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USE OF POWER LINES FOR TRANSMISSION OF MESSAGES (PLC, BPL)

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Explanatory Notes

$E=m\cdot c^2$	Definition
	Interesting
i	Note
	Example
	Summary
+	Advantage
–	Disadvantage

ANNOTATION

This module describes the methods and approaches for the use of power lines and networks (grids) for transmission of messages. It includes description of the telecommunications technologies that implement transmission through power lines and grids. It also describes the possible applications of these systems within the smart energy networks, known as Smart Grid.

OBJECTIVES

Students will acquire basic view on the differences between transmission properties of telecommunication lines and power lines. They will learn the principles of narrowband and broadband telecommunication technologies that operate on electric power lines and networks (mass remote control, high-frequency transmission systems, power plants telephony, local systems for transmission of remote metering, remote signalling, broadband systems for data transmission). This knowledge can help students to deal with data and access networks. Students will acquire basic knowledge about the development of electric power networks and deployment of "smart" power lines also known as Smart Grid. On this basis, a student should be able to evaluate goals and benefits of PLC and BPL systems, while implementing particular telecommunication networks.

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1 Introduction

1.1 Historical development

In 1866, German engineer Ernst Werner von Siemens (1823 – 1883) patented a dynamo with self-excitation. It was the basis for the initial development of the electricity industry, since it enabled the conversion of mechanical or thermal energy to electrical energy in devices with relatively low power. Since the original use of electrical energy, there was a huge progress towards far distance energy transfer. French electrical engineer, Marcel Deprez (1843 - 1918), was one of the firsts, who implemented DC transmission over greater distance. In 1873, he showed transmission between an engine and a dynamo to a distance of 1km, using a telegraph line.

At the time, first DC (direct current) electricity networks were built. They were used to enable production of electricity far from the location, where it is consumed (rivers, coal reserves, etc.). From the beginning, it was considered how to use the constructed power lines for transmission of messages. First, there was requirement to make possible transmission of control and management messages referred to the energy transfer. The AC (alternating current) power component was to be attached to DC voltage, which allowed creating a simple signalling system. It also required solving the compatibility of low-voltage control part with a high-voltage DC network, including safety equipment and handling.

Transmission of information in an AC electricity network could then be locally deployed with the use of DC pulses. However, these applications require additional DC sources and were very problematic in terms of equipment interconnections and compatibility with the lines. For this reason, they were soon replaced by systems transmitting AC signals with frequencies higher than the nominal frequency. The goal was to propose a simple signalization to control operation of these networks. Later on, there were simple systems for remote control, e.g. the network sectional disconnectors. It was always referred either to addressing the remote signalling of particular objects or addressing a single object from a remote command point, or a bi-directional combination of these systems. For these purposes, low-voltage networks were mostly involved; high-voltage networks - exceptionally.

At the same time, however, since the 30s of the previous century, there were *Mass Remote Control* (**MRC**) systems, which used to send a signal from one central location to branching high-voltage network, in which the group of remote-controlled devices were responding be sending either a common signal or a switching function.

Construction of robust and mechanically demanding long-distance high-power lines and very high power lines attracted the idea to use it for transmission of telephony. The very first attempts started to employ this principle also in power lines in the form of so-called high-frequency power telephony. In the Czech Republic, manufacturing of these devices started even before the Second World

War in the company “Telegrafia Prague” (the predecessor of Tesla Strašnice). After the war, production of these devices continued.

Currently, however, there is growth of free high-voltage three-phase lines, where a specialty optical cable is incorporated in a protective metallic rope, which enables transmission of relatively huge data flow, comparable with ones that are common in conventional telecommunication networks with fibre optic cables.

Further development of telecommunications technology then enabled applications using low-voltage distribution parts of energy networks to create narrow-band systems, which are used for local control, signalling and remote measurements (e.g. Remote power meters reading). Advanced transmission technology, developed especially for the transmission of telecommunication signals in radio environments with high levels of interference also enabled the implementation of broadband data systems with high data transfer rates in a relatively harsh electromagnetic environment of electricity distribution networks.

