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THE ROLE OF POWER LINE COMMUNICATION IN RURAL AREA

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Abstract- Power Line Communication (PLC) is recent and rapidly evolving technology, aiming at the utilization of the electricity power lines for transmission of data. PLC is considered an attractive system because it can reach more homes than coaxial cable systems or telephone lines. PLC can provide cost effective connectivity solution also known as third wire technology.The Power Line has been extensively studied as the media for high frequency signal transmission for use as a communications environment. In recent years, development of several power line communications protocols, namely X-10, CEBus and LonWorks, renewed.This seminar targets to study the evolution of powerline communication, the available technical benefits of PLC for non supplied rural areas and also studies the comparision of power line communication technology with other existing relevant technologies for communication.Power line communication (PLC) leverages the existing power line infrastructure and provides cost-effective approach for introducing intelligent monitoring and control to many industrial applications. It makes PLC one of the leading enabling technologies for Smart Grid applications ranging from smart metering, lighting control, solar, plug-in electrical vehicle home and building automation of heat and air conditioning, and security.

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Introduction

Power Line Communications (PLC) is the use of existing electrical cables to transport data, and it has been around for a very long time. The greatest advantage of power lines as communication media is its reach to customers. Power utilities have been using this technology for many years to send or receive data on the power grid using the existing infrastructure. More recently, the development of home automation (the current notion of smart houses) and car automation (cutting cable costs and weight, and networking the devices in-car) has pushed the use of low bit rate PLC techniques with technologies such as X10 or Lon Works[10].

Power line communication or power line carrier (PLC), also known as Power line Digital Subscriber Line (PDSL), mains communication, power line telecom (PLT), or power line networking (PLN), or Broadband over Power Lines (BPL) are systems for carrying data on a conductor also used for electric power transmission. Electrical power is transmitted over high voltage transmission lines, distributed over medium voltage, and used inside buildings at lower voltages.

The emerging PLC technology opens up new opportunities for the mass provision of local access at reasonable cost. It can applicable to remote and rural areas and in addition power line communication can provide a multitude of new services to the users which are difficult to implement by other technologies, e.g. remote electricity meter reading, appliances control and maintenance, energy management, home automation etc.

Principle

The technology consists in superimposing two signals of different frequencies-

- A signal of 50 Hz that provides supply to electrical equipment.
- A signal of higher frequency to enable data transfer.

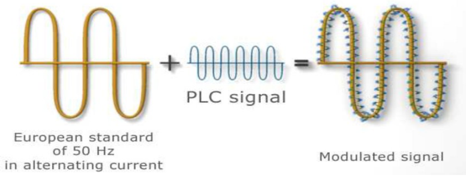


Fig. 1-Signal

The above diagram shows that by superimposing these two signals, we obtain a modulated signal. The modulated signal enables the transfer of information without disrupting the transfer of electrical current [1]. In above figure, the PLC signal which is high frequency signal acts as carrier signal. Modulation Techniques such as Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Spread Spectrum Modulation, Orthogonal Frequency Division Multiplexing (OFDM) etc. can be applied in Powerline Communication.

Conditioning Unit

The Conditioning Unit (CU) for the Digital PowerLine Network is placed near the electric meter at each customer's home. The CU uses band pass filters to segregate the electricity and data signals, which facilitate the link between a customers premise and an electricity substation.

The CU contains three coupling ports. The device receives aggregate input from its Network Port (NP). This aggregate input passes through a high pass filter. Filtering allows data signals to pass to a Communications Distribution Port (CDP) and a low pass filter sends electric signals to the Electricity Distribution Port (EDP)[2].

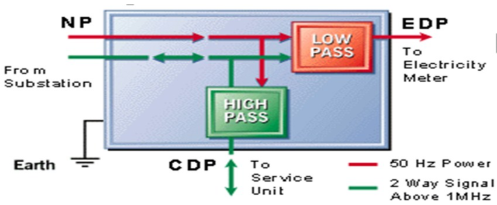


Fig. 2-Conditioning Unit

The 50 Hz signal flows from the low pass filter, out of the EDP and to the electricity meter. The low pass filter also serves to attenuate extraneous noise generated by electrical appliances at the customer premises. Left unconditioned, the aggregation of this extraneous noise from multiple homes would cause significant distortion in the network.

The high pass filter facilitates two way data traffic to and from the customer premise. Data signals flow through the CDP to the customer's service unit via standard coaxial cable.

