ANALYSIS OF POSSIBILITIES FOR DIGITAL DATA TRANSFER USING POWERLINE

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The paper discusses application of power line modems in homes and industry. The requirements of the standard EN 50065 are explained. Problems in power line modems operation are presented. The comparison of different devices is performed. The methods for electrical isolation are described. Proposals for using electric power network for data transfer are offered.

Keywords: Power Line Modem (PLM), communications, data transfer

1. INTRODUCTION

The idea for using the powerline for data transfer has a lot of advantages: there is no need of new wires, because the existing infrastructure is used, a duplex communication is available, electrical sockets become communication sockets, the power network and home communication networks are everywhere. In high voltage networks such connection is realized long ago – there is operational telephone connection and data transfer for electric power system control organization.

Using low voltage network for digital data transfer is extremely specious – an energy management system will be easily organized, which will be combined with other systems – for home automation, security and monitoring. Electric distribution companies might offer communication services using the existing infrastructure.

In 1991 The European Committee for Standardization in Electrotechnique CENELEC (**C**omite **E**uropeen de **N**ormalization **ELEC**trotechnique) developed the standard EN 50065. There are defined general requirements, bandwidth and electromagnetic confusion in data transfer using the low voltage power network.

The countries, members of CENELEC, are allowed to use the bandwidth from 3 kHz to 148,5 kHz, which is divided to four frequency bands – A, B, C and D. Band A (9 kHz to 95 kHz) is for the electric distribution companies. The other bands B (95 kHz to 125 kHz), C (125 kHz to 140 kHz) and D (140 kHz to 148,5 kHz) are for customers but using C-band (125 kHz to 140 kHz) requires respecting the described in the standard access protocol.

2. PROBLEMS

The main problem in such modems, because of the allowed bandwidth, is the difficult signal spreading in the quite long distance. First, all providers and consumers are connected to the electric network in parallel. From the other side in the energy system structure there are a lot of substations, including transformers. The signals of

Power Line modems practically can not pass via the transformers. Additionally, in most cases the signal can not pass between the different phases of the three phase system either. To overcome this restrictions is necessary to design specialized communication devices. For the most of the cases one phase of the reducing transformer is enough, because there are enough consumers which can use the network as an environment for data transfer.

Generally, problems which have to be overcome in PL modems realization are:

Signal reducing: Electric disturbances (especially in the modern electric devices) must be rejected, but this makes worse the communications conditions. The signal reducing increases with the increasing the distance between the correspondents and the signal frequency. Very often it is big and unpredictable and might reach 100 dB/km. The signal reducing is due to:

- using X and Y capacitors in the inputs of the electronic devices. The typical values of these components are 10 – 100 nF, and this means resistance of several decades Ohms only for one device. Using switching power supplies insists on using filters, which are designed that the device does not introduce disturbances in the network – parallel capacitors too.

- capacitors for inductive component compensation. In lighting network with luminescent lamps every device must have capacitor for power factor compensation. The same is the case with the compact luminescent lamps, which include input rectifier with a great capacitor.

- all most every device (home and industrial), which use electric motors has filter capacitors in the input from the network.

Because of the signal reducing, for reliable connection is proposed including regenerators at defined distance but this leads to system complication.

Disturbances in the network: Disturbances are generated in the different consumers and electric devices operation. Home appliances, office equipment, TV sets and computers, power factor correctors, motors, inverters and etc. are disturbances sources.

The working frequency (or the low harmonics frequency) of many devices matches the frequency bandwidth of the PL modems. These are compact luminescent lamps (30-35 kHz), TV sets (15-100 kHz) and all switching power supplies (20-200 kHz). The level of the disturbances in switching power supplies is not very high because of the obligatory precautions but if the working frequency matches the modem frequency, the connection is blocked.

The devices with working frequency 50 Hz (DC motors, relays, contactors and etc.) have larger specter and bigger amplitude than the disturbances, but because the disturbances are not periodic, they cause single errors in communication in contrary to the above mentioned, which block the modem operation in frequency matching.

Electric power network parameters changing in the time:

Before introducing the PL modems in exploitation is obligatory to analyze the line and prove the reliability of the communication devices. Independently of it in turning on, turning off or replacing different devices the characteristics of the network change (in most cases rapidly) – its impedance, disturbances level and reducing and these changes are different at the different frequencies in the different moments of time. Only at separate home consumer of electric power there are decades such appliances – lamps, TV and audio sets, computer and etc.

These problems can be solved by increasing the level of the emitted by the PL modem in the electric power network signal. In the same time for the energy network and the rest devices the PL modems signal is a disturbance which must not upset the operation of the other consumers and appliances – it must complete the requirements for permissible level. All these say that real (and approximately easy) use of PL modems is available in networks with not too many branches – in country and mountain regions, in separate blocks of houses and most easily in separate consumer – after the electricity meter. In these cases is easy to add proper filters for isolating from the supplying electric network.

