BROADBAND OVER POWER LINES (BPL)

FOR

INDIAN TELECOM NETWORK

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Abstract

In this paper various aspects of Broadband over Power line (BPL) in Communication Network have been presented. The objective of this paper is to highlight the BPL access technology in term of features, working, drawbacks, deployment & future challenges, advantages and scope etc. BPL is now a growing communication network technology which is quite fast hitting the competitive market of broad band internet services in international telecom environment. In addition, value added services like internet, voice, video applications etc. can also be provided by BPL. Broad band over power lines may also be an effective viable alternative for providing broadband in India. BPL technology has evolved rapidly over the past few years. This has been possible due to world wide technological developments and innovations on broadband over power lines.

Keywords: **Broadband, Internet Access, Power-line, Power-Line Communications, Communication Network.**

1.0 Introduction

The basic concept of this technology is that it offers high speed internet access to our homes through the commonly accessible electrical paths, thus eliminating the need of transmission of data over last mile through copper cable, short haul satellite systems, optical fibre cable and wireless technologies such as Wi-Max, Wi-Fi etc.

In BPL technology, by combining the technological principles of Radio, wireless networking, and modems, a mechanism has been created where one can plug in his computer into any electrical outlet in his home to have instantaneous access to high speed internet.

BPL uses the existing power grid infrastructure to provide high-speed, broadband Internet access to homes and businesses. It is a new innovation based upon existing Power-Line Communications (PLC) technology.

2.0 Background and current trends

2.1 Past BPL trends

Using power lines for telecommunication is very old and traditional, the term ‘Power Line Carrier (PLC)’ has been used to refer to the use of electrical lines as a medium for telecommunications.

Electric companies have deployed technologies such as SCADA (Supervisory Control and Data Acquisition) over powerlines to perform simple command/control functions at remote locations, such as sub-stations, using the electric transmissions lines as the medium.

Electric company linesmen have also used the transmission lines by tapping the wire with specialized radios for communicating with each other along through the line. On a smaller scale, in-home intercom systems have been available for many years that use the electric lines of the building to deliver audio data over the buildings electrical lines.

These historical uses of power-line communication typically operated at low frequencies, generally below 600 kHz. Modulation techniques vary for traditional PLC, from FM to Wideband. While the technology appears promising, there are a number of issues with respect to its operation as well as the possibility of it interfering into radio services in other frequencies range.

2.2 Kind of available Broadband Access Technologies

Internet access Network Technologies								
Network type	Wired					Wireless		
	Optical	Coaxial cable	Twisted pair	Phone line	Power line	Unlicensed terrestrial bands	Licensed terrestrial bands	Satellite
LAN	Ethernet	G.hn	Ethernet	HomePNA G.hn	G.hn HomePlug Powerline Alliance	Wi-Fi Bluetooth DECT Wireless USB	-	-
WAN	PON Ethernet	DOCSIS	Ethernet	Dial-up ISDN DSL	BPL	Muni Wi-Fi	GPRS iBurst WiBro/ WiMAX UMTS-TDD, HSPA EVDO LTE	Satellite

(Table 1: Source Wikipedia 2011)

2.3 Current Status of BPL in the World

A number of foreign governments including USA, Australia, Austria, China, Finland, Hong Kong, Hungary, Ireland, Italy, Korea, Japan, Netherlands, Poland, and Switzerland are currently studying BPL technology or have permitted equipment trials. The outcomes have shown mixed results and have led some administrations to ban BPL systems while other administrations have allowed deployment under various conditions. A number of administrations have suspended BPL trials pending international developments.

2.4 BPL deployment in India

Many rural residents and rural entrepreneurs in India don't have access to DSL, FTTX, Wireless, cable or other telephone medium. But mostly rural users in India have the power lines. BPL technology is desirable option for those residents who want to get broadband service. On the urban side, BPL may be used as another cheaper technology for broadband services. BPL for broadband application may be considered an effective and less costly solution as access network. The Broad Band Over Power Line communication network technologies are new for Indian telecom network and will grow extensively in near future.

