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Testing of Electromagnetic Compatibility of PLC Modems

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***Abstract*—The effect of electromagnetic field radiation from an electrical network is experimentally investigated. Several measurements were conducted, in an anechoic chamber and in an ideal open environment, by injecting different levels of Power Spectral Density (PSD) on different types of electrical cables. The network topology plays an important role on the measured radiated power, leading to different frequency peaks according to the network resonance frequency.**

Keywords—Electromagnetic field radiation, power line communication, power spectral density, radiation limit.

I. INTRODUCTION (*Heading 1*)

The electrical grid is the most widespread network in the world, which connects the large sites and in current developed world it is steered practically into every household.

This enables to use the power grid also for other purposes, not only for distribution of electric power. By following certain patterns and principles, it is possible to use electrical grid for telecommunications purposes - for example, to create a corporate telephone network based VoIP technology (Fig. 1).

Technology that enables it works on the principle of data transmission in the electricity distribution grid and it is called Power Line Communication (PLC). The entire operating principle consists in the fact, that there is modulated a high frequency signal to the low frequency signal in tens MHz which is suitable for transmitting information in the form of narrowband or broadband services. Therefore, it enables to provide a wide range of telecommunication services. Possibilities of using PLC technology in telecommunications and RF signal propagation conditions in the electricity networks are detailed described in [1-11].

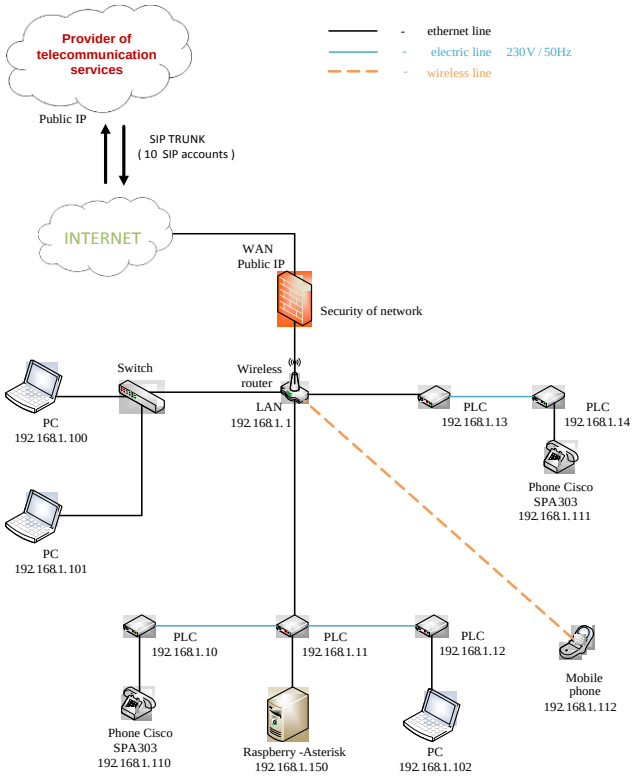

Fig. 1 Network topology with Asterisk PBX usage

Services using broadband PLC technology are characterized by requiring higher data transfer rates. It is mainly about multimedia services, such as the voice communication together with the traffic of HD video, combined with data traffic and so on.

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Broadband technology of PLC requires a much wider frequency range than narrowband technology. The frequency bands used for broadcast transmission in electric grids are classified depending on the type of technology it is. The most used technology is technology using HomePlug standard [12], [13], [14]:

- HomePlug 1.0 – uses frequency band 4,3 – 20,9 MHz and transmission rate 14 Mbit/s,
- HomePlug AV – uses frequency band 1,8 – 30 MHz and transmission rate 200 Mbit/s,
- HomePlug AV2 – uses frequency band 1,8 – 86 MHz and transmission rate higher than 600 Mbit/s.

