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Cable Identification as a New Application of Power-line Communication Technology

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Abstract. Power-line communication technology is applied to identify cables in power distribution system. The application area of power-line communication will be extended in this paper. Power cable circuits have only a limited ability to carry higher frequencies. Also, transformers prevent propagating the higher frequency carrier signal. The proposed method uses its limited propagation ability to identify the cable. A new cable identification system is proposed and implemented. The system consists of a transmitter and a receiver with power-line communication module. Some experiments are conducted to verify the theoretical concepts.

Keywords: Cable Identification, Power-line communication, Distribution lines, phase identification.

1 Introduction

Electricians on site should correctly figure out electrical configurations such as phases and cable connections. The unmistakable identification of cables and phases is an absolute safety related task. A wrong selection can result in fatal consequences for the operator and caused the loss of supply for the connected customers.

The need is increasing for determining phases and cables in the 3-phase 4-line type distribution lines with multiple grounds. When confusion in lines for phases and cables 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. Thus, electricians must become able to figure out cables on site as to which one of A, B and C phases the line conductors belong and as to which transformer the line conductors is connected.

Distribution lines branch into multiple circuits from power local pole- or pad-mounted transformers [1]. Usually in a substation, the A, B, C phase for cables are made known, however, as one approaches toward the end of the distribution lines, the effort to distinguish both an absolute phase and cable connections to transformer

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becomes more difficult. As such, most of phase identification methods employ the algorithm that distinguishes phase based on comparing the known phase in a substation to the unknown phase in a site [2][3][4][5] [6].

In addition to the phase identification, the cable identification is also a challenging issue. In this paper, we propose how to find out the cable identification by using power-line communication for the easy, reliable and safe selection of cables. The paper uses that power cable circuits have only a limited ability to carry higher frequencies because 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 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 Algorithm

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

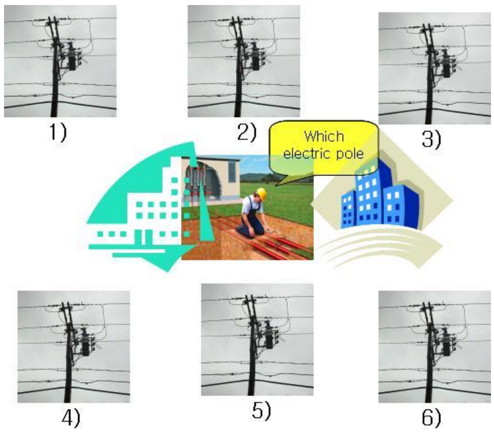

Fig. 1. Situation to require cable identification, because there are possibly many electric poles around an electric technician.

In this paper, power-line communication technology is used. Power-line communication is accomplished by adding a modulated carrier signal to the wiring system. The proposed cable identification system consists of client and server as shown in Fig. 2. Messages are transferred between client and server via power-line communication. Since the power distribution lines were originally intended for transmission of ac power signal at typical frequencies of 50 or 60 Hz, power cables have only a limited ability to carry higher frequencies. The limited characteristics of the high frequency signal cross over transformer shall also be an important factor for power-line communications.

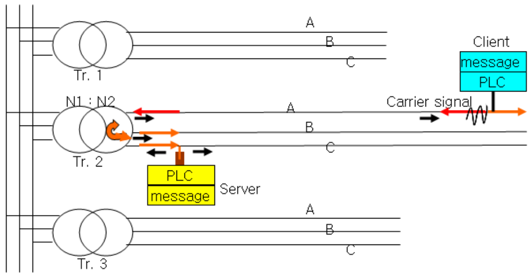

Fig. 2. Flow of operation to identify transformers.

In this paper, we utilize these limited characteristics to identify the cable. We consider that the added carrier signal by the client would not cross over the transformer 2 (Tr.2) in Fig. 2. The transmitted signal would not be detected from other distribution lines connected to Tr.1 or Tr.3. The server unit on distribution lines linked to Tr.2 would respond with the corresponding message. Also, the responded message would be received by the client. Then, we would say that the client and the server be connected over the same PLC channel over the same lines from the same transformer.

So, the other important issue is to determine the frequencies for power-line communication. Many nations regulate unshielded wired emissions as they have the potential to cause radio transmissions. It is recommended that unlicensed bands or below 500 kHz be used.

Fig. 3 shows how to figure out cable identification by using three servers with different messages. As one client sends out a request message, all the server would respond with different code messages. The client would receive sequentially message at different time depending on the distance between the client and servers.

Consider the distance of ‘Lt’ between the transformer Tr.2 and a server. Then, transmission time ‘TT’ becomes ‘Lt/S’ as the equation (1), where S is the propagation speed of carrier signal over the cable.

$$TT = Lt/S \tag{1}$$

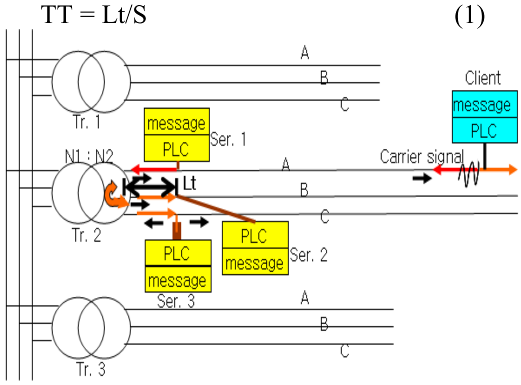

Fig. 3. Flow of operation to identify cables.

Consider that the client starts to send message at 'to' and receive messages from the nearest server 1 at time 't1'. The client may receive other messages from other servers (ser. 2 and ser. 3) at time 't2' (or 't3'), which is delayed two times of 'TT'. Geographically, other servers (ser. 2 and ser. 3) are located far way two times of 'Lt'.

As an example, Lt = 100 m, S = 3 x 10^8 m/s. Then the round delay time RDT (= 2 x TT) becomes around 700 microseconds.

Fig. 4 shows the configuration of cable identification systems, which is comprised of a server and a client. Message from the client program is transferred into PLC modem through the 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. The power needs to activate the microprocessor and system. The power source unit is for the power. Here the carrier frequencies are 290 KHz and 125 KHz with narrow band modulation of simple MAC.

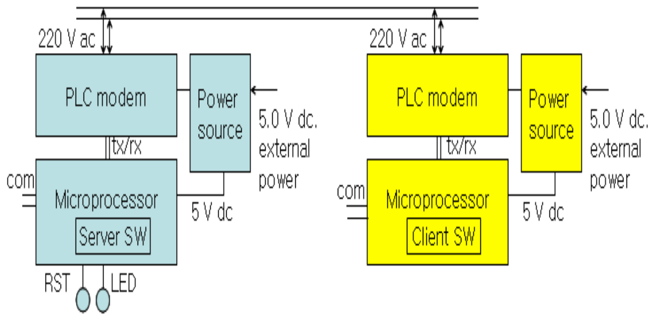

Fig. 4 Architecture for cable identification system

3 Conclusions

Cable identification system is designed and 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.

For the proper application of the cable identification technology, characteristics of higher frequency carrier propagation are analyzed through several transformers. Experiments shows also that the carrier signal is not transferred over the higher level transformer. For the further research topics, more experiments are considered.

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