1.2 Power Line Communication – parameters

Band name	Sub-voice band	Voice band	Medium band	High-frequency
Bandwidth	f < 300 Hz	f = 0,3 - 4 kHz	f = 4 - 150 kHz	f > 150 kHz
Application	MRC	MRC	RS, RO, RM Telephone and narrowband data services	Telephone and broadband data services
Exemplary frequencies	0 Hz, 50 Hz 166 Hz, 217 Hz	300 Hz – 2500Hz 300 Hz – 3400Hz 316 Hz, 425 Hz 1050 Hz	3 – 95 kHz 9 – 95 kHz 95 – 148,5 kHz	40 kHz – 750 kHz 1 MHz – 30 MHz

There are common terms used for all these systems: *Power Line Communication* (**PLC**), *Power Line Telecommunication* (**PLT**) or *Power Line* (**PL**) – however, they include both broadband and narrowband telecommunication systems over power lines. More accurate term for broadband systems is *Broadband Power Lines* (**BPL**).

PLC systems are criticized by their opponents due to electromagnetic interference, which originates during operation. Data signal, which is injected into a power line, may thus appear for other communication systems as a source of interference. In the development of PLC systems, there were various problems with their interaction with other media. *Electromagnetic compatibility* (**EMC**) must be strictly monitored in PLC. Broadband BPL signal emitted to the surroundings of the power distribution lines, often exceeds the permissible limits specified in the international EMC standards. These, however, were formulated in a specific historical period, particularly with regard to the protection of radio reception from interference with spurious sources. In addition, different generations of PLC systems or systems by different companies can exhibit quite different properties in terms of emission of spurious signals.

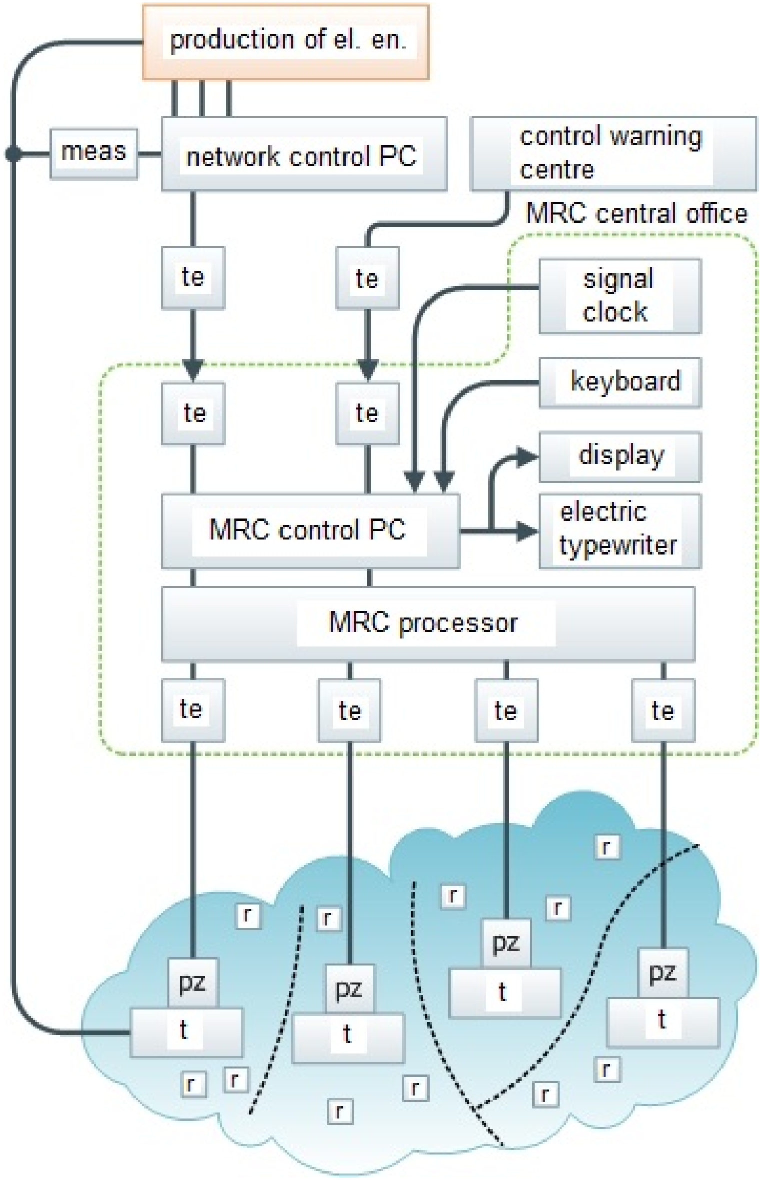
From the principles of broadband signals transmission over copper lines, it can be concluded that each of them can somehow radiate a certain part of signal energy into space, and that certain radiation coming from the surrounding electromagnetic environment can get into it, as well. The amount of this radiation depends on construction of particular types of line and light coupling in the lines. Spurious emission of wideband signals transmitted over metallic lines is therefore a fact, and it refers to both electric power transmission and weak current installations, including relatively new telecommunications systems (e.g., ADSL and VDSL).

