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Comparison of Power Line Communication Infrastructures

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Abstract

In this paper, better advantageous communication method is investigated by comparing powerline communication methods. Pros and cons of PLC method and wireless communication methods are compared. After choosing PLC as the communication method, noise, channel impedance and signal weakening problems that have negative effects of data transmission over the transmission line are examined. AMS, SCADA, PRIME, G3 methods were compared. Modulation methods that may be suitable for transmission line communication are compared. Transmission line communication system simulation is designed with BPSK modulation method. The carrier signal, which is at very high frequencies compared to the 50Hz frequency network signal transmitted over the transmission line, is modulated with the BPSK signal. The information signal to be transmitted is sent via BPSK modulation over the transmission line. At the transmission line output, the demodulation process is applied and the information signal at the input is read at the output. PSIM is used for computer simulations and performance curves are evaluated over different PLC modulation techniques.

Key words

Power Line Communication, Distribution Lines, Transmission Lines, Power Quality

1. INTRODUCTION

Rapid increase of technological developments in our country today, provides the infrastructure for studies on the use, security and analysis of powerlines. In our age there is a need for fast communication, apart from the need for a house or device where only electricity was transmitted. This situation creates an environment for a faultless, continuous and efficient energy to reach the consumer. In addition to technological developments, the increased day by day. Besides, the need for electrical energy in all areas, especially the production sector, service sector and telecommunication sector, is increasing day by day.

The use and dissemination of radio frequencies have played a major role in the development of communication. The advantages and disadvantages of two different communication methods, wired and wireless, have been examined and applied according to the area of use and purpose. Information exchange over energy transmission lines, which have a low-cost effect in wired communication, emerged in the 1800s with the studies of the scientists of the period and has reached to the present day.

The data signal to be transmitted in the exchange of information over the powerline is superimposed with the help of high-frequency carrier signals and applied to the energy transmission line. The signal transmitted over the transmission line is then filtered with the help of filters and the information signal is seen on the receiver side. By this way, communication takes place. Since the transmission line cabling had already been done, one of the biggest advantages of the communication system over the energy transmission line is that it is an economical method since there is no need for wiring.

2. MATERIALS AND METHODS

In this study, studies on power line communication, application areas, negative effects that may be encountered during transmission and thrust techniques have been examined. In this context, simulation studies that can set an example for power line communication have been done. For this purpose, the advantages and disadvantages of IHH applications compared to each other were compared. Transmission line communication applications are separated according to many characteristics. The pros and cons of AMS, SCADA, PRIME and G3 power line communication methods are examined below.

2.1. Plc Negative Effects

The main problems of powerline communication are noise, channel impedance and signal reduction. Information exchange for powerlines has a destructive channel effect. Changing impedance and noise cause the impact of communication to be questioned and to lose its importance. Therefore, it is required to propose a new solution to the three-way relationship depending on time, speed and signal level. Noise, channel impedance and signal weakening are examined below.

- Noise: Depending on the size of the noise, the disruptive effect on the sinusoidal wave increases. Increasing the disruptive effect is undesirable. It damages the functioning of the communication system. The effect of noise should be reduced as much as possible. When we apply 5- times to sinusoidal wave in MATLAB program, the changes that occur to the sign are seen in Figure 1 and Figure 2.

