Influence on transmission characteristics of power line communication when using surge protective devices

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Abstract: - Power line communication (PLC) has been available since October 2006 in Japan. Because no investigation has been done on transmission characteristics of PLC when using surge protective devices (SPDs), we examined PLC transmission performances using SPDs such as varistors and gas discharge tubes (GDTs) or a combination of the two. From our experiments we found that the transmission rate degraded when using varistors because of their low impedance values in the PLC frequency range. We also found that when installing an SPD on a PLC circuit, using only a GDT or connecting a GDT with a varistor in series is necessary.

Key-Words: - power line communication, transmission characteristic, surge protective device, varistor, gas discharge tube

1 Introduction

PLC has been available since October 2006 according to Japan's Official Gazette[1]. PLC is restricted to indoor use in the frequency range of 2 to 30 MHz[1]. Normally SPDs such as varistors and GDTs are installed on a main power distribution board or inside an electrical apparatus[2]~[4]. Because no investigation has been done on transmission characteristics of PLC when using SPDs[5],[6] we examined several examples of PLC transmission configurations using a PLC transmission channel simulator[7].

From our experiments we found that the transmission rate degraded when using a varistor-type SPD. When installing an SPD for a PLC circuit, it is necessary to only use a GDT or connect a GDT with a varistor in series.

2 Experimental Test Results when using Varistors

2.1 Overview of PLC transmission channel simulator PLCS3000 we used

The PLCS3000 transmission channel simulator produced by Nishiyama Corporation is a power line simulator for PLC in the frequency range of 2 to 35 MHz. This simulator can simulate white noise, attenuation, line characteristics and AC synchronized noise bi-directionally. Actual measured results can be duplicated using relevant PLC lines and noise profiles.

2.2 Measured PLC modem rates with and without a varistor

The capacitance and impedance values of the varistors we used are listed in Table 1.

Table 1: Measured capacitance and impedance values of varistors

Varistor	C [nF]	Z[Ω] (30 MHz)
Varistor A	**14.84**	**0.36**
Varistor B	**14.30**	**0.37**
Varistor C	**15.72**	**0.34**

Impedance values of varistors at the maximum frequency of 30 MHz for PLC are about 0.35 Ω, which are very low compared with those of commercial power frequencies. This low impedance almost creates short-circuit conditions for PLC trasmision signals. Measured line patter 1 profile without and with varistor A are shown in Figure 1 and Figure 2 respectively. Measured line patter 2 profile without and with varistor A lare shown in Figure 3 and Figure 4 respectively. In this experiment, we observed a more than 30-dB loss in the frequency range of 1 to 10 MHz when varistor A was installed in the PLC line.The measured PLC modem rates without and with varistor A are listed in Table 2. We used an HD-PLC modem produced by Matsushita Electric Industrial Co. Ltd.

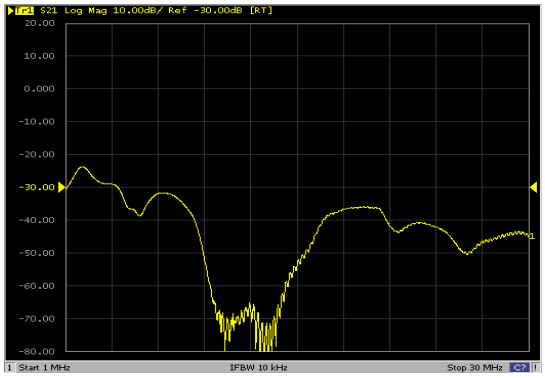

Figure 1 Actual line pattern 1 profile (without varistor)

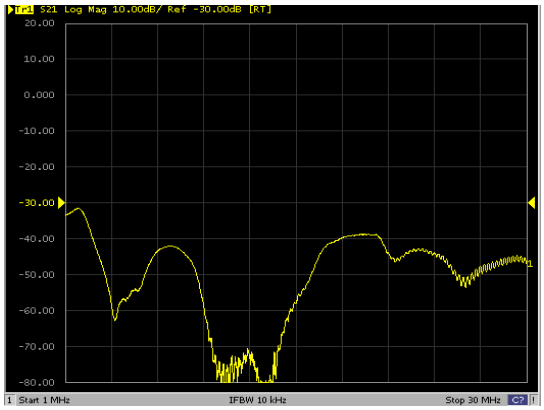

Figure 2 Actual line pattern 1 profile (with varistor A)

Table 2 PLC modem rates without and with varistor A

Line Condition	PLC Modem rate [Mbps]	
	Without Varistor	With Varistor A
40dB Flat	75.9	64.7
50dB Flat	56.6	41.4
Line Pattern1	52.2	45.1
Line Pattern2	42.7	34.1

Line conditions such as “40-dB flat” and “50-dB flat” mean that the attenuation of the power line characteristic is a constant 40 or 50 dB and do not depend on the frequency. Line patterns 1 and 2 are the actual power line profiles simulated by PLC3000 simulator. There was a 11-15 Mbps degradation when varistor A was installed under flat line conditions and there was about a 7-8 Mbps degradation when varistor A was installed under actual power line conditions.