2 Mass Remote Control (MRC)

In terms of classification of telecommunication services, MRC can be considered as one of the remote services. It can also include remote control systems (RCS), remote signalling (RS), remote measurement (RM), remote regulation (RR), Tele-Watching, and GPS navigation. Considering the type of transmission, MRC is a one-directional distribution system.

E=m·c²

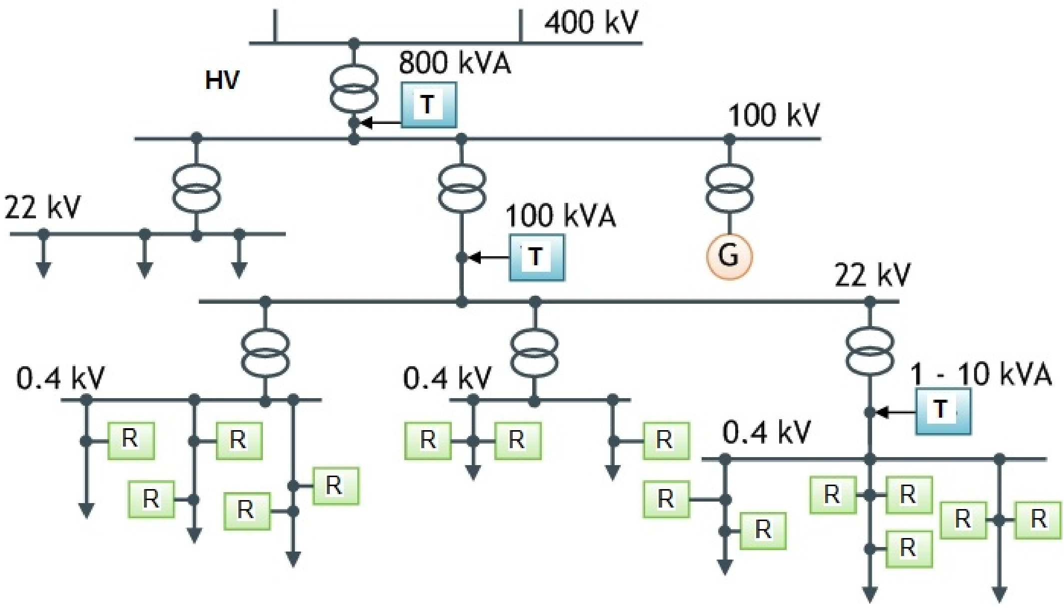
While the MRC system is the address that between the control and the only controlled place has a separate dedicated bi-directional circuit, the MRC system is a mass system, which sends a signal from a single centre via common unidirectional transmission path to many places. The result is not only management, but also the signalization for certain conditions and events.



General arrangement of a modern MRC; te – transmission equipment, t – local MRC transmitter, r – MRC receiver.

2.1 Access part of the network

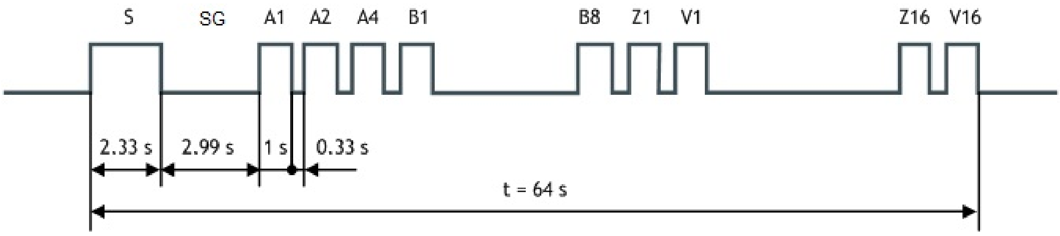
The access part of the network is displayed in the below figure. In the figure, MRC transmitters can be connected to the secondary side of the HV/MV (high voltage/low voltage) transformer, HV/HV and HV/LV transformer. It is associated with the dimensions of the controlled area and the power of a signal source (in a range of hundreds of kVA). Operating frequencies are in the range of 217Hz - 1050Hz.



Access part of the network.

To transmit MRC signals in an electric power grid, it is necessary to have a relatively powerful low-frequency AC power source signal with the output of hundreds kVA. They are also known as frequency converters. First, frequency converters were created using electromechanical rotating machines. At present, however, the power sources for MRC are constructed as Static Frequency converters (SFK), implemented by using a thyristor power inverter. The sources are mostly connected to the network using so-called serial links.