According to the standard EN 50065 the maximum level of the emitting signal from the communications set, connected to one phase and operating in band B (95 kHz to 125 kHz) must be less than 116 dB (1 μV) – 0,63 V.

Power Line Communication (PLC) system has to work reliably – to avoid and reject the different types of noise and to managed with the changing characteristics of the communications channel.

Most realizations give enough reliable operation of the PL modems at total length of the network 1 – 5 km, including all wires. This length might be realized with two wires just in one building. Of course, in accordance with the reasons above is more important what are the consumers, connected to the network.

3. Considerations for Field of Application

The described PL modems, matching the standard EN 50065 can not be used for high speed connections building and large amount of information transfer because of the limited frequency bandwidth. They can not be used for high reliable connection either – for fire alarm, inundation and etc., despite of that it is possible to be used as a parallel system for reserve connection. In some cases PL modems can not be used for duplex communication. Because of that all correspondents are connected in parallel (the nature of the supplying network) carefully must be chosen the way of access and transfer protocol – commonly is used one master.

Some fields of PL modems application:

1. Lighting control of parks, streets and etc.
2. Measuring devices tariff changing between summer and winter time.
3. Automation of distant control and reading the consumption of electricity, gas, heating energy, water and etc. This could be comparatively easy organized in a separate entrance, block of houses, street, hotel, little town and etc. Such system must be able to work in short communications failures. Collected by PL modems information could be transmitted in a long distance by phone, GSM, Internet and etc.

4. Distant clock setting, street lights regimes changing, advertising panels control and etc.
5. Security and alarm systems. In these cases might be permit increasing the signal level above the allowed for reliable connection. Must be paid attention that very often in average situations the electric supply fails.

4. REALIZATIONS, COMPARISON. BASIC PARAMETERS. TYPICAL SCHEMES

There are companies and associations offering communication devices using the electric power network:

ASCOM, Switzerland, (http://www.ascom.com/plc/home_plc.htm) begins investigations of the electric power network using for communications in 1997. Offers equipment and technology for communications via electric network in home and between buildings.

Domosys Corporation, Canada, (http://www.domosys.com) is established in 1994. Developed the technology PowerBus, apprpriate for homes and electric distribution companies. Offers products and software for networks for local and distant control.

Konnex Association, Belgium, (http://www.konnex.org) is established in 1999 by 9 companies. By now its members are more than 100 firms, working in the field of home and building electronic systems for monitoring, control and automation. Developed network standard KMX, based on 3 leading systems for home and building automation - EIB, EHS and BatiBus. One of the used environments is the electric network: **PL-110** (Power-line, 110 kHz, 1200 bits/s) used by EIB standard; **PL-132** (Power-line, 132 kHz, 2400 bits/s) used by EHS standard.

Intellon, Ocala, Florida, USA, (http://www.intellon.com) is established in 1989 and together with other firms is founder and sponsor of HomePlug Powerline Alliance, established in 2000 with more than 50 firms members. The aim is discussing and creating products and services specifications based on communications using home power line networking. **Intellon** develops and sells integrated circuits for powerline communications (PLC).

High Tech Horizon, Sweden, (http://www.hth.com) offers products PLM-24 for communications via electric network and transfer protocol S.N.A.P (Scaleable Node Address Protocol).

Table 1 summarizes the information for some types PLM.

In all realizations isolation from the supplying network is ensured. In some solutions are used opto-couplers, in others – transformers. There are more important differences about the place of isolation. In part of the modems the isolation is between the PL modem and the information consumer – computer, microcontroller and etc. In other cases the signal is filtered and separated from the supplying network and transmitted to the processing block of the modem by opto-coupler or transformer. In some cases for disturbances reducing there is an isolation on both places. Commonly the supply of the high voltage side, which is not isolated from the network, is without transformer using capacitor.

