PLC FIELD TESTS RESULTS USING PLC G3 PROTOCOL

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REZUMAT. În această lucrare sunt prezentate rezultatele obţinute în urma testării performanţei comunicaţiei prin reţeaua electrică (PLC – Power Line Communications) prin liniile de joasă tensiune atunci când s-a utilizat protocolul PLC G3. Testele au fost efectuate prin linii de joasă tensiune cu lungimi de 600m şi 1.500m, în cel de-al doilea caz s-a testat şi posibilitatea realizării comunicaţiei prin secundarul unui transformator de MT/JT de pe o fază pe alta. Un alt test a analizat posibilitatea comunicaţiei prim miezul unui transformator de MT/JT şi preluarea datelor de pe linia de Mt prin intermediul unui transformator de măsură de tensiune.

Cuvinte cheie: PLC G3, joasă tensiune, OFDM, bandă îngustă

ABSTRACT. In this paper are presented the field tests resuls of power line communication (PLC) over low voltage power line when PLC G3 protocol has been used. Test have been made over different lengths of low voltage (LV) power lines respectively 600m and 1.500m. For the second length case there have been tested the posibility of data transfer when the communication was made through the secondary winding of a MV/LV power transformer from one phase to another. Another test analyzed the possibility of sending data through the core of a MV/LV power transformer and receiving data from the MV line using a voltage measurement transformer.

Keywords: PLC G3, low voltage, OFDM, narrowband

1. INTRODUCTION

Power Line Communications (PLC) are communications that use as physical environment for data transmission the power lines. PLC applications use two segments of a power distribution network, which are the low voltage (LV) and medium voltage (MV) power lines. The most used by the current solutions of PLC are the LV power line for broadband and narrowband communications, but solutions for using the MV power lines are also available on the market. The main problem is raised by the existence of the MV/LV power transformer which strongly attenuates the PLC signal when a transfer is made between the LV and MV lines. For this reason present solution available on the market use a combination of technologies in Automatic Meter Reading (AMR) systems, the PLC and GPRS are the most used solution.

AMR systems in Europe use the narrowband PLC solution as specified in EN 50065-1 and the frequency band CENELEC A (9 kHz - 95 kHz). Signal injected in the power line by the PLC modems is limited to 120 dBμV. An AMR system is made to handle and collect data from a big number of meters (electricity, gas or water) without the necessity of traveling to it for that reason as it was made in the past. This automation exclude a number of problems which where in the past when an employ of the company had to personally go an read index and other information from the meters and errors occurred in the process of manipulating this data until it reached the billing department. This leads to advantages such as faster and easy remote access to information about consumer consumption and quick identify of network segments where electricity supply was interrupted [1-3].

PLC are very important for the present and future of the smart grids, because it can be used with low costs and no third party solutions.

In this paper are presented field test results when data transfer was made over LV power lines and PLC G3 protocol was used. The communication performances where tested when DBPSK (Differential Binary Phase Shift Keying), DQPSK and ROBO modulations were used. The tests were made on long distances over the LV power lines. Communication through the secondary winding of a MV/LV transformer was also been observed. A test has been made to analyse the possibility of using a voltage measurement transformer for receiving data on the MV power line when data has been sent from the LV power line of MV/LV power transformer. The speed data transfer, bit loss, packet loss, SNR and signal strength are presented for every modulation tested.

Results presented in this paper are a continue work of the evaluation presented in [4] and additional to those presented in [5], analyzing the limits of the PLC over the LV power lines.

2. PLC G3 PROTOCOL

PLC G3 is a protocol developed by eRDF (Electricite Reseau Distribution France) and sent as a proposal for creation of the first standard for narrowband PLC in Europe, which is IEEE 1901.2. At the moment this standard is still in work, only the IEEE 1901 standard was published but its area of expertise are general aspects about both broadband and narrowband communications.

PLC G3 is using a part of the CENELEC A (9-95 kHz) band, that being the frequency band 35,938 kHz – 90,625 kHz. The frequency band is spread over 36 ortogonal fequencies with a theoretical data speed transfer of 33,4 kbps. Modulations used by the protocol are DBPSK, DQPSK and ROBO. Acces medium technique used is CSMA/CA (Carrier Sense Multiple Access / Collision Avoidance) and OFDM (Orthogonal Frequency-Division Multiplexing) as spectrum spreading technique [6].