The need to distinguish between a number of objects and necessity to enhance operation security led to the creation of modern types of command codes for MRC. A command code with serial expression of dual commands (see picture) includes a start pulse (S) and a security gap (SG). Furthermore, it is the address part (A, B), which enables creating the conditions to increase the number of a possible dual command (up to hundreds). The command part includes 16 commands.



Command code with dual command serial expression.

The original purpose of MRC, which was to support the operation of electric power grids during their development, exhibited considerable growth in amount of potential applications that can be divided into three main application groups.

2.2 Application

- The first group is the management of electricity consumption and balancing the total electricity consumption. Assigning individual commands used in this area exhibits for example management of hot water tanks in households, industry and agriculture, control of electric heaters, electrically heated boilers, air conditioners and heat pumps, control of industrial and bakery ovens, irrigation pumps, electric motors, of diagrams electricity consumption control, or steam inside the big races, and others.

- The second group of MRC applications represents so-called switching functions. We deal with switching of two-tariff electricity, control meters for measurement of peak consumption, control of power limiters, switches of secondary power lines and secondary transforming stations, control switches for testing of ground connection, switching geographically distributed measurement points for statistical purposes, switching of capacitor banks, control of various modes of public lighting, traffic signs lightning, neon signs and shop windows, etc.

- The third group consists of signals for information, recall and warning functions. We deal with public time signals, synchronizing of public hours, convening the maintenance and fault workers, volunteer firefighters, members of the Mountain Rescue Service, alarms for members of the rescue and emergency services, police and army, control public sirens, announcing alarms in the system of civil protection, natural disasters or increase of radiation around nuclear power plants, and others.

Modern MRC receivers should be considered as very sophisticated telecommunication equipment designed using advanced electronic components.

With the new telecommunications technologies, the significance of MRC systems became less important, however, it is still one of the most necessary systems for further development of electricity industry.

3 High Frequency Power Plants Telephony (HFPPT)

E=m·c²

Transmission equipment had been created based on the principle known from the high-frequency carrier telephone systems. It was used with amplitude modulation or frequency modulation. Domestic Standard CSN 33 4640 permitted, based on an exemption from the Telecommunications Act, to implement service transmission for energy purposes in the band of 30-750 kHz and the width of each channel of 2.5 kHz and 4 kHz. At the same time, the recommendation specified the parameters of splitters and safety requirements.

Coupling devices for connecting communication equipment to power lines must provide several basic parameters. First of all, they must exhibit high attenuation for the frequency of 50 Hz, and the smallest possible attenuation for the telecommunications band. It must contain components that ensure safe handling, not only up to the nominal voltage and phase, but also at the overvoltage or short-cut conditions. It should also contain components for signal routing (i.e. there should be huge attenuation for the direction to a power transformer and small attenuation in the direction to a line).

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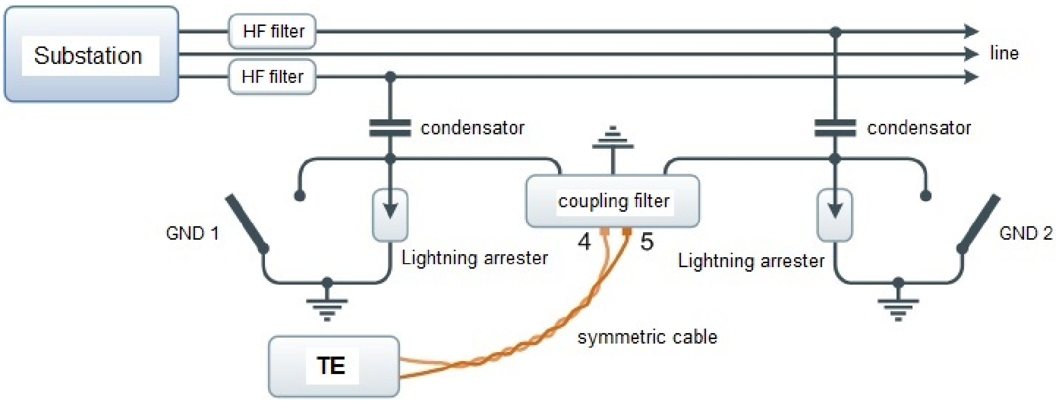
Exemplary schematic arrangement of the most widely used interphase capacitive coupling of high-frequency devices to high-voltage power lines is shown in the following figure.