Таблица 1

Company	Ariane Controls	Intellon	National Semicond	ST	Echelon
Model	**AC-PLM-1**	**INT51X1**	**LM1893/LM2893**	**ST7538**	**PL3120 / PL3150**
Full name	*Powerline Modem*	*Single Chip PowerPacket™ Transceiver*	*Carrier-Current Transceiver*	*Power line FSK Transceiver*	*Power line Smart Transceivers*
Modulation	*FSK*	*OFDM*(6)	*FSK*	*FSK*	*BPSK using DSP*
Data transmission rate	*100 baud to 30,000 bauds*	*Up to 14 Mbps*	*Up to 4.8 kBaud*	*600 to 4800 Baud*	*5.4 kbps* *3.6 kbps*
Carrier frequency	*50 to 500 kHz*	-	*50 to 300 kHz*	*8 programmable frequencies (60; 66; 72; 76; 82,05; 86; 110; 132,5 кHz)*	*132kHz (115kHz secondary) for C - band; 86kHz (75kHz secondary) for A - band;*
Connection type	*Half-duplex*	-	*Half-duplex*	*Half-duplex*	
Protocol	-	*HomePlug 1.0*	-	-	*LonTalk*
Interface	*SPI or paralell*	*USB1.1;* *MII PHY / GPSI;* *MII Host / DTE.*	*UART*	*Programmable:* *- synchronous* *- asynchronous*	*UART and SPI*
Supply	*3,3 V*	*3,3V*	*13 V*	*7.5 to 12.5V*	*5V*
Additional functions	*MAC*(5) *logic;* *Packet-priority management;* *FEC*(3)*;* *CRC*(7)*.*	*56-bit DES Link Encryption;* *MAC CSMA/CA;* *ARQ.*	*ALC*(1)*;LCD*(4)	*CARRIER DETECTION;* *ALC*(1)*;* *Watchdog;* *PLI*(2)	*FEC*(3)*;* *embedded EEPROM;* *Power Management;*

(1)ALC - Automatic Level Control; (2)PLI - Power Line Interface; (3)FEC - Forward Error Correction; (4)LCD - Line Carrier Detection; (5)MAC - Medium Access Controls; (6)OFDM - Orthogonal frequency-division multiplexing; (7)CRC – Cyclic Redundan Cheching

On fig. 1 is shown PLM realization with transformer isolation and on fig. 2 is shown realization without isolation of the specialized integrated circuit. In some cases the isolation is done in the modem itself. Such is the modem HCPL-800J, where is used isolation with opto-couplers [6,7].

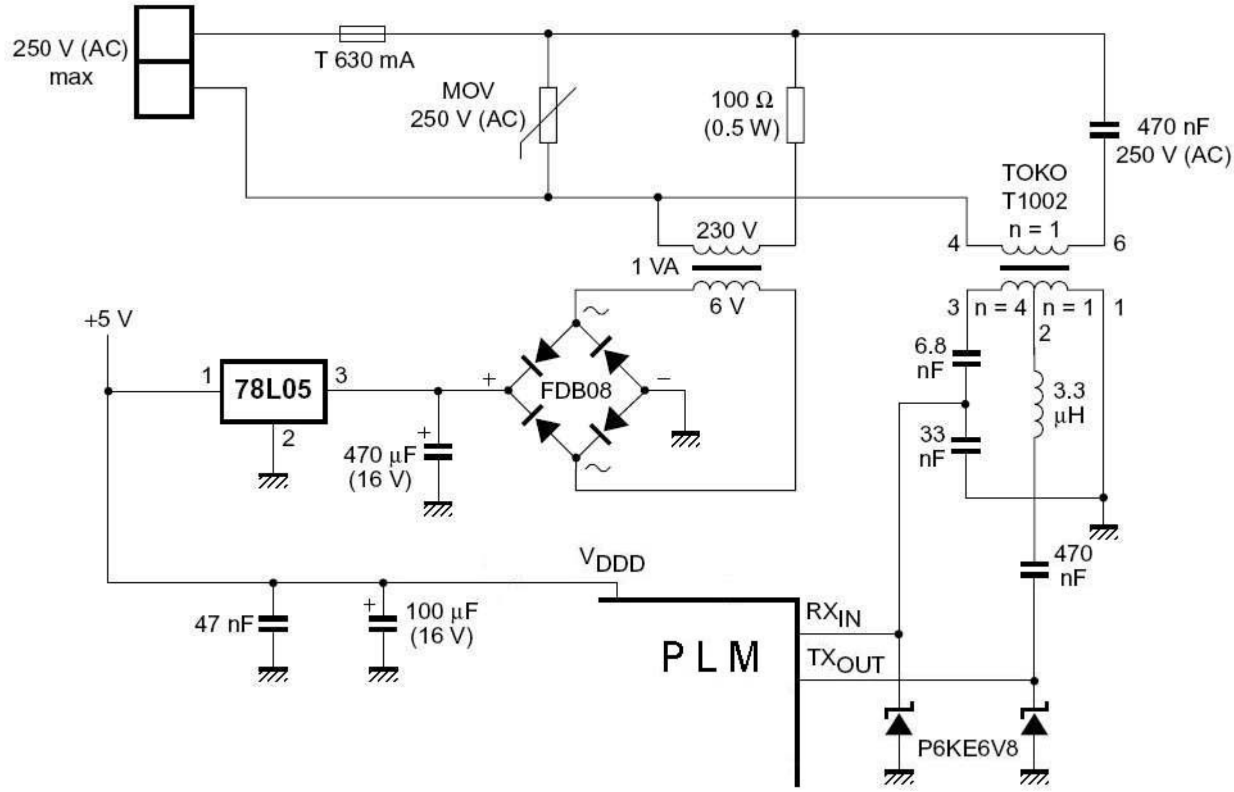

fig. 1.

