Elucidation of Transmission Characteristics of Power Line Communication (PLC) Signal – Development of Calculation Method of Coupling Efficiency in Out-phase Lines –

Background

Power line communication (PLC), which uses existing power lines as communication circuits, is very promising for constructing LAN. However, there are in-phase lines and out-phase lines in indoor main power lines of single-phase three-wire systems. PLC modems are connected to in-phase and out-phase lines arbitrarily as shown in Fig.1. Transmission speed is not enough sometimes when a pair of outlets which connect to out-phase lines are used. Although we have already developed a simulator *1 to estimate transmission characteristics in in-phase connection, the transmission characteristics in out-phase connection have not been studied sufficiently.

Objectives

To clear up transmission characteristics of out-phase lines, a dominant part of signal transition is experimentally investigated by using samples of indoor main power lines, and a calculation method of signal transmission characteristics of out-phase using distributed constant circuit is proposed.

Principal Results

1. Specifying a dominant part of signal transitions in out-phase lines

It was clarified that significant signal transitions in out-phase lines occur in indoor main power lines such as CVT cables *2 because in-phase and out-phase lines are aligned closely. CVT cables and multidrop lines used in interior wirings were simplified as shown in Fig. 2. Signals were inputted into between black and white lines and then the outputted signals between red and white lines were measured as out-phase signal transitions. In-phase signal transitions were also measured as reference. Termination conditions shown as "A" were changed open, short or resistance (75 Ω). Measured results of coupling efficiency are shown in Fig. 3. From this result, it became clear that PLC signals significantly transferred to out-phase lines in indoor main power lines, though the lines were not connected directly.

2. Development of a calculation method for signal transmission characteristics of out-phase lines

A calculation method of signal transmission characteristics of out-phase lines using distributed constant circuit was developed. Indoor main power lines should be explained using distributed constant circuit because wavelengths of PLC signals are 10m (at 30MHz) to 150m (at 2MHz). An equivalent circuit model of divisive indoor main power lines which used capacitance, self-inductance and a mutual-inductance was developed as shown in Fig. 4. The values of each element were calculated from geometric layout of copper lines. The equivalent circuit model of divisive indoor main power lines was connected in series and coupling efficiencies of each termination conditions were calculated. The calculated results and measured results are shown in Fig. 5. The peak levels of calculated results and measured results were well in agreement. Signal transmission characteristics of out-phase lines could be calculated by this proposed method.

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Future Developments

Transmission characteristics of out-phase connection including distribution board and interior wiring with indoor main power lines will be clarified.

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Reference

K. Ikeda, et al., 2008, "An estimation method of PLC signal transition level in indoor main power line," The paper of technical meeting on communication, IEE Japan, CMN-08-2, pp. 7-12. (in Japanese)

*1 : R. Ishino, K. Takeshita and T. Suzuki, 2001, "Power line communication Simulator on low voltage distribution lines with OFDM modulator", CRIEPI Report R00009 (in Japanese)

*2 : CVT cable: Triplex type cross-linked polyethylene insulated vinyl sheath cable

