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Cable Identification and Application of Power Line Carrier Communication for Distribution Lines

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Abstract. Power Line carrier communication is applied to identify cables in power distribution systems. Cable in distribution systems has only a limited ability to carry higher frequencies. To the top of that, transformers prevent propagating its higher frequency carrier signal. A new cable identification system is proposed to use its limited propagation characteristics. The cable identification system is designed and implemented based on a transmitter and a receiver with power line carrier communication. Some experiments are conducted to verify the theoretical concepts. Also some simulations are done to help and understand the concepts by using Simulink simulator.

Keywords: Simulink, Cable Identification, Power line carrier communication, Distribution lines.

1 Introduction

To determine phases and cables in the 3-phase 4-line type distribution lines with multiple grounds is gradually increased. The determination of absolute phases and cables is difficult on site. When confusion for phases and cable connections occurs, disproportionate concentrations of loads can easily occur, and this type of disproportionate concentration of loads can cause phase unbalance that can lead to power loss or power failure and, further, equipment failure due to excessive voltage regulation or reduction of useful life, etc. What this would all mean is that it can result in substantial management difficulties such as economic losses, all because of the reduced quality of voltage supplied to the customer. Thus, engineers must become able to figure out as to which phase of A, B and C the line conductors belong and as to which transformer the line conductors is connected to.

Distribution lines are branched into multiple circuits from power local pole- or pad-mounted transformers [1]. As such, most of phase identification methods are based on comparisons the known phase in a substation with the unknown phase on a local site [2][3][4][5][6]. In addition to phase identification, cable identification is also a challenging issue.

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In this paper, we propose how to find out cable connections by using power line carrier communication. The paper uses that power cable circuits have only a limited ability to carry higher frequencies and transformers prevent propagating the carrier signal. A new cable identification system is designed and implemented. The system consists of a transmitter and a receiver with power line carrier communication module. Some experiments are conducted to verify the theoretical concepts. Also some simulations are done to help and understand the proposed system by using Simulink simulator.

2 Proposal of Cable Identification System

Consider the situation that many transformers and distribution lines are deployed along the street as shown in Fig. 1. There, an electric technician wants to find out transformers or distribution lines to which power cables are connected. It is not easy to figure out because there are many obstacles such as buildings, trees, or hills.

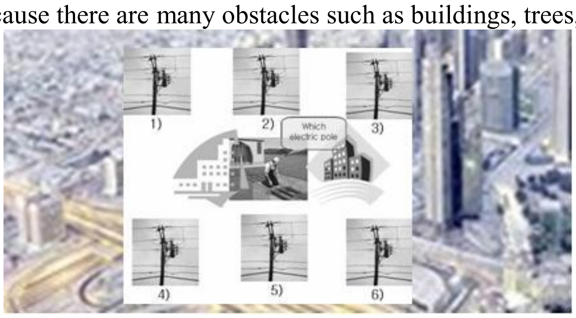

Fig. 1. Situation to figure out cable configurations

In the first, some backgrounds are investigated about the way to identify cables at local site. The cable identification systems basically consist of a current impulse generator and a receiver. The receiver is connected to a clamp for decoupling the current signal. The impulse generator sends out some special type of pulses and transmits them into the cables being to be identified [7]. The sent impulse signal radiates an electromagnetic field with a defined polarity around the cable which is received with the flex coupler of the receiver, automatically synchronized. The directional clamp in combination with the parameter monitoring by the receiver provides a safe selection regardless of any interference. It means that only one conductor or cable has the correct polarity while all other cables have the opposite polarity. As another method, direct signals are injected on the transmitter and the received signals are analyzed in terms of amplitude-time-phase at receiver [8]. Another method is to communicate coded messages between central device and line device through the distribution networks [9].

The key advantage of PLC is the use of existing electrical lines as communication medium, which provides the major benefit of eliminating considerable costs of installing networking infrastructure, like dedicated cables or antennas. Data is sent on the power lines by superposing a modulated high-frequency carrier signal on the line voltage, being high, medium or low, AC or DC. The carrier signal is then de-coupled and demodulated at the receiving end to recover the information.