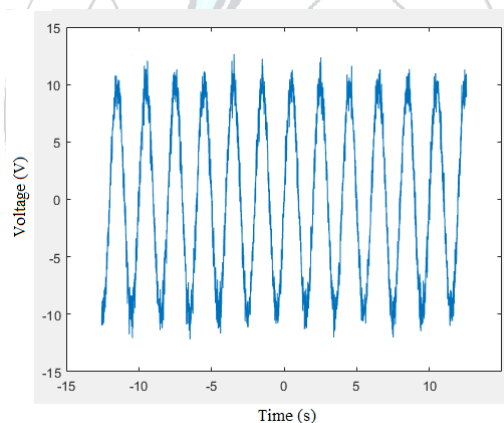


Figure 1. One way noiseless

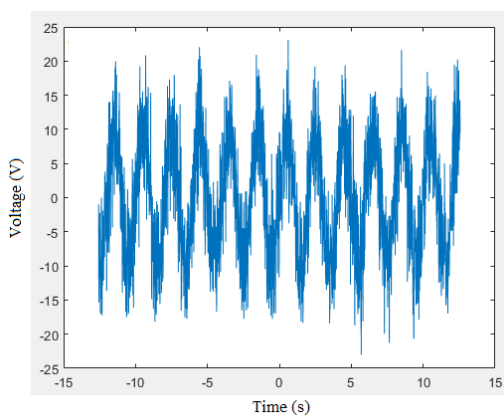


Figure 2. One way 5 times noise

- **Channel Impedance:** The electricity grid is quite complex and brings together many systems simultaneously. The imbalance in channel impedance caused by system-connected loads and distribution elements makes it difficult to exchange information. The imbalance that comes to the challenge in the channel impedance negatively affects the signal strength in the output. This causes a failed communication environment between the informational and the receiver. In order to investigate the effect of channel impedance disorder on the sign, in urban and industrial areas, CENELEC in Turkey, B, a series of measurements between 10 and 170 kHz bands C and D were obtained. Based on these measurements, 3-17 Ω in rural areas, 1-17 Ω in urban areas and 1-21 Ω in industrial areas were determined. In addition, signal weakening in these bands was found to be 4-30 dB when looking at phase-neutral, phase-earth and neutral-earth measurements for different power lines. The output ports and modem output impedance and power line input impedance must be mapped appropriately for the transfer of power between the power line and IHH. For an efficient modem design, the power line impedance must be known. Power line impedance varies according to the location of the power lines. Time impedance depends on many factors, including loads on transmission lines, day or night power levels. Therefore, bands, sign levels and procedures have been determined in Europe and CENELEC, EN-50,065-1 has emerged.
- **Signal Reduction:** On the transmission line, there may be differences between the signal sent from the input and the signal received from the output, and deterioration of the signal quality may occur. The main causes of disturbances on the power line are as follows. Transmission Stage Type, Transmission speed, Communication Distance. The reasons for distortion of the transmission are as follows. Signal Weakening, Restricted Bandwidth, Delay Corruption, Noise. Signal reduction occurs by decreasing signal strength depending on communication distance. Solution can be provided by using signal booster or repeater. This change in signal level can be shown as in equation (1).

$$dB = 10 \log \left(\frac{\text{Signal Output Power}}{\text{Signal Input Power}} \right) \quad (1)$$

If we talk about the effect of noise on the signal, the most important criterion is the SNR shown in equation (2). The following formula is used to understand how much the sign is weakened. Signal reduction is 100 dB per kilometer for LV lines and 10 dB per kilometer for MV lines. The more signal reduction is seen in Low Voltage networks. By using repeaters at distances less than 1 km, signal reduction is prevented.

$$SNR(dB) = 10 \log \left(\frac{\text{Signal Power}}{\text{Noise Power}} \right) \quad (2)$$

2.2. Qpsk Modulation Methods

QPSK modulation is a type of numerical modulation. PSK enters the modulation class. The process of transmitting the logic1 and logic0 information given by the 2-bit information signal to be transmitted at the input with the help of four different and high frequency carrier signals with 90° phase difference between them is called QPSK modulation. The carrier phase angles connected to the information sign bits are included in Table 1.

Table 1. QPSK Data Signal Bits and Carrier Signal Phase Angles

BIT	PHASE
00	45°
01	135°
10	225°
11	315°

The four carrier signs with 90° phase difference between them are high frequency sinus signs named as 00, 01, 10, 11 as seen in Figure 3.