PLC Components

PLC network components may vary according to different commercial solutions. Most common elements include-

PLC Modem

The power line modem uses the power line cable as communication medium. It is convenient as it eliminates the need to lay additional cables. The modem at the transmission end modulates the signal from data terminal through RS-232 interface onto the carrier signal in the power line. At the receiving end, the modem recovers the data from the power line carrier signal by demodulation and sends the data to data terminals through RS-232 interface. Inject data communication signals over wire network and/or connect customer's PC on the network.

Bridges

Bridges are used to interconnect PLC network with backbone provided by fiber (SDH) or satellite.

Repeaters

In case of long distance connections such as PLC backbone, signal regenerators must be used to reinforce signal levels.

Coupling devices

Data communication signals may not surpass HV-LV transformers. This device bypasses the signal to the other level of electric network.

Home gateway

Optional device used according to the PLC provider should be installed in the meter board of user's house.

Evolition of powerline communication

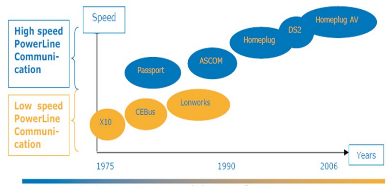


Fig. 3-Protocols

As shown in above figure, there are different protocols in power line communication such as X10, CEBus, Lonworks, Passport, ASCOM, Homeplug, DS2, Homeplug AV etc. In which X10, CEBus, Lonworks are Low Speed Powerline Communication and Passport, ASCOM, Homeplug, DS2, Homeplug AV are High Speed Power Line Communication.

Advantages	PLC low speed	PLC high speed
Reduction in wiring	Utilized on the existing electrical network	Utilized on the existing electrical network
High performance technology in several applications	Control command for housing or business buildings	sharing of multimedia data
Standardization	NF EN 50065	in progress
Distance of communication	several kilometers	a few tens of meters

X10 Protocol

The X-10 technology is one of the oldest power line communications protocol and uses a form of Amplitude Modulation (ASK Modulation) to transmit information. Although it was originally unidirectional (controller to controlled modules) recent developments indicate that some bi-directional products are being implemented.

X10 protocol consists of a four bit house code followed by one or more four bit unit code, finally followed by a four bit command. For the convenience of users configuring a system, the four bit house code is selected as a letter from A through P while the four bit unit code is a number 1 through 16. When the system is installed, each controlled device is configured to respond to one of the 256 possible addresses (16 house codes × 16 unit codes); each device reacts to commands specifically addressed to it, or possibly to several broadcast commands[3].

The protocol may transmit a message that says "select code A3", followed by "turn on", which commands unit "A3" to turn on its device. Several units can be addressed before giving the command, allowing a command to affect several units simultaneously. For example, "select A3", "select A15", "select A4", and finally, "turn on", causes units A3, A4, and A15 to all turn on.

Limitations

Compatibility

X10 controllers with triac solid-state outputs may not work well or at all with low power devices (below 50 watts) or devices like fluorescent bulbs that do not present resistive loads, due to the small leakage current of the device and any protective filtering around the triac.

Wiring and interfering sources

One problem with X10 is excessive attenuation of signals between the two live conductors.

Commands getting lost

X10 signals can only be transmitted one command at a time, first by addressing the device to control, and then sending an operation for that device to perform. If two X10 signals are transmitted at the same time they may collide or interleave, leading to commands that either cannot be decoded or that trigger incorrect operations.

Relatively slow

The X10 protocol is slow. It takes roughly three quarters of a second to transmit a device address and a command.

Limited functionality

X10 protocol does support more advanced control over the dimming speed, direct dim level setting and group control (scene settings).

Interference and lack of encryption

The standard X10 power line and RF protocols lack support for encryption, and can only address 256 devices. Unfiltered power line signals from close neighbours using the same X10 device addresses may interfere with each other.

CEBus Protocol

In 1984, members of the Electronic Industries Alliance (EIA) identified a need for standards that included more capability than the defacto home automation standard X10. X10 provided blind transmission of the commands ON, OFF, DIM, BRIGHT, ALL LIGHTS ON, and ALL UNITS OFF over powerline carrier, and later infrared and short range radio mediums. Over a six year period, engineers representing international companies met on a regular basis and developed a proposed standard. They called this standard CEBus (pronounced "see bus"). The CEBus standard was released in September 1992.