When designing and projecting PLC networks beside examining transmission rates there should be also aspects of electromagnetic disturbance considered. Electric distribution grids are not in fact specifically designed to information transfer [15], [16]. PLC network is characterized by showing similar characteristics as the antenna – it acts as a source of disturbance, and it may be interfered itself. Electric grid, that should be in the future, in addition to distribution of electricity also data network. Therefore it should be examined in a detail ways, so that the required network performance could be secured. Depending on the position and the location of the PLC equipment, the transmission quality may vary. The transmission quality may be affected by some disturbance caused by different electric devices, filtres protecting electric grids and many others [12].

II. TESTING OF PLC DEVICES

After a guideline number 89/336/EEC, or 2004/108/EC having been introduced into practice and electromagnetic compatibility has become one of the most important characteristics of electric devices, which are imported into European markets. All supplied electrical equipment should be tested in specialized laboratories, so that it could be found out if any undesirable electromagnetic radiation of electromagnetic field which has an unwanted affect on the activity of other electric devices and vice versa. These PLC modems were tested for the telecommunication purposes. One of them was the radiated disturbance test. In this test maximum level of radiated electromagnetic field from tested PLC modems was observed. According to [12] maximum level of radiated electromagnetic field can be made by looking for:

- different geometric configuration of tested modems,
- different rotation of tested modems around own axis (0° až 360°),
- different measuring height of an antenna above the conducting plane (1 ÷ 4 m),
- different polarization of the measured antenna (horizontal and vertical),
- frequency measurement range (30 ÷ 100 MHz).

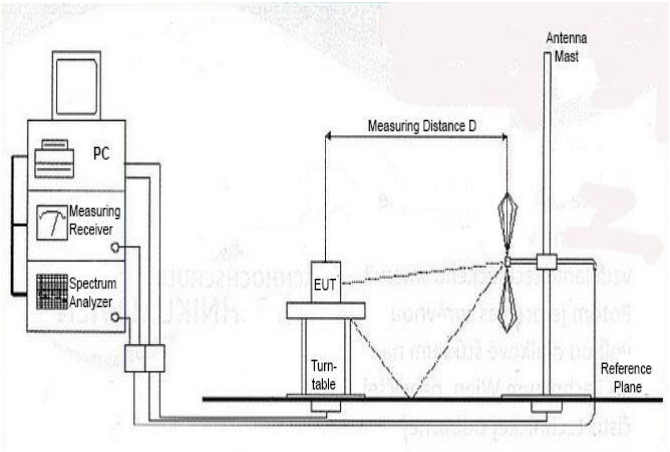

Fig. 2 Arrangement of the measuring EMC place [18]

Measurement principle of radiated disturbance from the tested devices is given by the Slovak Technical Standard STN EN 55016-2-3. The arrangement of the measuring place is shown in Fig. 2.

There cannot be any objects at the measuring place which might cause deformation of electromagnetic field, excluding ground reference plane, which should be made from perfectly conductive material.

Tested modems are placed at a height of 80 cm above a ground plane on a nonconductive substrate in the working position. Disturbance could be measured in the frequency range of 150 kHz to 30 MHz.

Within the measurements of disturbance voltage in electric grid CE (Conducted Emission) there were measured four types of PLC modems from two suppliers that provide different transmission rates and operate on the basis of different technologies.

There were used two types of detectors for emission measurements [19]:

- Peak detector – there was the value of the output voltage equal to the maximum the maximum voltage envelope. The advantage was the fast response of the detector, which at its outlet stores reached maximum value. This measurement itself did not involve repetition frequency of the disturbance signal. This measurement is used for fast measurements and initial orientation. The orientation is used to get to know what values of the disturbance voltage the given device radiates.
- Average detector – It represented the value of an output voltage, which was equal to the average arithmetical value of an intermediate frequency voltage envelope in the input. The detector, which measured the average value, it is not appropriate to use to measure broadband disturbances of an impulse character. The specific scheme of the measurement place, which was used at PLC modems testing employed the PLC modems is shown in Fig. 3.