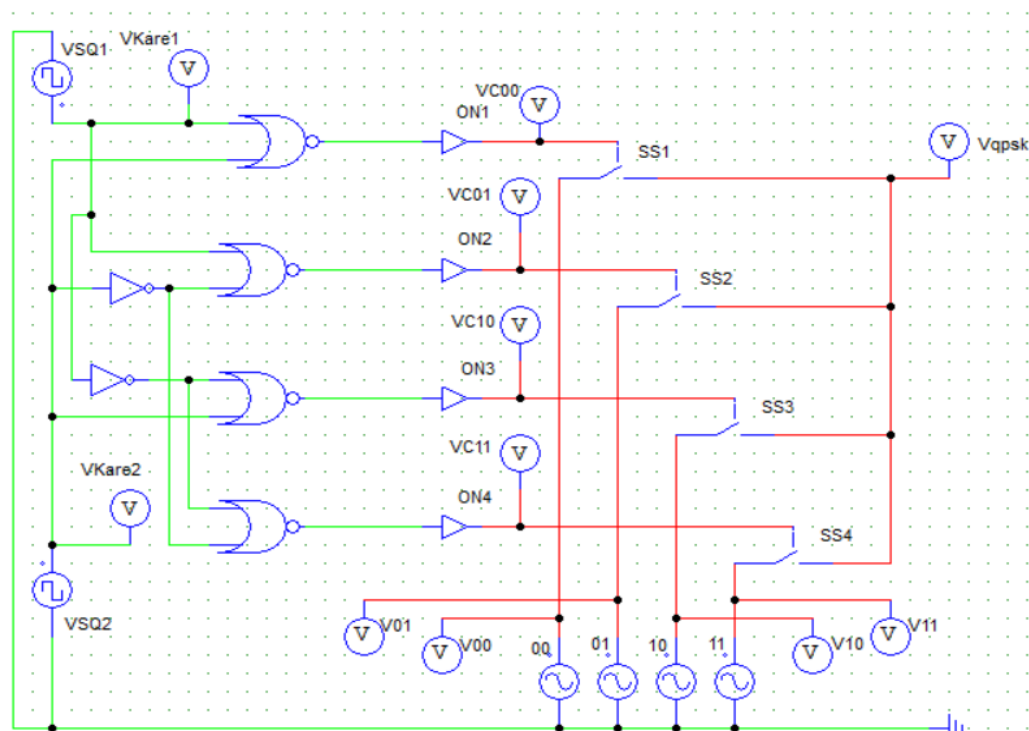


Figure 3. QPSK Modulation Circuit on PSIM

The carrier signal chart simulated in the PSIM program is as follows.

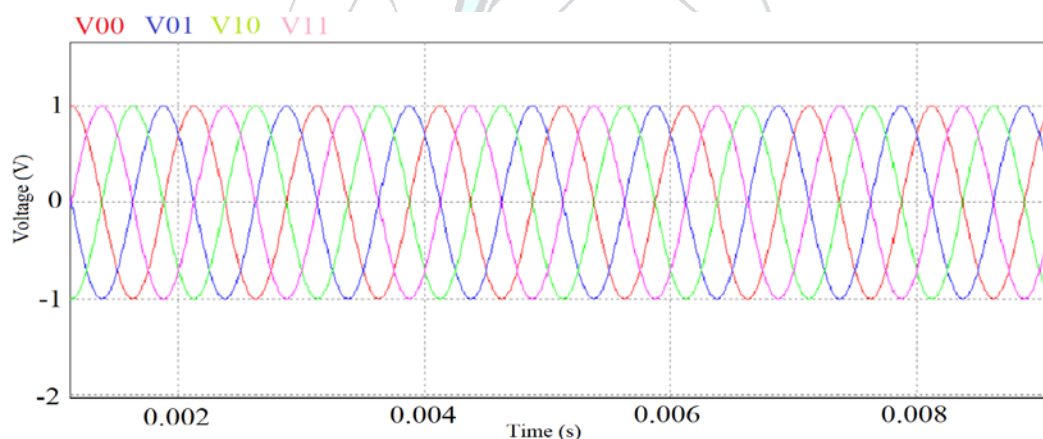


Figure 4. 90° Phase Angel High Frequency 4 Carrier Signal on PSIM

Depending on the 1 or 0 status of the information to be ed, only one of the carrier signs is turned on and the others are closed, with the help of switching the mark from 1 to 0 and 0 to 1 of the mark coming out of 2 different square waves. Thus, only one superimposed sign is seen. In Figure 3, this switching is provided with the help of ON and SS elements, and the Vqpsk signal is seen in Figure 5.

As seen in Figure 3, four different carriers are activated and deactivated according to the 1 and 0 states of the elements Vkare1 and Vkare2. The open-closed state of the carriers switched by square waves is shown in Figure 4. When examined in certain time frame intervals, only one carrier is active for each second interval. Information transmission is carried out by that carrier for the time intervals during which carriers are active. This is how Vqpsk is working for the modulation method. Table 2 and Figure 5 has a QPSK modular output mark.