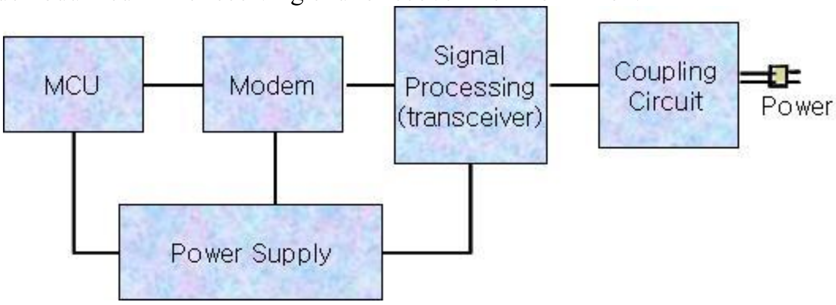

Fig. 2. Architecture of PLC transceiver

Whatever the type of modulation used, a PLC transceiver includes a few basic blocks as shown in Fig. 2. Different solutions use various levels of integration of these components, from full-digital modems with external discrete components to highly integrated systems-on-chip [10][11][12].

Fig. 3 shows architecture of cable identification systems, which is comprised of a server and a client. Message from client program is transferred into PLC modem through interface. PLC modem converts the message into signal, which is modulated into higher carrier frequency. The modulated signal is transferred into the server. The server side's PLC modem receives the modulated signal and demodulates that into data. Then it is moved into the microprocessor. The server program responds to the client.

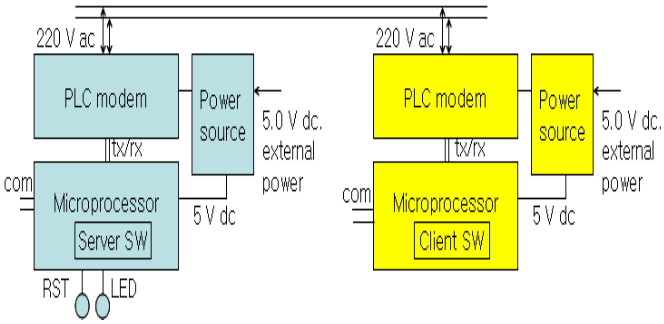

Fig. 3. Architecture of proposed cable identification systems

3 Simulation and Experimental Results

For the proper application of the cable identification technology, characteristics of higher frequency carrier propagation are analyzed through several transformers with Simulink. Simulink models are presented for the analyses. Theoretical simulations result in that the injected carrier signal is hard to cross over the higher level transformer. Using the sample distribution model, the distribution system is analyzed with Simulink when carrier signal of 290 kHz and 300 mA is injected onto the distribution lines.

In order to show the characteristics of modulated signal, some larger carrier signal of 300 mA is adopted even though it is bigger than usual. In general, the primary side of the transformer is high voltage of 22.9 kV and the secondary side is 220 V. So the turn ratio between the primary and the secondary is about 100 (= 22.9 kV/ 220 V). The amplitude of the modulated signal injected from the secondary becomes much lesser. We can see that modulated signal is gone away at the primary side. Fig. 4 shows the modulated voltage waveform for three different phases injected at the secondary side..

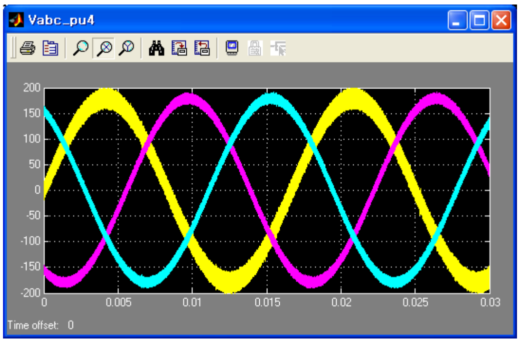

Fig. 4. Modulated voltage waveform with the carrier signal of 290 kHz and 300 mA

A test system is implemented. The PLC modem chip with carrier frequency of 290 kHz /125 kHz and narrowband simple MAC is used. Arduino Uno board is used for microprocessor unit. Experiments show that the PLC carrier signal is transferred into the range of PLC carrier propagation.

In order to verify the idea, the proposed cable identification system is implemented with narrowband power-line communication module with simple MAC and 290 kHz and 125 kHz. Experiments show also that the carrier signal is not transferred over the higher level transformer.

In the last, we can conclude that the power line carrier technology can be utilized to figure out cable configurations in the complex distribution lines. For the further research topics, more experiments are considered.

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