Schematic arrangement of most widely used interphase capacitive coupling high-frequency devices to high-voltage power lines.

Coupling capacitors for outdoor use (of the order of nF) are connected to a coupling filter and create a bandpass filter tuned to the telecommunications signal band. A glow is used as internal overvoltage protection. Coupling filter also provides impedance match of the coupling elements with the impedance of a high-frequency symmetrical cable, which is brought to a transmission device.

Signal routing towards high-voltage line or from the line towards transmission facilities provide high-frequency band stop filters. These filters are tuned to the transmitted high-frequency band around the carrier and thus prevent the loss of signal in the transformer substation, and reduce crosstalk to other lines. The technologically most challenging part of the filter is a choke that must be dimensioned for the short circuit current for a given phase, which is of the order to hundreds of amperes. Safety functions are ensured by lightning arresters, working even in the case of failure of coupling capacitors. When handling with a coupling device, appropriate working conditions are ensured by earthing.

Although implementation of narrow-band high-frequency systems was very demanding from the technological and economical perspective, their deployment was very purposeful. High-frequency systems were used not only for telephony, but also for data transmission, telex and telemetry. Individual high-frequency lines in the Czech Republic were gradually interconnected to create a vast and robust network, used for the control of the operation of a power system. At the end of the last century, therefore, there was a nationwide dispatching network, connecting all power plants and important switching stations.

A new component of remote external energy network - fibre optic cable incorporated into the protective steel rope in outdoor high-voltage and very-high voltage links, opened door for a technically and economically advantageous transmission path with variety of broadband transmission options. We deal with the replacement of original copper wires (R, AlFe) by specialty combined grounding cables (CGC), in which telecommunication optical cables are combined with the conductive wires. Optical cables are for broadband telecommunication channels used in long-distance telecommunications transmission technology.

3.1 Power Plant Telephony in the Czech Republic

While conventional devices of high-frequency power plant telephony were practically uninstalled in the Czech Republic, and replaced by transmission technologies using combined ground cables with built-in optical cables, this change is still in progress especially in countries with vast energy grids, mainly for economic reasons. In these networks it is therefore expected to introduce several "temporary periods" to move to optical transmission systems. That is why in these countries (e.g. The Russian Federation, Ukraine, China, India, etc.), optimizing conventional high-frequency devices is current issue. The progress is towards digitizing the high-frequency transmission channels.

4 Narrowband PLC Systems for Local Telematics

Narrowband PLC services can be split into three groups:

- Speech
- Broadcasting
- Non-speech

Speech services are analogue services or standard telephony.

4.1 Development of Services

During the development of PLC applications, there was a series of experiments with PLC audio services. Transmission of radio programs using amplitude modulation using long or medium-frequency bands for the local needs of larger objects (e.g. student dormitories) was dependent mainly on "clear energy networks", i.e. on the level of interference in the used band.

Business telephone transmission was much more durable, when implemented via traction power lines. The most common applications were operating on electrical traction lines in underground coal mines, which were used for communication of work crews.

In some cases, however, such systems were experimentally implemented on railway traction lines to connect the rail dispatchers with the locomotive crew. In both cases interference (noise) was the main limitation, caused by moving trolley adapters of driving vehicles on the contact line, (i.e. sparking at the lines).

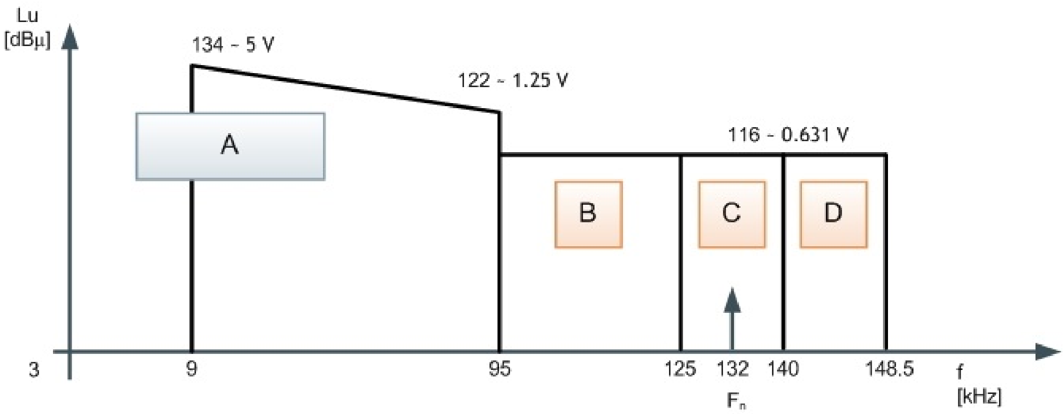
A much larger application refers to the PLC non-speech services, including remote sensing, remote control and signalling, and mentioned mass remote control. Lately, there have been applications for remote reading of power meters in households. There are also requirements for implant the transmission into the infrastructure of security systems.