3.0 BPL Main Features

Many powerline devices use Othogonal Frequency Division Multiplexing (OFDM) to extend Ethernet connections to other rooms in a home through its power wiring. Adaptive modulation used in OFDM helps it to cope up with such a noisy channel as electrical wiring. Accepted international standard ITU-T G.hn for high speed local area networking over existing home wiring (power lines, phone lines and coaxial cables) uses OFDM with adaptive modulation and Low Density Parity Check (LDPC) FEC code. Thus PLC technology based on OFDM technique with adaptive modulation is quite consistent with envisaged ITU standards regulating BPL functioning.

In order to achieve high bandwidth levels, BPL operates at higher frequencies than traditional power line communications, typically in the range between 2 and 80 MHz. The modulation technique of choice for BPL is Orthogonal Frequency Division Multiplexing. OFDM is superior to Spread Spectrum or Narrowband for spectral efficiency, robustness against channel distortions, and the ability to adapt to channel changes.

4.0 BPL Architecture

A BPL General Architecture and Schematic has been shown in fig.1. Various network components have been indicated in the diagram between Broadband OFC Media Backbone/Wireless Media Backbone to User's work station.

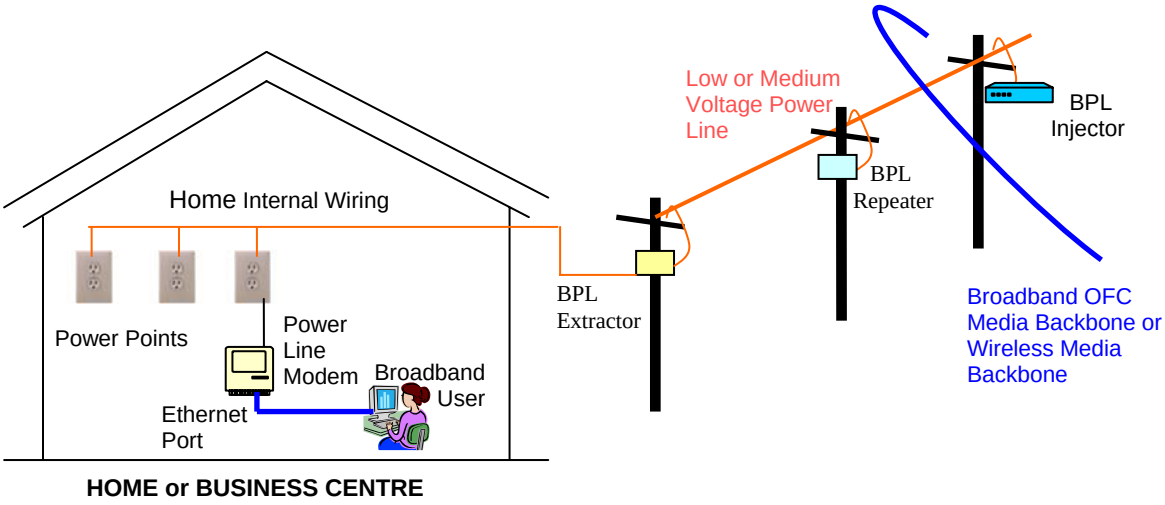

Fig 1: BPL General Architecture and Schematic.

5.0 BPL Working

Broad band over power lines uses Power Line Communications (PLC) technology to provide broad band internet access over ordinary power lines. A computer (or any other device) would need only to plug a BPL “modem” into any outlet in an equipped building to have high speed internet access in this case.

Internet signals using a fibre are dropped at medium voltage using a device called “ head end” Once the data is dropped onto the medium voltage lines, it cannot travel too far before it degrades. To overcome the problem of degradation of data before it reaches its final customer destination in a healthy condition, special devices which act as repeaters are installed on the medium voltage lines to amplify the data for further smooth transmission. Finally internet is accessed by the end user using the plug in BPL modem.