3. FIELD TESTS

In this study we examined PLC communication performance in different scenarios: through the LV power line at a distance of 600m and 1.500m, and through the secondary winding of a power transformer of 250 KVA at a distance of 1.500m from one phase to another. Tests have been made using the power distribution network of E.ON Moldova Distribution in the Suceava city, Romania country.

The data transfer was made between two PLC modems, TMDSPLCKIT-V3 PLC kit manufactured by Texas Instruments. PLC modems were connected each to the LV line on the same phase or different phases of the same power transformer. Data transfer was performed between two units connected to laptops via USB cables. Modems were configured via the Zero Configuration GUI application that was supplied with the PLC kit, as presented in Figure 1. Using this application the packet transfer mode was used and modulation has been set. The parameters observed were BER (Bit Error Rate), PER (Packet Error Rate), SNR (Signal to Noise Ratio), RX (Received data speed transfer) and signal strength. All data presented below were registered when BER and PER were null.

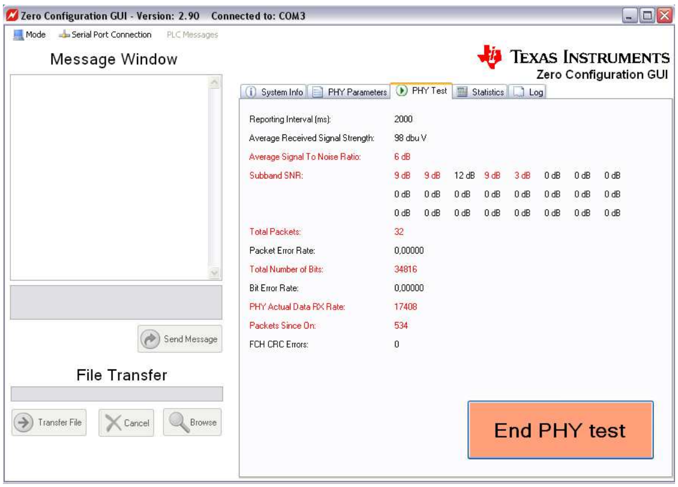

Fig. 1. Zero Configuration GUI application.

● PLC study over LV power lines at 600 m

In this chapter are presented the configuration and test result when communications has been made through a LV power line with a length of 600m. All three modulation of the PLC-G3 protocol have been tested. The first PLC modem has been connected to the LV line of a power transformer of 400 KVA inside an electric transformer station (PT 26) and the other one to a LV niche situated at specified distance of power line from the first modem on the same phase. The configuration map of the tests is presented in Figure 2.

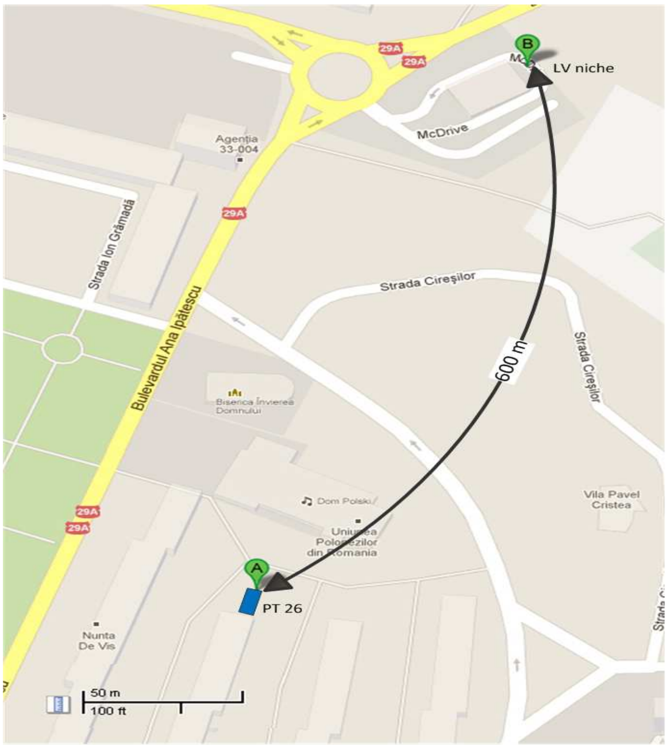

Fig. 2. Map of 600 m field tests.