Narrowband PLC technology has got its limits that have their source in communication in existing power lines. PLC is significantly influenced by attenuation, which is the function of frequency, depends on used splitters, inductance of lines, configuration of lines and distribution of load, number of taps (outlets), type of appliances bridging capabilities (e.g. for noise suppression in the appliances). Furthermore, unsatisfactory relation between the phases, if the transmitter and receiver are at different stages of distribution. Another problem for successful transmission is high level of interfering voltage that is mostly sent back to the network by the appliances themselves. This is particularly the lighting controlled by AC inverters, transformerless power supplies, electro-motors with thyristor control (drills, vacuum cleaners, mixers etc.), or even home network phones (intercoms) that operate in the same frequency bands. Furthermore, a PLC signal can be distorted because of non-linear frequency and phase or because of time-varying impedance. In order to improve broadband transmission systems, one can use an appropriate modulation, echo canceller, suppression of noise etc., Nowadays, the implementation of narrowband data transmission in a typical distribution grid to the distance of about hundreds meters up to about 5 km, is considered.

Currently, there are more applications that utilize narrowband PLC channels in an LV network for local purposes. These are mainly remote data collection systems that collect signals from various distributed media meters (electrical energy, water, gas, hot water, cold, etc.). These systems provide accurate and reliable information without the need to visit the measurement point. This reduces human error reading and labour costs. Other media distributors can profit from it, as well.

4.2 Recommendations for PLC, frequency bands

For the area of broadband PLC systems in the Czech Republic, there was a recommendation EN 50065-1, valid since 1991. The name of this standard is "Signalization in low voltage electrical installations in the frequency range from 3 kHz to 148.5 kHz." The recommendation specifies particular frequency bands and limits the output voltage, as it is shown in the following figure.



Frequency bands and limit values of the output voltage.

Absolute voltage levels of stress in [dBμ] voltage values in [V] can be read from the figure for the corresponding frequency amplitude limits. However, there are a few more standards for the application of narrowband PLC used worldwide.

5 Broadband PLC systems for data transmission

In classical telecommunication technology, there is increased demand for broadband channels and circuits in access networks. This trend is also reflected in transmission resources using distribution power lines as a transmission path.

Electric power distribution grids also exhibits infrastructure that is very little exploited in terms of transmission capacity. However, it represents the access network brought to individual consumers of electric energy and allowing transmission of digital signals at the transmission rate in the range of tens to hundreds Mbps.

The last decade of the previous century has brought the requirement to use some part of the high-voltage transmission networks also for broadband high-speed data signals. This requirement was caused mainly by mass expansion of the Internet and the idea to use power lines for access to this information technology. The beginnings of this approach dates back to the 90s of the 20th century.

5.1 BPL options in practice

Transmission it the distribution network can be considered in two types of BPL systems.

- Outdoor or access BPL systems use either high-voltage lines or low-voltage lines from transformers to the supplied objects, i.e. public parts of the power line networks.
- Indoor or in-house BPL systems use the internal wiring of buildings, which are usually private property. The most used band for outdoor applications is from 1 to 18 MHz, and for indoor applications 18–30 MHz. The reach is relatively small, and depending on grid configuration, it is mostly tens to hundreds of meters and the bit rates are up to hundreds of Mbps.

The mechanism of signal propagation using power lines is getting more and more difficult and confusing, if the signal frequency is higher, and therefore the relevant wavelength is comparable with the geometric lengths of the sub-sections (e.g. branches). Parallel and serial resonance emerges very often. Furthermore, besides the inhomogeneities of particular sections, it is necessary to consider in transmission parameters, caused by configuration changes and instantaneous changes of the load, and, of course, by relatively high level of noise generated by different sources. It is also necessary to consider transmission properties of the splitters and junctions.

To successfully solve problems in aggressive environment of power lines, one could use experiences that telecommunications equipment manufacturers have gathered during development and operation of cable television and modern radio communication systems. That is why specific solutions for BPL systems use the latest modulation and access methods. A current development of PLC is focused on two types of modulation: Direct Sequence Spread Spectrum Modulation (DSSSM) and OFDM (Orthogonal Frequency Division Multiplex).