5.1 The function of BPL Modems

BPL modems use silicon chipsets specially designed to handle the workload of extracting data out of an electric current. These modems are capable of handling power noise on a wide spectrum. BPL modems are roughly the size of a comon power adapter and plugs into a common wall socket and an ethernet cable running to computer finishes th connection. There are various approaches available as far as last mile solution for BPL is concerned. While some carry the signal in with electricity on the power line, others use wireless links on the poles to send the data wirelessly into the homes. The BPL Modem simply plugs into the wall and then into subscribers computer. These modems are capable of speeds comparable to DSL or cable modems.

5.2 Power Line Communication (PLC) Technology

BPL systems function by coupling radio frequency energy to the existing electrical power lines. For deliverance of high speed data communication to customers, technology is based on high density advanced modulation using Othogonal Frequency Division Multiplexing (OFDM) modulation technique. To ensure that download and upload speeds are customer specific, data transmission is made configurable. The system is capable of working in the frequency band of 10-30 Mhz, amidst harmonics and distortions in the supply on line so that problems of noise and power quality do not arise. The strength of signal should not be less than 30 dB in any case throughout the network. This is achieved by optimizing the usage of repeaters.

PLC communication technology uses High Density Advanced Modulation at each sub carrier of the OFDM signal. It uses the highest number of sub carriers (1536) for any technology used in any wire communications at each of the possible operation modes (10, 20 and 30 MHz). In this technology a modulation density of 2to 10 bits per sub carrier is added. This technology ensures highest quality communications even in the face of interference and this is particularly achieved by adapting number of bits for each and every carrier in real time to obtain high reliability and maximum performance. The number of bits to be adapted for each and every carrier depends upon the condition of the transmission medium and the signal received. As a consequence of using high density

configurations, PLC delivers speeds of up to 200 Mbps throughout data journey for bandwidth hungry applications like BPL.

PLC is based on OFDM technique mainly because of immunity of OFDM towards interference which is an issue of serious nature encountered while transmitting data over mediums such as power lines. OFDM is not a new modulation technique and is being used in many other communication systems such as ADSL, VDSL, DAB, DVB etc. Besides, implementation of OFDM modulation in PLC results in highest level of spectral efficiency and performance of any wireline communication technology in the market.

5.3 OFDM Modulation

Orthogonal frequency-division multiplexing (OFDM) is a frequency multiplexing scheme utilized as a digital multi carrier modulation method. In this technique, a large number o closely spaced orthogonal sub carriers are used to carry data. The data is further divided into several data cannels, one for each sub carrier. Each sub carrier is then modulated with a conventional modulation scheme. Low symbol rate helps in maintaining total data rates similar to conventional modulation schemes in the same range of bandwidth.

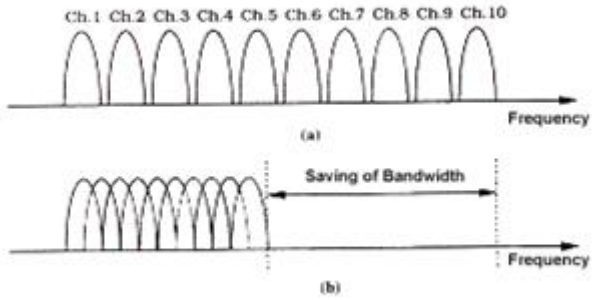

Fig 2: OFDM spectrum with 10 carriers

The orthogonality of sub carriers in OFDM scheme enables it to achieve distinct advantages over conventional modulation schemes in that it eliminates serious issues of cross talk and interference between sub channels. Besides, inter carrier guards are not required in OFDM scheme. OFDM technique has acquired added significance in broad band internet access because of its ability to deal with issues of attenuation of high frequencies, narrow band interference and frequency selective fading. The overriding

feature of OFDM is that in this technique many slowly modulated narrow band signals rather than one rapidly modulated wide band signal is used and this helps in simplification of channel equalization.