As presented in Table 1, the communication was a success on the 600 m distance with good data speed transfer up to 28,2 kbps when DQPSK was used. During tests the SNR value was 12 dB and the PLC signal strength was of 90-94 dBµV.

Table 1

Data packet transfer over the 600 m LV power line

Modulation	RX (kbps)
DBPSK	16,6
DQPSK	28,2
ROBO	5,6

● PLC study over LV power lines at 1.500 m

In this chapter are presented the configuration and test results when communications has been made through a LV power line with a length of 1.500m. All three modulation of the PLC G3 protocol have been tested. The first PLC modem has been connected to the LV line of a power transformer of 250 KVA of an aerial electric transformer station (PTA 45) and the other one to a LV niche situated at the Forest District Adâncata at specified distance of power line from the first modem on the same phase. The power cable that connects the two points is TYIR 4x16 type. The configuration map of the tests is presented in the Figure 3. The tests were made between points A and B.

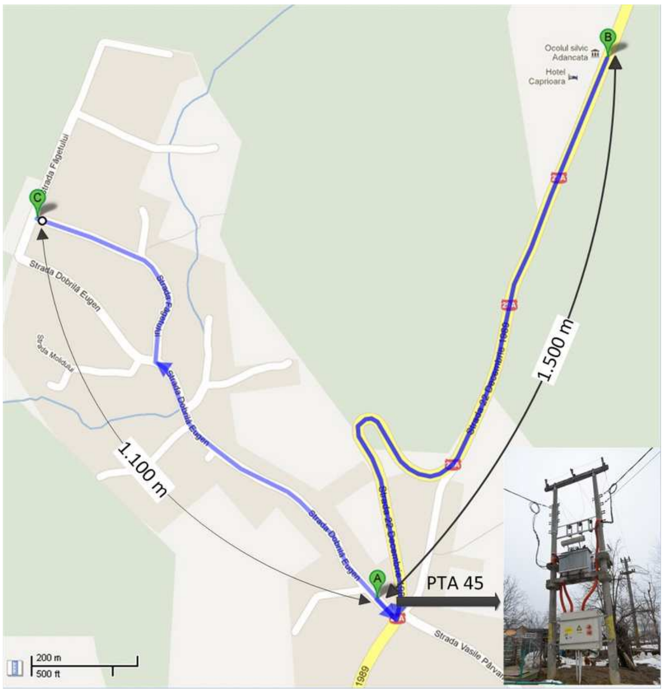

Fig. 3. Map of 1.500 m field tests.

As presented in Table 2, the communication was a success on the 1.500 m distance but with low data rate, the higher transfer speed was 2 kbps when DQPSK was used. During tests the SNR value was 0-6 dB and the PLC signal strength was of 74-80 dBµV.

Table 2

Data packet transfer over the 1.500 m LV power line

Modulation	RX (kbps)
DBPSK	1,2
DQPSK	2
ROBO	0,8

● PLC study through the secondary winding of a MV/LV power transformer at 1.500m

As presented in the previous chapter the same configuration has been used but the PLC modem that was connected at the LV power line near the power transformer was moved and reconnected to another phase of the power transformer. So the PLC signal was sent from a phase to another, through the secondary winding of the MV/LV power transformer from a distance of 1.500 m, as presented in Figures 3 (A-B) and Figure 4.

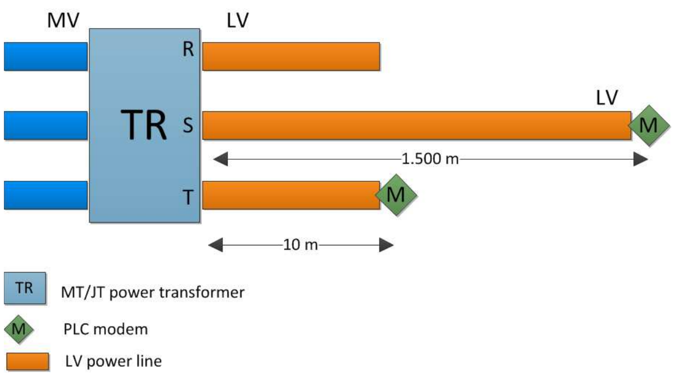

Fig. 4. Configuration of the 1.500 m test over the secondary winding of a MV/LV power transformer.

