WHITE PAPER

Practical, Proven Broadband over Power Line

The Powerline LV Solution

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MOTOROLA

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Executive Summary

There is a lot of discussion about Broadband over Power Line (BPL) technology in the utility industry today. Knowledgeable people have widely divergent views about what BPL is, what the ramifications are if it is widely deployed, and what it can do for the utility and—even more essential—utility customers. BPL offers an array of potential benefits. Most important, it offers the opportunity to expand the range of services provided by utilities to currently underserved communities, many of which would gain access to broadband Internet and associated services for the first time. Moreover, BPL can provide real-time access for utility applications, from usage information, proactive outage notification, and automatic meter reading to load-management capabilities, among other utility management and customer service enhancements.

Virtually all BPL technologies can provide these benefits. But can the costs associated with installing new equipment, increasing staff, and dealing with additional maintenance requirements justify deployment? And are the benefits of BPL worth the risks in a highly competitive marketplace? In other words, can a practical business case be made for deployment?

It is Motorola's contention that, given the right BPL solution, the answer to all of these questions is an emphatic yes.

Powerline LV, Motorola's BPL solution, is a scalable, end-to-end hybrid system that utilizes Motorola's Canopy™ high-speed wireless broadband internet platform as the overlay network, providing high bandwidth and coverage for the utility. When digital transmissions are sent to the Powerline LV Bridge (mounted in the communications or utility space of the utility pole), low-voltage connection to the transformer is enabled, and the signal is delivered to the customer via non-invasive HomePlug™ protocol. All the customer needs is a low-cost Powerline LV modem that plugs into standard 110-volt outlets and allows Ethernet or Wi-Fi connections to PCs and other digital devices. There is no need to drill holes or route cables, and no reason for service calls.

The Powerline LV Solution is the first wireless-to-low-voltage solution for widespread commercial use. It offers the flexibility to let utilities target specific areas of service territories without requiring a full build-out. No pole-mounted equipment is needed until there is a customer at that particular location. In this "build as you grow" model, coverage is added where you want it and as your business requirements dictate; and costs are incurred only as customers are added to the system. What's more, the Powerline LV Solution makes administration easy with MiBAS™ (Motorola Integrated Billing & Administration System). MiBAS provides convergent billing, flexible rating and multi-service provisioning. Utilities can assess the merits of BPL implementation in an incremental, cost-effective manner—without the downside of extensive, upfront capital and labor inputs.

Powerline LV is the flexible, affordable BPL solution that is designed to help create new revenue streams virtually overnight, increase the reliability of your power grid, and provide the basis for greater real-time information gathering and control. By the end of 2005, approximately 13 million U.S. households were without access to DSL or cable broadband services, while some 102 million U.S. households had access.[1]

Powerline LV could change the economics and the logistics of reaching underserved customers. This document provides an introduction to the Motorola Powerline LV solution and identifies the key factors for a successful business case.

A Brief Broadband over Power Line Backgrounder

Broadband over Power Line is access technology that enables delivery of broadband services, including Internet service, utility monitoring and management applications via power lines. Various methodologies are utilized by different vendors to deliver signals across the primary voltages, commonly known as Medium Voltage BPL solutions. These are access broadband Medium Voltage BPL solutions that most people are familiar with and are the most discussed aspect of BPL overall. Motorola's Powerline LV does not use the primary medium voltage distribution lines; instead it uses proven wireless technology that delivers a digital content transmission to an interface bridge on the pole, connected to the Low Voltage side of the transformer. This enables the radio signal that was sent to the bridge on the pole to be carried into the home or business via low-voltage lines. In implementations such as the Motorola Powerline LV Solution, customers simply plug a BPL Modem based on the HomePlug protocol into a standard 110-volt power outlet to gain access to the network.

BPL networking can achieve Ethernet-like bandwidth (14Mbps raw data rate now, and the potential for up to 200Mbps raw data rate in the near future), which makes it competitive with cable and DSL product offerings, and ideal for VoIP and video transmissions. In addition to being very competitive with DSL and cable, depending on the area, BPL provides a high-speed broadband Internet alternative for underserved populations whose only options prior to BPL were dial-up or no access at all.