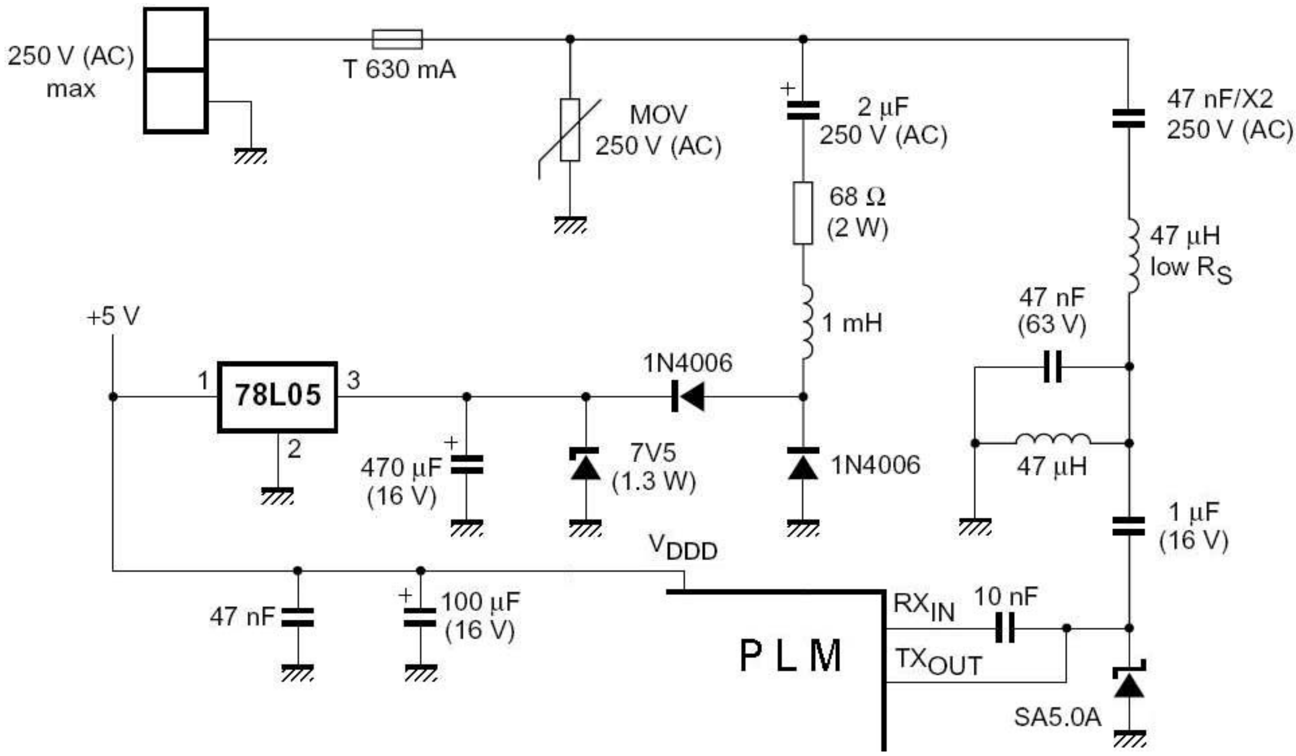

fig. 2

The typical input scheme of PLM includes limiting and secure components and filters. The filters are wide band and the real filtering is realized by the chosen methods for modulation and demodulation. For the purpose in some models are used DSP.

5. CONCLUSION

Using PL modems is connected with a lot of limitations and problems. The comparison between them and wireless communications (Wireless, Bluetooth, ZigBee) shows the advantage of the last. The disadvantage of the wireless – short distance of reliable work is a disadvantage of the PL modems too although they can operate up to 5-10 km.

The pointed advantage for simplicity and low price of PLM is not strong because of the lowering prices of the wireless communications devices.

The application of the PLM might be in devices with direct connection to the power network – electricity meters, tariff clocks and etc. and in the places with not good radio signals spreading – electric housings, metal cabinets, underground devices and etc. The type of modulation and the way of message transfer are of great importance. More efficient will be debugging codes. The possibility for changing the frequency in disturbance matching will have a good effect.

They could be used for long distances in the open (irrigate and other systems) where there are not many electric consumers and the disturbances level is lower.

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