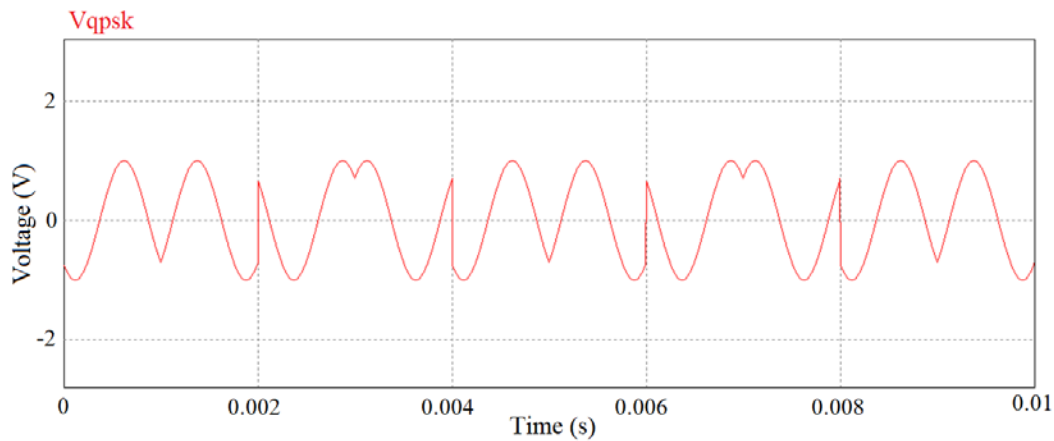


Figure 5. QPSK Modulation Output Signal on PSIM

2.3. Bpsk Modulation Methods

We will carry out the data transmission with BPSK modulation with the circuits we have built on PSIM. BPSK, which is treated with switching logic, will be provided by in and out of the open-closed state of carriers with different phase angle and the same frequency. Thus, continuity will be provided in the information mark to be transmitted and a healthy communication will be made.

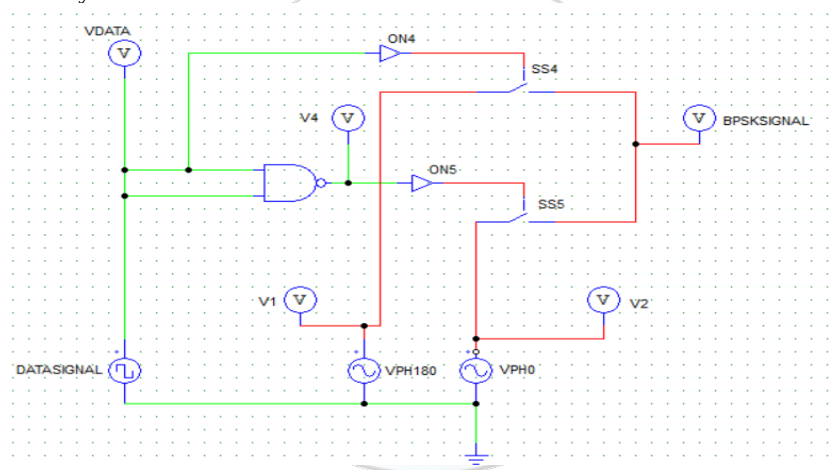


Figure 6. BPSK Modulation Circuit on PSIM

The data signal to be transmitted in the circuit above has a frequency of 1 Volt and 100 Hz. The VPH180 is a carrier signal with a phase angle of 10000 Hz 180°. Our other carrier signal is the VPH0, a carrier signal with a phase angle of 10000 Hz 0°. With the NAND gate in the circuit, the data signal creates the modular signal by switching according to the status of 1 and 0.