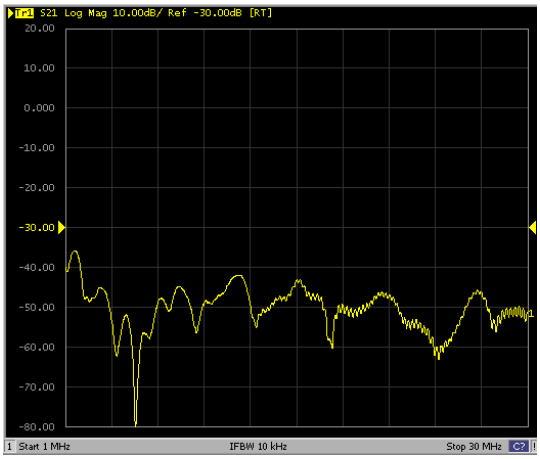

Figure 3 Actual line pattern 2 profile (without varistor)

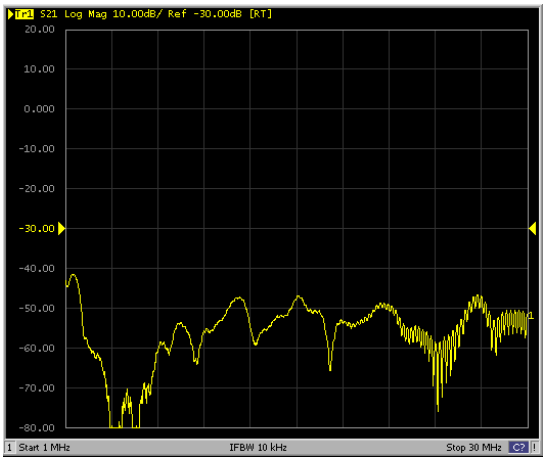

Figure 4 Actual line pattern 2 profile (with varistor A)

The measured PLC modem rates with multiple varistors as delt with in Table 1 under the condition of 60-dB flat attenuation are listed in Table 3.

Table 3 PLC modem rate with multiple varistors

Number of Varistors	**PLC modem rate [Mbps]**
0	**25.5**
1 (A)	**20.3**
2 (A+B)	**13.9**
3 (A+B+C)	**11.0**

3 Problem Solution by using a GDT

Low impedance values of varistors caused a PLC modem rate degradation. We improved the PLC transmission characteristics using a gas discharge tube (GDT).When a GDT was inserted in a varistor in series, the degradation of the PLC modem rate was less than 1 Mbps under the previously mentioned conditions. We can achieve an almost ideal environment for PLC by using a GDT. This is because the capacitance of a GDT is as low as several 10 pF and the impedance at 30 MHz is comparatively as high as several 100 Ω, which does not affect the transmission characteristics of PLC.

When installing an SPD for a PLC circuit, it is necessary to only use a GDT or connect a GDT with a varistor in series.

4 Conclusion

We investigated the effects of transmission characteristics on power line communication when using surge protective devices.

(1)Impedance values of varistors at the maximum frequency of 30 MHz for PLC communication are about 0.35 Ω and are very low compared with those of commercial frequencies. This low impedance nearly creates short-circuit conditions for PLC trasmision signals and causes PLC modem rate degradation.

(2)When a GDT is inserted in a varistor in series, the degradation of the PLC modem rate is less than 1 Mbps, which does not affect transmission characteristics of PLC.

(3)When installing an SPD on a PLC circuit, using only a GDT or connecting a GDT with a varistor in series is necessary.

References:

[1] Ministry of Internal Affairs and Communications, Authorities Report, Oct. 2006 (in Japanese)

[2] IEC 61643-1, Surge protective devices connected to low-voltage power distribution systems- Performance requirements and testing methods, 2005

[3] IEC61643-12, Surge protective devices connected to low-voltage power distribution systems- Selection and application principles, 2004

[4]H.Kijima, K.Taketani, R. Tobisawa, Proposal on grafhical analytical method how to estimate energy coordination of mulistage SPD, pp1180~1183, 28th International conferance on lightning protection, 2006

[5]K.Kurosawa, H.Kijima, recent lightning protection systems, pp76~84,ISBN4-542-30397-7,2006 (in Japanese)

[6] Fujitsu access review , 2006

[7] Hitoshi Kijima, an influence on transmission characteristics of power line communication when using surge protective devices, IECSC37A WG4 meeting held in Germany Sep.2007 and WG 3 & 5 meeting held in China Oct.2007.