The CEBus protocol uses a peer-to-peer communications model so that any node on the network has access to the media at any time. To avoid data collisions, it uses a Carrier Sense Multiple Access/Collision Detection and Collision Resolution (CSMA/CDCR) protocol.

The CEBus standard includes such things as spread spectrum modulation on the power line to overcome narrow band impairments in communication medium. Spread spectrum involves starting a modulation at one frequency, and altering the frequency during its cycle. The CEBus power line standard begins each burst at 100 KHz, and increases linearly to 400 kHz during a 100 microsecond duration. Both the bursts (referred to as "superior" state) and the absence of burst (referred to as the "inferior" state) create similar digits, so a pause in between is not necessary. CEBus based products consists of two fundamental components a transreceiver and microcontroller. This protocol uses the spread spectrum carrier technology[4].

LonWorks Protocol

LonWorks technology is available as an open standard to all manufacturers with open and highly distributed architecture. Lon Works technology makes possible information based control systems, rather than old style command based systems. LonWorks is a technology developed by Echelon Corporation and provides a peer-to peer communication protocol, implementing Carrier Sense Multiple Access (CSMA) techniques LonWorks is a narrow band spread spectrum modulation scheme (125-140 kHz, BPSK), that uses a multi-bit correlator intended to preserve data in the presence of interference noise[5].

LonWorks technology provides the concept of network variables, which makes it easy for manufacturers to design devices which can incorporate readily into information based control system. the advantages of using LonWorks protocol is compatibility, easy to use, reduced wiring costs, reliability and easy to implement new functionality.

Passport and Plug-in PLX Protocol

It is first protocol used in High Powerline Communication. Passport protocol realises on Frequency Shift keying (FSK) to send data back and forth over the home electrical wiring. FSK uses two frequencies, one for 1's and other for 0's, to send digital information between computers on network.

Limited functionality, Data needs to be encrypted for secure network these are the limitation using passport protocol.

DS2 Protocol

DS2 is the leading technology innovator and a global provider of high-speed semiconductor solutions for Powerline Communications and other wire-line network communications products. DS2 invented high-speed Powerline Communications delivering the first 200 Mbps Powerline Communications IC to enable quality multimedia home networking, networked entertainment and broadband access applications to and throughout the home, office, or building, and to and throughout urban and rural communities.

Homeplug Protocol

Home plug protocol is used in High Speed Powerline Communication. Home Plug protocol uses Physical Layer Protocol based on equally spaced, 128 carrier Orthogonal Frequency Division Multiplexing (OFDM) from 0 Hz to 25 Hz. BPSK, DBPSK,DQPSK techniques are used in powerline communication using homeplug protocol. Homeplug PHY occupies the band from about 4.5 to 21 MHz. This includes reduced transmitter power spectral density in radio bands to minimize the risk of radiated energy from line interfering with these systems. HomePlug AV is the next generation of powerline technology. HomePlug AV will provide a convenient and cost effective method of distributing HDTV in the home without new wires.

The role of powerline communication in rural area

The strengthening of rural communication services is an important ingredient for the welfare and development of rural India as it has many advantages such as-

- It helps in access to health care and other allied services in the time of urgency.
- It gives timely information on business, price, market, and demands within few minutes and that to paying a very small amount of price.
- It helps in better coordination for delivery of administration and public services including health, education, etc.
- It provides information about employment and generates opportunities to women and underprivileged people regarding self employment and income resources.
- It interacts with neighbouring market regarding business expansion and creates more job opportunities in the local market.
- It creates an atmosphere of national and regional integration, economic diversification, employment, and promotes socio-cultural relation.
- It also opens gateway to the foreign participants in rural sector and establishes a spirit of competitiveness with the Indian players in development of rural infrastructure and economy.
- Besides, in the present era of information technology, the telecom services are important for all round development of the society.

Though about 70 per cent population of India live in the villages and rural areas account for about 30 per cent of the gross domestic product (GDP), the development in this sector is far from satisfactory. The teledensity in rural areas is only 1.14 against 10.16 in the urban areas.