5.2 Parameters of BPL

From the perspective of BPL signal transfer, two parameters are important:

- Transmission rate
- Bit error rate

As already stated, a power distribution network, considered as a transmission medium, represents a very problematic environment in terms of electromagnetic compatibility. Moreover, the conditions for the energy transfer vary every moment (due to operational handling and connecting/switching on appliances). It is therefore necessary to carefully select appropriate modulations in BPL, (but also coding methods and methods for detection and correction of errors). This, however, increases the necessary number of service bits, which actually decreases the effective transmission rate of user data.

E=m·c²

Generally speaking, the higher the bit rate, the lower the immunity to errors, and therefore more transmission capacity must be reserved for error detection and correction. In systems with smaller transmission rates, the ratio of useful and redundant data is about 1: 1. In systems with a transmission rate of 200 Mbps, this ratio is about 1: 3 (thus only about 30% of the transmission capacity is accounted for useful data). The maximum achievable distance between two BPL modems depends mainly on the output power of BPL signal, its attenuation and also at the level of interference at the receiving side. Without repeaters, it can reach the distance of hundreds meters, but only in public electrical networks with outdoor or underground wires. For the inner part of the network with a variety of sources of interference, any average value of the span does not provide useful information, because different installation affects the reach of tens of meters in both directions. In indoor systems, the reachable distance is about 100 m.

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A BPL modem can be attached to the power grid either directly or inductively. Direct conductive connection of the BPL modem by using the output power cable, of course, assumes that the capacitive coupling enabling to connect the modem to 230 V is its internal part.

While the narrowband PLC systems are designed based on the international standards, the standardization for broadband BPL systems is still unresolved internationally.

The electricity network in more developed countries offers 100% coverage of buildings, i.e. both households and companies. In less developed countries, BPL can substitute the lack of telecommunications infrastructure. One of the results of negotiations between manufacturers, electric utility companies, is the project entitled *Open PLC European Research Alliance* (**OPERA**), its main sponsor is the

European Commission. OPERA project involved 37 companies and universities from ten European countries. OPERA was then officially launched in 2004 at the European BPL meeting, held in Madrid.

During the development of BPL systems there were a large number of manufacturers. Particular products can be classified based on the specific production generations, which differ mainly in terms of modulation type and achievable bit rate of transmitted data. In Europe, most modern BPL modems of the 3rd generation uses DS2 chip using OFDM modulation. Such BPL systems become competitive to conventional telecommunications technologies used in access networks.

Although BPL technology is still developing, one cannot ignore the fact that even after many years of technical development and testing, practical use of BPL is usually limited to a relatively small pilot projects, of which only some have the ambition to grow into a much larger scale. Probably the largest project about PLC/BPL system was run in Texas in the US companies ONCOR Texas, CURRENT Group, LLC. The goal was to implant these technologies within the framework of the project Smart Grid. At present, BPL systems can be commercially offered in the following application areas, e.g.: low area industrial networks, internet connectivity for local providers, supplementing the existing fixed networks in areas where they are not yet implemented, temporary solutions for exhibitions, seminars, training or presentations, construction of data networks in the areas with limited construction or reconstruction possibilities - e.g. historic buildings, museums, galleries; domestic LANs (e.g. linking PCs, printers, phones, fax), access network combined with the use of other telecommunication systems (fixed telephony and data networks, GSM, GPRS, WiFi radio networks, etc.), and finally the use in countries with less developed communications infrastructure in Asia, Africa and South America.

Observing current development of BPL systems, one can conclude that these systems are already part of telecommunications access networks, and their further development is related to the issues of standardization, which suggests lowering their prices due to larger production series, thus increasing the efficiency of their deployment. Future approach to the problem of their deployment in the electromagnetic environment of new intelligent buildings and modern management systems, especially in case of Smart Grids, is found to be very important.

6 PLC Systems in Convergence of Teleinformatic Networks and Services and Smart Grids Development

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Building broadband distribution access to existing power line distribution system is of course economically beneficial. However, advanced modulation and signalling procedures allows to significantly reducing their interference to neighbouring teleinformatic systems. However, it is clear that the profitability of deployment of BPL systems for broadband distribution may be very different based on geographical location, infrastructure, power grid, telecommunications advancement of the country, population density and other aspects.

One of them is also benefit of using BPL systems to access Internet, distribution of audio, video programs or building local area networks in buildings, where are limited possibilities for construction works, installing new cabling (historic buildings, museums, exhibition halls, old school buildings etc.). On the other hand, modern PLC/BPL systems can be an important component while implementing certain services in "smart buildings." Some of these applications have already been implemented in various parts of the world.