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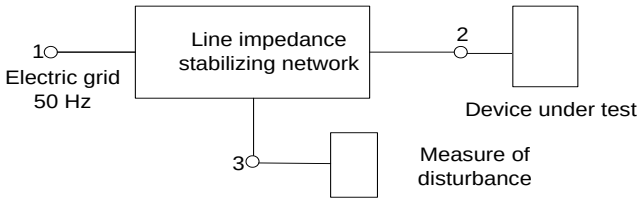

Fig. 3 The specific scheme of measurement place for PLC modems testing

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The workstation for PLC modems testing consists of several components:

- LISN (Line Impedance Stabilizing Network) – it represents a simulated load a line and i tis used for measuring of disturbance signal, which are generated and the devices that are powered from an electric grid.

  There is the simulated load connected to an electric grid on the connector number 1, within the measurement was applied the load - type Rohde & Schwarz ESH3 9k-30MHz,

- DUT (Device Under Test) – the tested modems were connected by the connectors 2 to block LISN,

- Measure of disturbance – LISN block was connected to the measurement device via connector number 3. As a measurement device the appliance Rohde & Schwarz ESPI07 9k-7GHz was used.

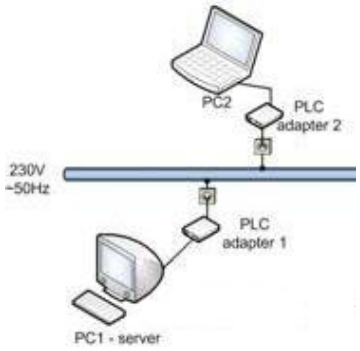

Fig. 4 Connection of tested modems

The tested modems (as sources of disturbance - adapters 1 and 2) were connected according to a scheme shown in Fig.4 and they were tested into two states – while they did not communicate with one another or while they communicated with one another. The block LISN was connected to the measurement device via connector number 3. As a measurement device there was used an appliance Rohde&Schwarz ESPI07 9k-7GHz.

III. METHOD OF MANAGEMENT

Testing of electromagnetic compatibility of PLC modems was made in a certified workplace for measurement of radiated emissions in the Department of Electrical FEI STU in Bratislava. There was used the standard the CISPR (International Special Committee on Radio disturbance), at measurement which deals with electromagnetic radiation of overhead power lines with alternating current in the frequency range 150 kHz - 30 MHz. For information and tele-communication technology is designed the standard CISPR 22, whom the mentioned European standard EN 55022 corresponds.

Within the PLC testing there were measured disturbance voltage in the electric line by four different types of PLC modems. They were measured two types of the disturbance voltage values – peak disturbance and average disturbance values in active and passive mode of PLC technology.

First there was tested a couple of PLC modems of the brand Corinex AV200 Powerline Ethernet Wall Mount, which are shown in Fig. 5.

Fig. 5 PLC modems of the brand Corinex AV200 Powerline Ethernet Wall Mount

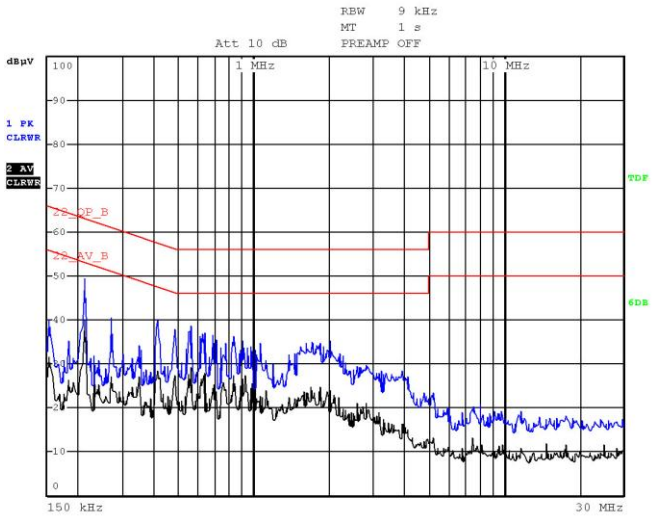

Fig. 6 Measurement number 1 Corinex AV200 Powerline Ethernet Wall Mount – passive mode