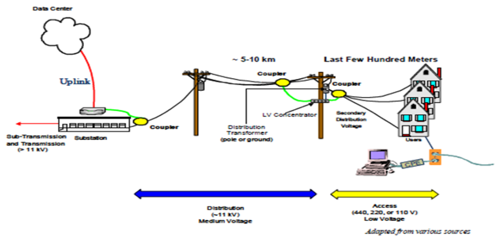
Deployment Techniques

Typical deployment

PLC in High Voltage- High-voltage lines (155,000 to 765,000V) is a very noisy environment to data transmission. The amount of power can cause interference in all PLC frequency spectrum.[6] For rural application this options is practically unfeasible. High voltage lines require high investments in towers, substations and high-quality materials. Usually HV networks can be equipped with fiber optics in the top of the structure, as electric storm protection and a solution for broadband backbone.

PLC in Medium Voltage- Medium Voltage (7,200 V) access is pointed as the most important configuration to assure time to market and roll-out economics due to cost and delays compared to fiber optics and other backbone alternatives. One of the substations must be connected to the main backbone (WAN link) and repeaters needs to be installed to assure signal through the distances. According to a PLC report, field tests for MV lines provided throughputs of up to 45 Mbps (27 Mbps downstream and 18 Mbps upstream) over a distance of 600 m.

PLC in Low Voltage- Uses the low voltage grid to connect the household to the network. Basically three main elements are used in this network- Head-End, Repeater and CPE. The head-end is located at the LV substation, where the data communication signal is injected. The repeater expands the coverage according to network size and other grid characteristic. CPE (Customer Premise Equipment) is a PLC modem that makes the interface from powerline to user's LAN.



Hybrid deployment

- **Fiber and low voltage PLC-** Similarly to the HFC (Hybrid Fiber Coax) concept from cable TV operators [7], Fiber and LV can compose a hybrid solution feasible to rural areas. Some electric networks (MV and HV) are equipped with fiber optics from its construction, connecting poles to substations. Telecommunication companies also own fiber optics rings that can connect to LV grid in the nearest point of the rural area. This configuration solves the problem of the low bandwidth of the pure PLC backbone, since fiber have a higher and upgradable capacity. Disadvantages of this configuration lie in the economical inefficiency caused by optical equipments, since the number of potential users in rural zones tends to be small. Even with high-speed services possible with fiber-optics, PLC last mile will limit the connection.
- **Medium voltage and low voltage (All PLC)-**In this architecture signals are fully transmitted over powerlines. In the connection point between MV and LV grids, is necessary the installation of a bypass-transformer device. Transformers are designed to operate in electric signal frequencies (50 or 60Hz) and blocks higher frequencies [7]. Advantages of this configuration for rural areas are the full use of existing infrastructure. The bypass device can represent additional cost to rural areas, since a small group of costumers requires one transformer. So, the ratio bypass device per user tends to be high.
- **Medium voltage and wireless-** This architecture uses wireless technologies to replace LV PLC connections. MV lines is used as backbone, delivering connection to rural "hot-spots" composed by Wi-fi or Wimax or other existent RF technologies. This configuration can be a good solution for rural areas with some degree of concentration of users, such as small villages with schools, commerce and residences. Advantages are small risk of interference from MV network than LV and the natural robustness of MV grid. Problems are the possible cost of antennas and wireless equipments. Also, Wimax coverage can reach a high number of users in rural areas, making the broadband provided by MV lines possibly not enough (45Mbps) according to PLC vendor Amperion (USA).
- **Low voltage and Satellite-** in order to connect more remote users where fiber and MV repeaters becomes critical, satel-

lites connection can be considered as backbone providers. Advances in satellite technology and related ground equipment appear to offer the potential to connect remote communities to backbone services, with savings accruing if these costs can be shared through the LV connections. The last few years have seen Very Small Aperture Satellite Terminals (VSATs) and IP-related satellite services become significantly cheaper.

Rural Broadband Analysis Model

In order to explore the feasibility of PLC to rural areas, it is important to define a model that can explain the characteristics of the environment. First, it is common sense that broadband can play a key role in the development of a region, providing basic voice, market prices and weather, agricultural practices, distance learning, telemedicine and so on second, the population and number of villages located in rural areas are huge, representing a considerable demand especially in South Asian countries. India, for example, has 70% of its population living in 600,000 rural villages with telephone and internet penetration lower then 11 and 1.5% respectively .Third, rural zones are areas where population is high, but paying capacities are very low, as well demographic density. At same time revenue potential is low and network complexity high. Indeed, primary requirement of building rural telecommunication is keeping the cost as low as possible. Rural areas represent a challenge for both telecommunication and energy networks[8]. Taking rural India as example, statistics estimates that about 43.5% of rural homes are connected to electrical grid and up to 96,000 villages are still to be electrified. From this number, 20,000 villages are considered difficult access areas, which are recommended the use of alternative energy supply like photovoltaic cells. For this group, PLC is not a feasible broadband option and represents an exception in the possible applications, unless for the indoor residential networking. On the other hand, increment on electrification demand rate of 9% in India is motivating village electrification programs that can potentially carry broadband signals.