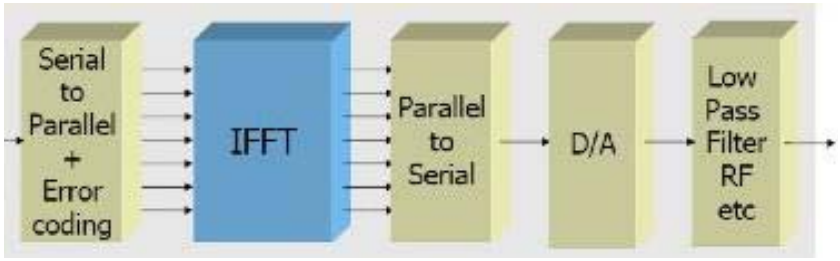

Fig 3: OFDM Transmitter Block Diagram

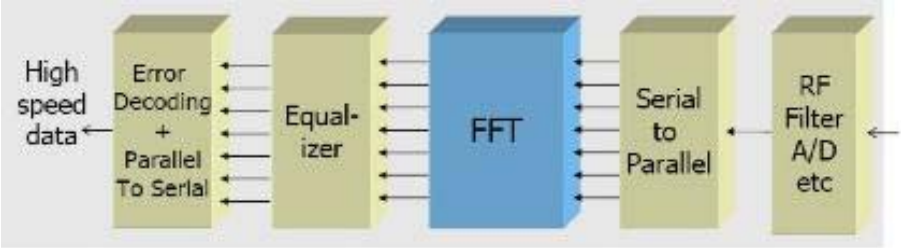

Fig 4: OFDM Receiver Block Diagram

6.0 Advantages of BPL over other connections

Wide, spread and extensive infrastructure that is already available in remote areas in terms of electrical cables allow easy access to internet with relatively very little equipment investment, particularly in areas where limitations in terms of having a cable or DSL connections are experienced by service providers. Maintenance costs of BPL are also extremely low. In nutshell, cost effectiveness and large scale broadband penetration are two distinct and unique advantages of BPL. In addition, installation time is less than 45 minutes and rural penetration is relatively easy.

BPL is a good solution for Home Networking than other available solutions as no other infrastructures is required.

Access BPL systems have the potential in increasing the availability of broadband services to homes and businesses.

BPL systems have been increasing the competitiveness of the broadband services market.

BPL systems have also been identified as a means of improving the quality and reliability of electric power delivery and creating a more intelligent power grid. BPL technology could allow utilities to more effectively manage power, perform automated metering and monitor the existing power grid for potential failures.8

7.0 International Standardization

Interoperability that ensures that products from different vendors work well together to create healthy competition in the marketplace, accelerate technical innovation and ensure that customers get the best products at the best price has been one of the key issues confronting the power line industry. Unfortunately, incompatible PHY/MAC standards led to the creation of multiple industry alliances.

However, realizing that an altogether different approach was needed to address the issue of interoperability in a comprehensive manner, a number of companies started an effort inside ITU-T to create a unified G.hn networking standard that would bring three key advantages;

a) Would unify the power line networking industry and resolve the interoperability problem.
b) Would unify the power line, phone line and coaxial networking industries to create single market.
C) Would be “Next Generation Standard” that would bring performance levels significantly higher than what is available today.

In a landmark development, on Dec 12th 2008, ITU-T announced the adoption of draft G.hn standard (now officially called G.9960) as the international standard for networking over power lines, phone lines and co-axial cable. The very fat that ITU-T G.hn’s single-PHY/MA architecture ensures full multi vendor interoperability, and the fact that the same standard can operate over multiple wires (power lines, phone lines and coaxial

cable) is expected to make G.hn as the dominant and acceptable standard for wired home-networking industry.

8.0 Issues, Challenges, Uncertainties and Drawbacks

Because of enormous variations in the physical characteristics of the electricity network and virtual absence of international standards make the provisioning of service far from being standard and a repeatable process. Besides, the amount of bandwidth that a BPL system can provide compared to cable and wireless is in question. The issues being faced by BPL is that power lines are inherently very noisy due to high energy that they carry. Thus, turning on or off every time of any electrical device introduces a click into the line. And this becomes quite predominant in case of enegy saving devices which introduce quite noisy harmonics into the line. The system has thus to be designed to effetively deal with these natural signalling disruptions.