The results of the first measurements of modems Corinex AV200 Powerline Ethernet Wall Mount, which are shown in Fig. 6 and FIG. 7, show that in the state when the devices do not communicate with each other the value (excluding peak and average disturbance voltage) permanently below 40 dB,

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there was one exception - a peak value occurring around the frequency of 200 kHz. If the PLC modems start communicating with each other, the peak disturbance values are increased rapidly to the value of 80 dB in the entire frequency range. The increasing of the average disturbance voltage values appears on the frequency above 10 MHz.

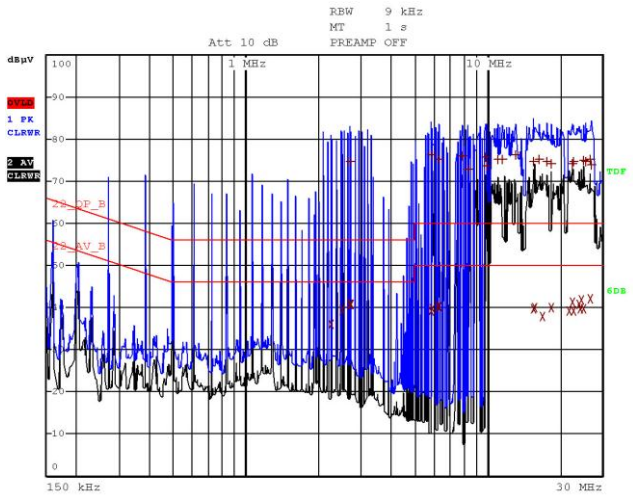

Fig. 7 Measurement number 1, Corinex AV200 Powerline Ethernet Wall Mount – active mode

Fig. 8 PLC modems Corinex HD200 Powerline Wall Mount F

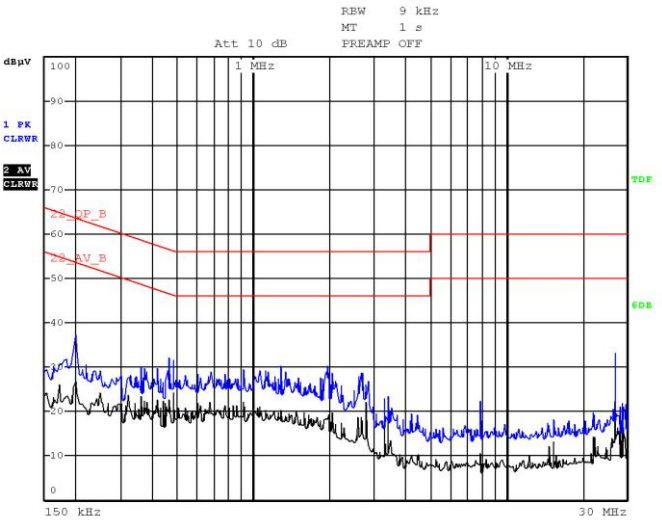

Fig. 9 Measurement number 2, Corinex HD200 Powerline Wall Mount F – passive mode

At the second measurement there was tested a couple of PLC modems of the brand Corinex HD200 Powerline Wall Mount F, which are shown in Fig. 8.