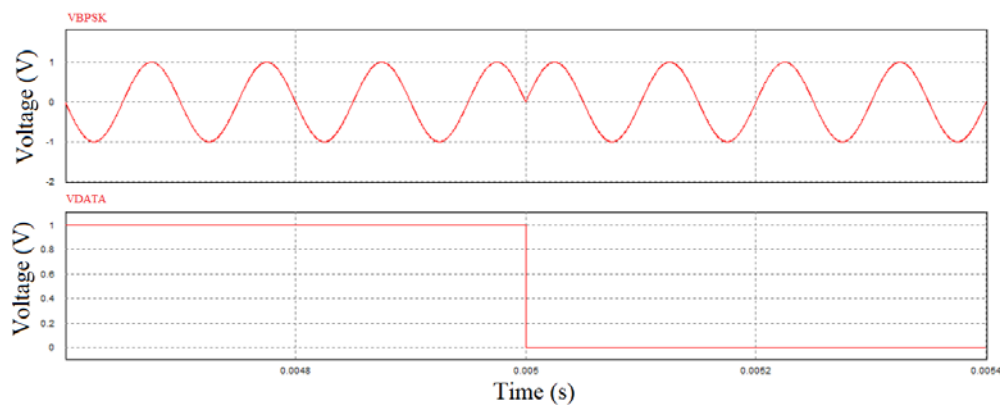


Figure 7. Data Signal and BPSK Modulated Signal

3. RESULTS AND DISCUSSION

The combination of 2FKA superimposed data signal and grid signal is applied to the transmission line. The shape of the signal passing over the Vihson voltage probe after its transmission over the transmission line is as follows.

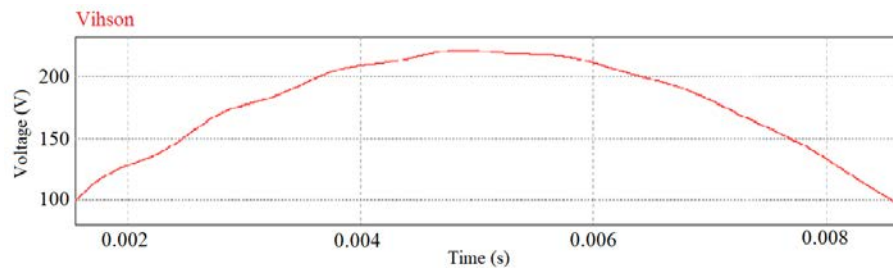


Figure 8. Power Line Output Signal

Since the BPSK signal is a very high frequency sign, it shows faster and shorter changes on a 220 Volt and 50 Hz grid signal. Therefore, it is observed that it creates small fluctuations on the network signal. The data signal is transmitted over the power line after BPSK modulation. However, the system cannot detect the function of the signal and does not work because the signal that appear from the power line output is over-boarded. For this reason, the superimposed signal at the exit of the transmission line must go through the decomposition process and return to the square wave format. Thus, the system continues to run by getting the correct input-output information. BPSK sign demodulation circuit is as follows.

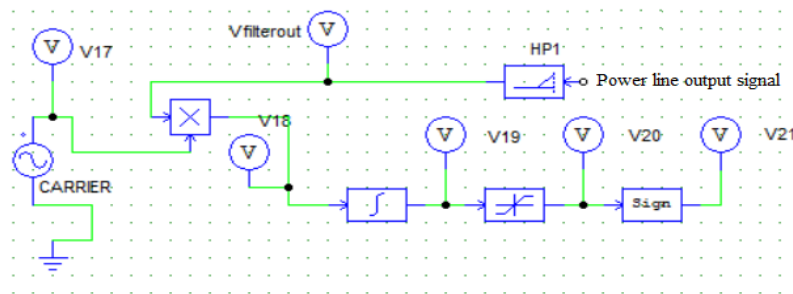


Figure 9. BPSK Demodulation Circuit

The signal from the power line is filtered with the help of a high pass filter. Then, the separation process is completed by taking integral and derivative functions of the mark combined with the carrier signal, respectively. At the beginning of the circuit, the desired square wave, at the end of the circuit with the demodulation process will find its own form.