As presented in the Table 3, the communication was a success on the 1.500 m distance with the crossing of the secondary winding of the power transformer but with low data rates, the higher transfer speed was 2,5 kbps when ROBO modulation was used. During tests the SNR value was 0-6 dB and the PLC injected signal was of 78-80 dBµV.

Table 3

Data packet transfer at 1.500 m from phase S to phase T of the MV/LV power transformer

Modulation	RX (kbps)
DBPSK	1,4
DQPSK	1,8
ROBO	2,5

Another test was made in this case, then the distance on the T phase was increased to 1.100 m as presented in Figure 3 (C), but the communication could not be made with neither of the modulations used.

- PLC study over MV power lines at 100 m

In this chapter are presented the configuration and test results when communications has been made through a MV power line with a length of 100m as follow: one PLC modem was connected to a voltage transformer at 110V, the voltage transformer was connected to a MV power line that is distributing the energy to a power transformer of 1200 KVA, at the secondary winding of the power transformer was connected the second PLC modem. This configuration is present in Tricotaje power station located in Suceava city, Romania country. The distances between the modems and transformers are presented in Figure 5. The conection between the two transformers is made from power cable and partial from aluminium bars.

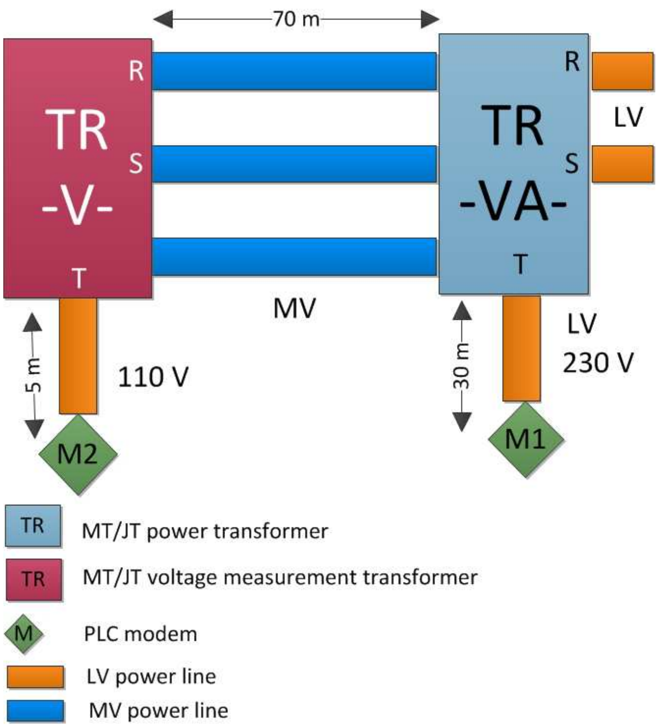

Fig. 5. Map of 1.500 m field tests.

Using this configuration communication has been made from M1 to M2. During tests the SNR value was 0-3 dB and the PLC signal strength was of 72-78 dBμV. Data regarding speed transfer for each modulation used are presented in Table 4.

Table 4

Data packet transfer at 100 over MT power line

Modulation	BER	PER	RX (kbps)
DBPSK	0,49	0,9-1	0,4
DQPSK	0,49	0,9-1	0,6
ROBO	0,02-0,08	0,75-1	1

As presented in Table 4 communication could take place but with bery big bits loss with an average value of 49% in the ocase of DBPSK and DQPSK and packet loss up to 100% in all modulation cases. When distance between the voltage measurement transformer and the power transformer was increase to 150m and 200m the communication between M1 and M2 could not be made.

4. CONCLUSIONS

✓ PLC can be a solution for last mile automatic meter systems because it can provide data transfer between meters and a concentrator connected to the secondary winding of a power transformer over big distance reaching 1.500m or more.

✓ A voltage measurement transformer can be used to receive data on MV power lines when data it is sent from a LV line of a MV/LV power transformer but with loss of data and at distances up to 70m between the two transformers. This solution is not better than using a MV coupling unit but it can be used if nequired.

✓ PLC G3 is a good candidate for the next generation of the power line communication devices and can provide good data rates over long distances with all modulations used by the protocol.

✓ Results presented show that using PLC G3 communication can be made over long distances and through seconday winding of a power transformer with no bit or packet loss.

✓ PLC can be a solution for data transfer although the power line is a noisi channel and the signal suffers big attenuation with SNR tacking values down to 0 dB.

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