Another major issue is signal strength and operating frequency. The system is expected to use frequencies of 10 to 30 MHZ. Since power lines are unshielded and act as antennas for the signals they carry, they have to interfere with short wave radio frequencies over which BPL operates. And this interference becomes quite perceptible in cases where the antennas are physically close to the power lines. However, this interference considerably diminishes and is barely perceptible where the antennas are moderately separated from the power network.

It is not yet clear completely that the deployment of operational BPL systems will not cause other problems like:

(i) Compatibility problems with other users of the radio spectrum,
(ii) RFI related issues with other users of the spectrum,
(iii) Signal attenuation,
(iv) Signal boosting and repeater design,
(v) Coordination among Telecom & Power service providers,
(vi) Security issues in adoption of Internet Services

(vii) LV transformers act as a low-pass filter, allowing electricity through it with low losses at low frequencies but not higher frequencies etc.

9.0 Conclusion, Recommendations and Future of BPL

In a Country like India where broad band penetration is extremely low and the costs of laying down copper cable or providing short haul satellite for providing broad band for its final leg of journey is very high, providing broad band over power lines holds a great promise, provided issues relating to interference etc are sorted out. Even in advanced Countries like USA, Europe etc., the larger issues of interference remain unaddressed because of absence of stringent regulatory measures.Even in the absence of these regulatory measures, BPL is gaining ground in these Countries despite strong protests from those agencies which are vulnerable to interference because of BPL.

In our Country where serious financial constraints exist in terms of heavy investments to be made for laying copper or installing satellite as a mode of final broad band transmission, giving serious consideration and priority to BPL would be worthwhile, while addressing other pertinent issues. Another great potential that BPL holds in future is that it can be used as a backhaul for wireless communications, for instance by hanging Wi-Fi access points or cell phone base stations on poles, thus allowing end users within a certain range to connect with the equipment they already have.

Besides, low maintenance costs and lesser installation time make BPL a worth technology for increasing broad band penetration.

The Broad Band over Power Line communication network technologies are new for Indian telecom network and will grow extensively in near future for higher capacity applications e.g. Triple Play services (telephony, data and TV etc.). Also BPL is a better option with less cost for network operators.

BPL is already on the scene with commercial products readily available. Green Energy technologies like Solar, Wind etc. may be used as Power Line solutions. Combination of BPL with FTTX, DSL, PON etc. may be economic solution for access networks in future.

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Abbreviations

APON	Asynchronous Transfer Mode Passive Optical Network
ATM	Asynchronous Transfer Mode
BPL	Broadband over Power Lines
BPON	Broadband PON
CATV	Cable Television
CO	Central Office
CPE	Customer-Premises equipment
CSMA/CD	Carrier Sense Multiple Access with Collision Detection
DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name System
DS	Down-Stream
DS1	Digital Signal 1
DSL	Digital Subscriber Line

DSLAM	DSL Access Multiplexer
DWDM	Digital Wavelength Division Multiplexing
E1	E-carrier level 1
EFM	Ethernet in the First Mile
EPON	Ethernet PON
FMC	Fixed Mobil Convergence
FSAN	Full Service Access Network
FTTB	Fiber To The Building
FTTC	Fiber To The Curb,
FTTH	Fiber To The Home
FTTN	Fiber-To-The-Neighborhood
FTTN	Fiber To the Node
GPON	Gigabit-capable PON
HDTV	High Definition Television
HSPA	High-Speed Packet Access
HV	High Voltage
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
IPTV	IP Television
ITU-T	International Telecommunication Union - Telecommunication Standardization Sector
LTE	Long-Term Evolution
LV	Low Voltage
PLC	Power-Line Communications
PON	Passive Optical network
RF	Radio Frequency
RFI	Radio Frequency Intereference
SBU	Single Business Unit
SDH	Synchronous Digital Hierarchy
SONET	Synchronous Optical Network
STB	Set Top Box
STP	Signalling Transfer Point

STS	Synchronous Transfer Mode
TDM	Time Division Multiplexing
US	Up-Stream
VDSL	Very High-speed Digital Subscriber Line
VLAN	Virtual LAN
VoD	Video on Demand
VoIP	Voice Over Internet Protocol
VPN	Virtual Private Network
WDM	Wavelength Division Multiplexing