, pp7~38
[8] Matthew M. Radmanesh, ,"Radio Rrequency and Microwave Electronics,"Prentice Hall PTR Upper Saddel River, NJ, 2001,pp287-318
[9] Guillermo Gonzalez ,"Microwave Transistor Amplifiers Analysis and Design," Prentice Hall Upper Saddel River, NJ, 1997,pp4-66