A-BARD (Analysing Broadband Access for Rural Development) is a Coordination Action that is researching rural broadband provision and use. A-BARD is continuously identifying views on the issues and barriers to widespread broadband provision and the extent to which broadband can act as an external driver of change in rural economies[9].

A-BARD developed a typology method in order to categorize or measure different features for rural broadband provision. The objective is to identify the size of rural markets and the nature and possible extent of rural broadband solutions. Also provide local rural interests with intelligence and reasons to initiate local broadband infrastructure deployment. A-BARD studies so far do not consider PLC technologies as a potential solution. In fact, there are a very low number of PLC applications in use and most of the industry efforts are concentrated in new commercial applications of the technology.

Comparision of PLC with other relevent technologies

There are several alternative technologies, beside PLC for data communication and services. Each technology has its own strength and weakness. A state of art comparision between PLC and other Relevent Technologies are as follows-

Technologies	Merits	Demerit
Public Switched Telephone network (PSTN)	Mature and Robust, good installed based, wide choice of product, easy to use and install, relatively cost effective.	Relatively slow, on demand only
Integrated Service Digital Network (ISDN)	Mature and robust, Widely available	Expensive for consumer market, on demand only
Cable Modem	Excellent Performance, permanently on line	Limited geographical coverage, currently only available in limited trial, connection based.
Microwave Communication	good geographical coverage, Superior Performance, Flexible Configuration	costly compared to PLC, Coverage not Wide as PLC
Powerline communication	Good Performance, Existing infrastructure, permanently on line, good geographical coverage.	Still at Development stage.

Applications

PLC is widely used in the Smart Grid and in micro-inverters. As the market gets familiar with this technology, PLC should see wider adoption in other applications like lighting (e.g. traffic light control, LED dimming), industrial (e.g. UPS communicating to a network device, irrigation control), machine-to-machine (e.g. vending machines, a hotel's reception-to-room communication), telemetry (e.g. offshore oil rigs), transport (e.g. Electronics in cars, trains and airplanes) and indeed, applications of PLC are only limited by one's creativity and also Broadband Over Powerline Brings Smart Grid to Rural Areas.

The generally used applications of PLC are as mentioned below-

- Home Automation
- Car automation
- Remote Electricity Meter Reading
- Energy Management
- E-Learning

Conclusion

As PLC is cost effective, permanently online and more feasible than other relevent techniques.Plc can play a key role in the development of rural area by providing basic voice, market prices and weather, agricultural practices, distance learning, telemedicine etc. Power Line Communications (PLC) is a promising emerging technology, which has attracted much attention due to the wide availability of power distribution lines. PLC is an important alternative to be considered for providing broadband access to remote areas. Even though there are still a limited number of cases for metropolitan and rural applications, Efforts on standardization and strong incentives from utilities companies are empowering the future for PLC

References

[1] Powerline Communication. *http://www.wirecom-tech.com*

[2] http://www.iplcforum.org (2007)

[3] Dave Rye, *Technical note, Revision* 2.4, X-10.

[4] Grayson Evans, *CEBus Communication standard.*

[5] *LonWorks Technology Overview*, Technical Document, Echelon Corporation.

[6] Singh S.M. *Broadband Over Power Lines A White Paper*,

http://www.state.nj.us/rpa/BPLwhitepaper.pdf.
[7] Atsumasa Sakai (2003) *Internet Service over Power Lines in Japan: Costs and Policy Implications*, *http://itc.mit.edu/itel/students/papers/Atsu_thesis.pdf* .
[8] Dutta P. (2007) *Bell Labs Technical Journal*.
[9] A-BARD (2006) D3.3 - *Second Rural Region with detailed typology mapping.*
[10] Majumder A., Caffrey J. (2004) *IEEE Potentials*, 23, 4-13.