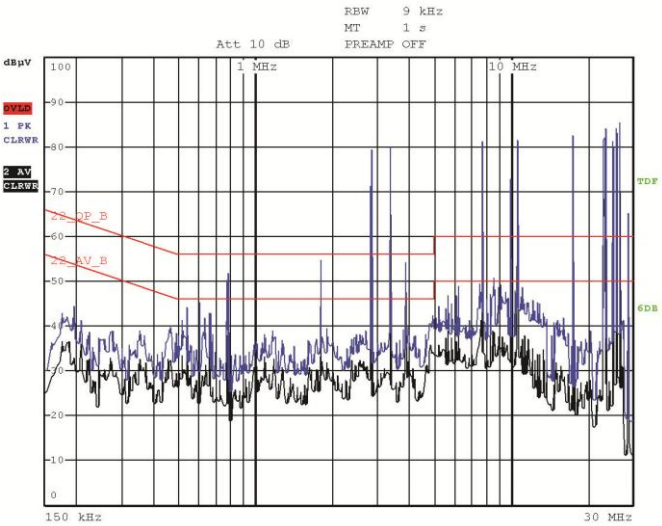

Fig. 10 Measurement number 2, Corinex HD200 Powerline Wall Mount F – active mode

At this second measurement of the disturbance on the modems Corinex HD200 Powerline Wall Mount F in the passive state (Fig. 9 and Fig 10) the values of the peak voltage did not overcome the limit of 30 dB, excluding a few frequencies. In an active mode, the peak voltae values were the below the limit of 50 dB, excluding a few frequencies, there were values around 80 dB.

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Fig. 11 PLC modems Corinex AV500 Powerline

At the third measurement was tested a couple of PLC modems of the brand Corinex AV500 Powerline, which are shown in Fig. 11.

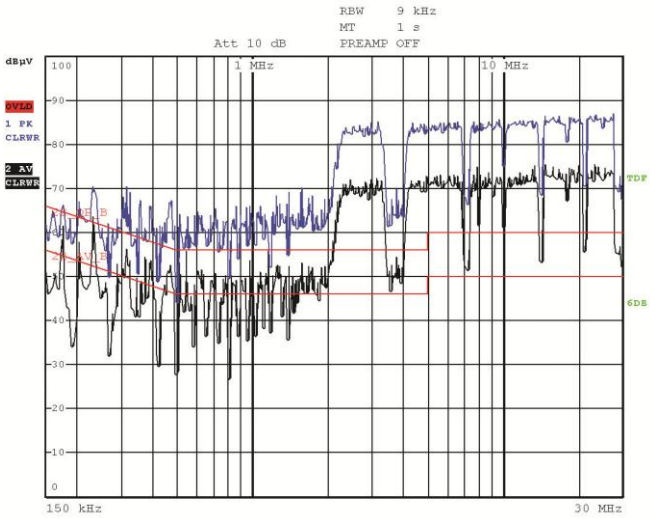

Fig. 12 Measurement number 3, Corinex AV500 Powerline – passive mode

At the third measurements (Fig. 12 and Fig. 13) there were used PLC modems Corinex AV500 Powerline which used HomePlug technology, there was the peak voltage value measured around 50 dB and from the frequency of 2 MHz it is increasing up to 85 dB. At the shown pictures (Fig. 12 and Fig. 13) it is also seen that the continuance of disturbance voltage does not have such a rapid increasement of the peak disturbance voltage as it was in previous the cases. The values of the average disturbance voltage range from 40 dB to 75 dB.

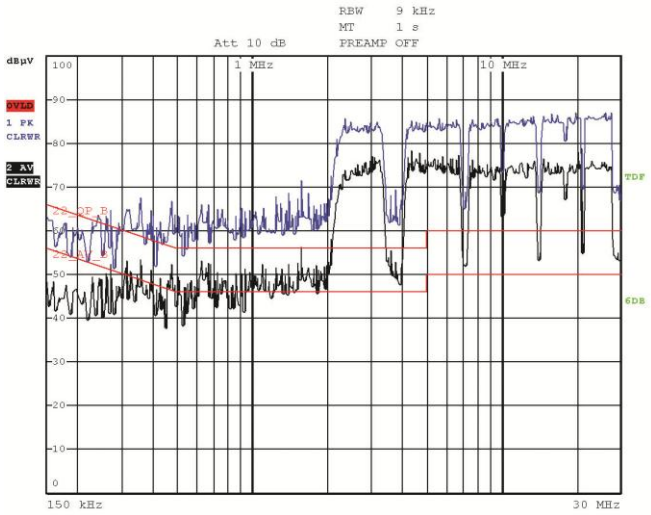

Fig. 13 Measurement number 3, Corinex AV500 Powerline – active mode

At the fourth measurement there was tested a couple of PLC modems ZyXEL HD Adapter Poweline PLA5215 that are shown in Fig. 14.