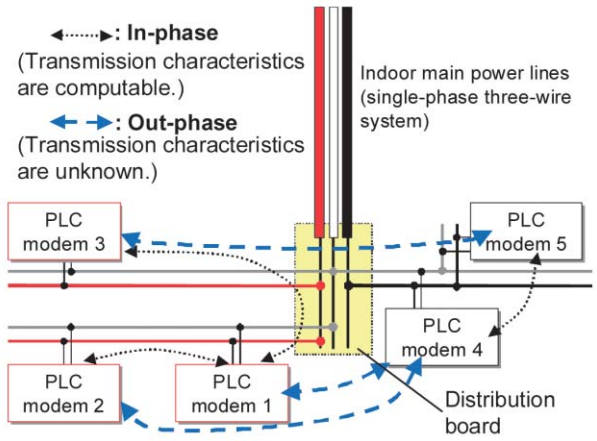

Fig.1 Connection configuration of PLC modems

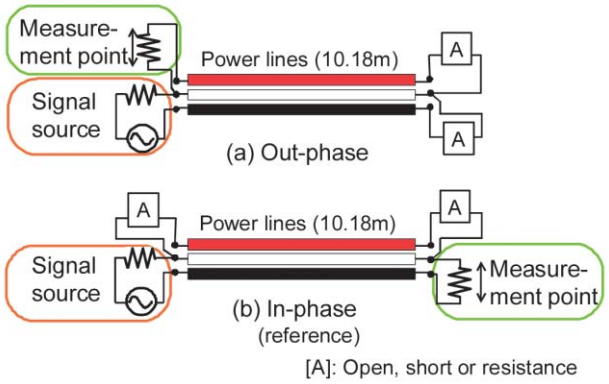

Fig.2 Measured setup of coupling efficiency

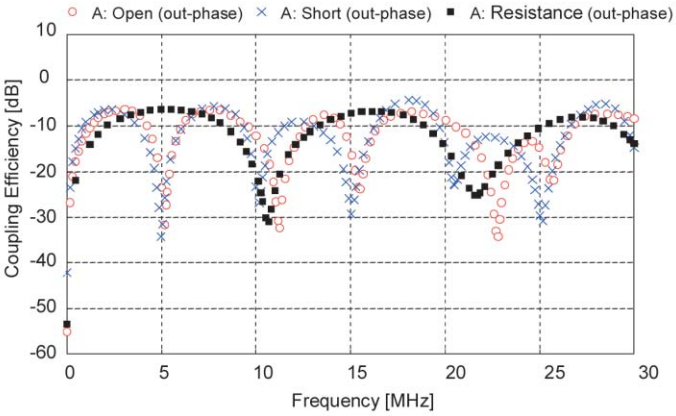

Fig.3 Measured results of coupling efficiency

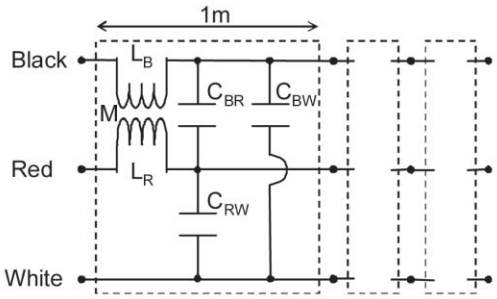

Fig.4 Equivalent circuit of CVT cable

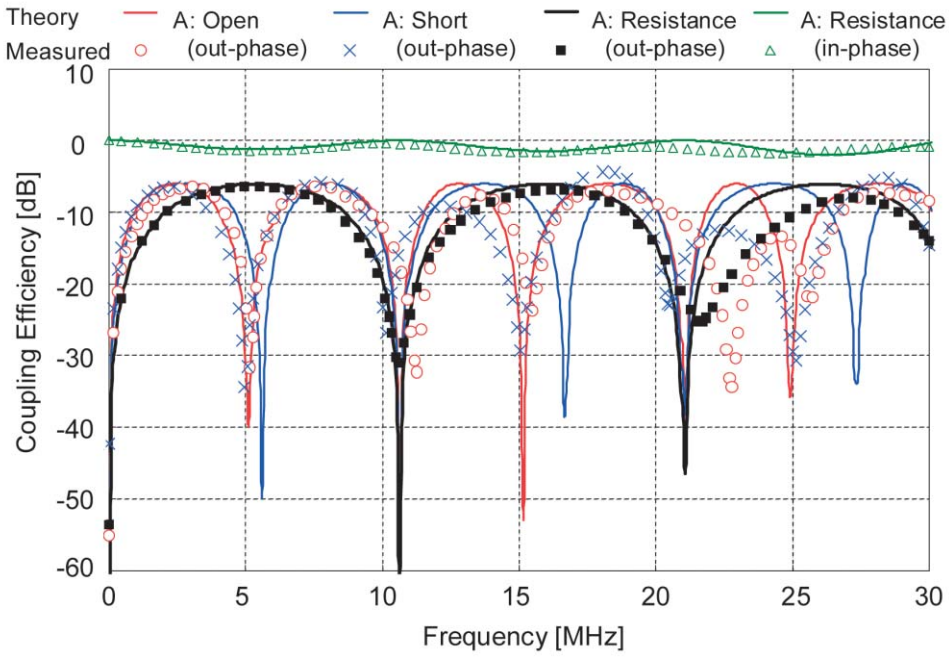

Fig.5 Calculated and measured results of coupling efficiency