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Despite the considerable potential that incorporates BPL access networks, however, compared with wideband x-DSL and CATV, their current percentage share of the global telecommunications market is relatively small. It is also necessary to take into account the increasingly stronger succession of technologies for fast wireless access, fixed or mobile. On the global scale, PLC/BPL technology will only gradually catch up with some competitive tele information technologies.

BPL systems still have their chance to be exploited on a mass scale. In addition to the already built basic access to all potential customers in developed countries, majority of electric power companies possesses relatively significant resources that can be invested in new services and effective marketing. Although PLC/BPL systems can find application in all of these areas, they are the most promising is in the implementation of so-called smart energy networks, known as Smart Grids (SG).

6.1 Smart Grids

Smart Grid (**SG**) is an integral connection of energy and telecommunications networks, which leads to efficient management of energy production and consumption in real time in local and global areas. The principle of operation of these networks is based on two-way interactive communication between partial operating points of the grid on the side of production, distribution and consumption of energy. Teleinformatic resources allow real-time collection of information, diagnostics of individual parts of the network and operational management on the side of production and distribution, as well as expansion opportunities in sales, as well as the choice of tariff options on the consumer’s side, according to programmed or immediate requirements of consumers. The term “power grid” can be understood not only as the electricity distribution network, but also as the network for production and distribution of gas and heat, water supply and distribution system, and others.

The biggest advent of SG can be observed in electricity networks. The control system should constantly monitor the network traffic and ensure so called "self healing", i.e. a process in which a network can automatically set the original conditions after any abnormal operation. Continuous diagnosis of operation parameters’ should help it (parameters of substations, transformers and distribution lines), together with immediate indication of fault states.

Majority of current electricity grids is built on the concept of a relatively small number of conventional sources of energy (thermal, hydro and nuclear power) with high power (hundreds and thousands of MW), from which a distribution network (HV, MV, and LV) transmits energy to a relatively large number of consumers. While this arrangement allows relatively easy synchronization of a network, it’s mostly a star topology, which can cause significant problems in case of power source failure of power lines damage.

6.2 Alternative Energy Sources

At present, however, we can observe new alternative energy sources, which can be low-power sources, scattered throughout the distribution area. Some sources (e.g. small photovoltaic systems) are detached to the level of individual buildings; however, they can add their low power to the public power grid. There is therefore a need for a major reconfiguration of electricity networks, which are associated with the expansion of SG. Such structure causes problems with stable operation and synchronization of a common network. To prevent a network from a collapse due to a variety of sources, it is necessary to establish a network of highly sophisticated and efficient management, which enables control of the power grid up to the level of the individual sources. The efficiency of successful management of smart grids network, which consists of a large number of sources (hundreds), and several times larger number of supply points (hundreds thousands), is dependent on the type and quantity of the information sources and consumers of energy. This should help the deployment of SG, which should enable optimum use of all its resources. In addition, however, dispersed distribution of individual sources and intelligent management should also provide fast and effective solutions to critical conditions that occur during failures of the distribution network due to the failures of sources or damaged lines.

An important aspect, especially for the future, refers to returning to DC energy distribution and building the power stations for electric cars. A current trend is to build intelligent buildings, which should ensure ecological and economic operating parameters, high degree of automation of operational processes, including the development of so-called communal services.

SG thus represent for both current and future electricity networks a number of other operational and economic advantages. They enable a higher degree of automation of substations and transformers, which results in reduction of operating expenses.

7 Conclusion

All these facts clearly emphasize the necessity to build Smart Grids. In order to ensure effective management, it is necessary to create a sufficiently dimensioned data infrastructure between the source and the appliance, data centre and dispatching control. From this description, it can be concluded that building SG generates not only high costs, but also considerable demands on electromagnetic compatibility of cooperating and neighbouring systems.

Telecom operators and manufacturers of information and telecommunications devices, in the present situation of relative saturation of the classical telecommunications markets, have already understood that there is an essential need for the development of SG. It can become very promising for their current and future business.

It can be concluded that to ensure effective management, it is necessary to create a sufficiently dimensioned teleinformatic infrastructure between different energy sources and appliances, data centres, dispatching control and some other components of the energy companies. In this infrastructure, for technical and economic reasons, various PLC systems must be incorporated. An important aspect for the application of PLC/BPL resources is the possibility of combination with other teleinformatic technologies. PLC/BPL systems can provide not only the “last mile” section, but also access to the final distribution.