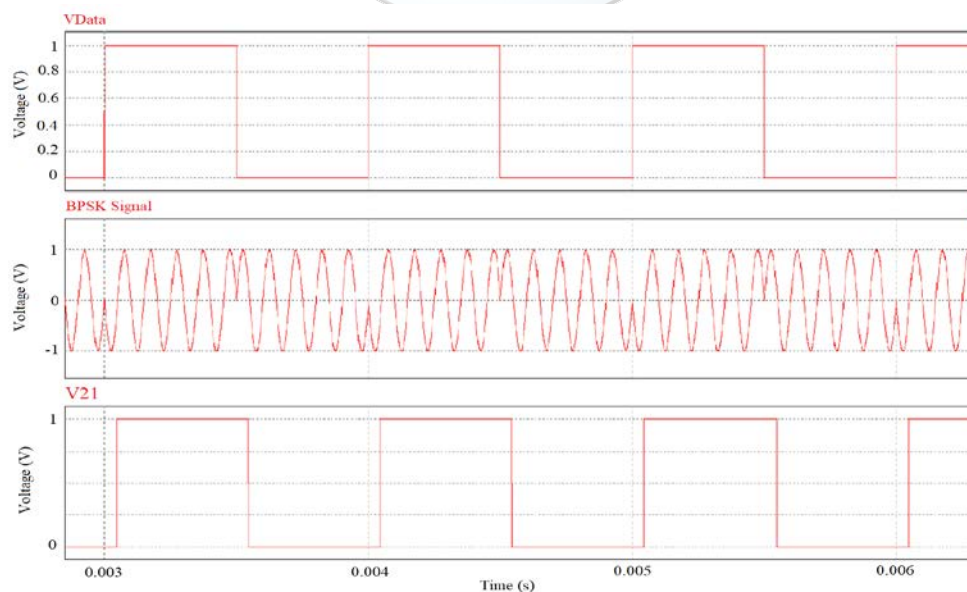


Figure 10. Input Data Signal, BPSK Signal and Output Data Signal

In this study, studies on power line communication, application areas, negative effects that may be encountered during transmission and thrust techniques have been examined. In this context, simulation studies that can set an example for power line communication have been done. For this purpose, the advantages and disadvantages of IHH applications compared to each other were compared. Transmission line communication applications are separated according to many characteristics. The pros and cons of AMS, SCADA, PRIME and G3 power line communication methods are examined below.

AMS is a remote meter reading application. With AMS, consumption values on the counter can be read remotely. If we look at the pros, personnel expenses have been reduced with this application. Reading consumer consumption values is done more accurately without allowing human error. Missing fugitives can be tracked. Cons, on the other hand, cannot provide control along the power line. It cannot analyze the entire power line system between the source and the consumer. It cannot predetermine the interruptions that may be caused by line protection elements and provide an instant solution. It cannot offer improvement by matching and comparing the information received from the meters with each other. It cannot locate fault. It cannot keep records because it cannot detect malfunctions.

The SCADA system is a central inspection and information collection application in which complex system transmission lines are managed from a single center. It can switch on and off remotely. In case of line failure, it can control the feeding of the transmission line from a different place. It can instantly monitor all consumers and feeders along the power transmission line. The malfunction can be located. It can keep track of where and when the fault occurred. When we examine these features, it can be seen that the SCADA system is much superior to the AMS system.

G3 and PRIME have more developed features than SCADA and AMS. Scada is an energy monitoring system. Compared to SCADA, G3 and PRIME are superior because it works based on PLC. It can make more detailed power line analysis. It can create and apply different solution scenarios according to the failure situations that may occur.

4. CONCLUSIONS

G3 power line communication system emerged after the PRIME system. G3, one of the new technologies of the last period, has similar features to PRIME. Remote on-off and line fault location detection. It is able to control all systems along the power line by doing network analysis. It can prepare different consumer feeding scenarios depending on the on-off situations of the protection elements for each failure situation. G3 transmission speed is slower than PRIME. More G3s are preferred for long-distance transmissions as a plus of noise resistance. PRIME has more transport channels than G3. G3 uses the IPv6 package. PRIME uses the IPv4 package. Therefore, G3, which uses an IPv6 package, provides a more secure network environment than prime. The G3 can find up to 36 different transport channels, while PRIME can have 96 different transport channels. This allows larger data to be sent through different channels in terms of data submission. In terms of noise resistance, the G3 is more advanced. The G3 system has more noise resistance than the PRIME system. This provides a win for communication over long distances. G3 is more stable than PRIME. The priority in the powerline is to maintain the communication more stable. Therefore, G3 is more preferred than PRIME.

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CONFLICT OF INTEREST STATEMENT

The author(s) declare(s) that there is no conflict of interest.

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