According to a producer this type of modems theoretically allows to use data transmission rates of up to 1 GHz. At this measurement, there were no major fluctuations while transition from the passive state to the active state (Fig. 15 and Fig. 16). An interesting finding is that in an active state there was no reduction of the peak and average disturbance voltage around 20-15 dB in the frequency range 150 kHz - 2 MHz. The values above 3 MHz in the case of peak voltage are around 85 dB, and in the case of average disturbance voltage they range from 70-75 dB.

Fig. 14 PLC modems Zyxel HD Poweline Adapter PLA5215

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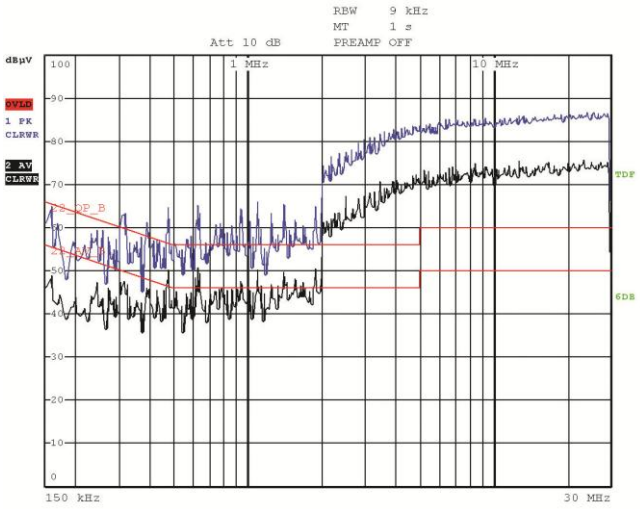

Fig. 15 Measurement number 4, Zyxel HD Poweline Adapter PLA5215 – passive mode

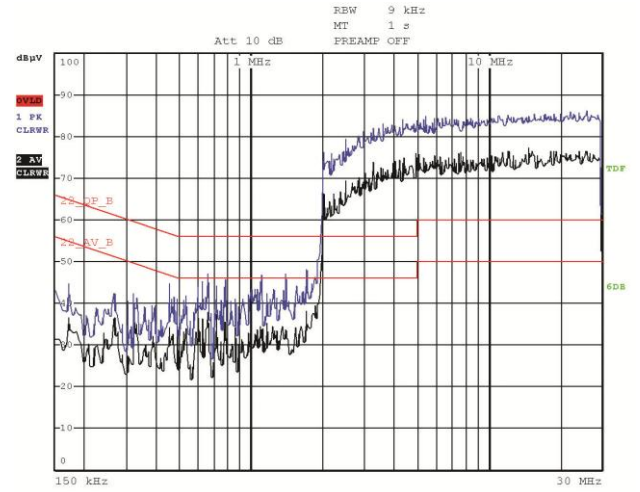

Fig. 16 Measurement number 4, Zyxel HD Poweline Adapter PLA5215 – active mode

Mentioned tested modems were used in PLC networks for various telecommunication purposes (such as implementation of the corporate telephone network PBX Asterisk soft-type panel - see Fig. 1), disturbance measured in PLC modems did not affected negatively the activities of these applications.

IV. CONCLUSION

In this work there was described an influence of electromagnetic field of PLC modems by measuring the disturbance voltage value in an electric grid by using four different types of PLC modems. In particular two types of disturbance were measured – peak disturbance and average disturbance values in active and passive mode of PLC technology.

The measurements were made in an anechoic chamber on four different types of PLC modems. Despite the fact, the measured disturbance voltage values slightly exceeded radiation limits set by CISPR, these values of disturbance radiation did not affect the activity of PLC network and applications run on the network.

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