POWERLINE LV SECURITY

Of course data transmissions of all kinds must be protected. But broadband, by spawning a revolution in high-value services, is raising the ante. Video on demand, music downloads, videoconferencing and VoIP services make end-to-end security more essential than ever before in order to prevent theft of intellectual property. Motorola provides the security assessment and architecting expertise needed to create dependable networking environments. As for Powerline LV, Motorola's Canopy platform offers security with over-the-air Data Encryption Standard (DES) and optional Advanced Encryption Standard (AES) Subscriber Module capabilities, which provide 128-bit encryption to help ensure secure data delivery. Security extends right to the customer, as the Powerline LV Modem provides 56-bit encryption and helps enable secure access for the end user—from the Powerline LV Bridge to the home or business.

Broadband over Power Line: Medium-Voltage versus Low-Voltage Solutions

All commercially viable BPL solutions, with the exception of Motorola's Powerline LV solution, are Access BPL solutions that use medium-voltage power lines to extend current fiber or broadband networks to the pole. This type of solution requires "fixed" infrastructure along the grid, whether customers are using the service or not. Installation is labor-intensive and, consequently, must be completed by highly skilled technicians. Specifically, repeaters and couplers have to be installed on medium-voltage lines at intervals of 800 to 2,400 feet, which adds a serious burden with regard to staffing costs, safety issues, and ongoing maintenance requirements. Repeaters can also reduce the reliability of the grid by adding more components and more potential points of failure.

Scalability, or lack of it, is another cause for concern. Medium-voltage BPL solutions require an extensive build-out that can make small-scale initiatives risky.

Another identified drawback of medium-voltage BPL solutions is interference. BPL operates on frequencies between 1.705 MHz and 80 MHz, which is used by amateur radio operators, public safety disaster relief workers, aeronautical teams, CB operators and shortwave radio listeners. Medium-voltage BPL vendors are hopeful that they can remedy this problem, but the issue has yet to be resolved to the satisfaction of ham radio operators and others who are seeking to prohibit medium-voltage BPL deployments.

Motorola's Powerline LV Solution uses a different broadband-delivery paradigm. It extends the utility enterprise network and broadband Internet service via the Motorola Canopy high-capacity broadband infrastructure, low-voltage lines, and enhanced HomePlug-compatible technologies. With the Powerline LV solution, there is less equipment to purchase, install and maintain. In addition, because it is a low-voltage solution, the installation can be done by a variety of utility trained personnel, from electricians to linemen. Because work is being done on the low voltage side of the network as opposed to the primary lines, risks of worker injury and grid disruptions are significantly reduced. Lastly, the Powerline LV solution is significantly less susceptible to interference because it operates only on low-voltage power lines and features integrated, true radio-frequency (RF) hardware notch filtering, providing additional protection to and from amateur radio operators.

Motorola's Canopy wireless broadband technology is used by over 2,000 Internet service providers worldwide. Many enterprises use it as a backhaul for internal applications. It can reach up to 40 miles in a point-to-multipoint, line-of-sight application and provides outstanding penetration for non-line-of-sight applications. Canopy also provides an easy migration to WiMAX™ and other emerging technologies.

The Powerline LV solution provides the scalable infrastructure for cost-effective delivery of broadband Internet and VoIP services to underserved populations. In areas that have high transformer densities and a poor or non-existent telecommunications infrastructure, Powerline LV is ideal. Return on investment has been shown to occur with just one customer per transformer, for some utilities.

Powerline LV Solution Components

The Powerline LV solution is composed of four parts (See Figure 1.):

- The Access Points, located on a tower site, provide the radio access communication cluster that allows for transmission between individual Subscriber Modules located on the poles with the Bridges and the fiber backhaul or Internet POP (Point of Presence). You can also remotely backhaul from individual Access Points using Canopy backhaul units, as indicated by the left side of the diagram below
- The Bridges (also on pole tops or near pad-mounted transformers) inject the Internet signal onto low-voltage wires that connect to homes and businesses
- Powerline LV Modems plug into electrical outlets and transmit signals through the electrical wiring in the home or business to a customer's Ethernet, USB or 802.11b wireless router

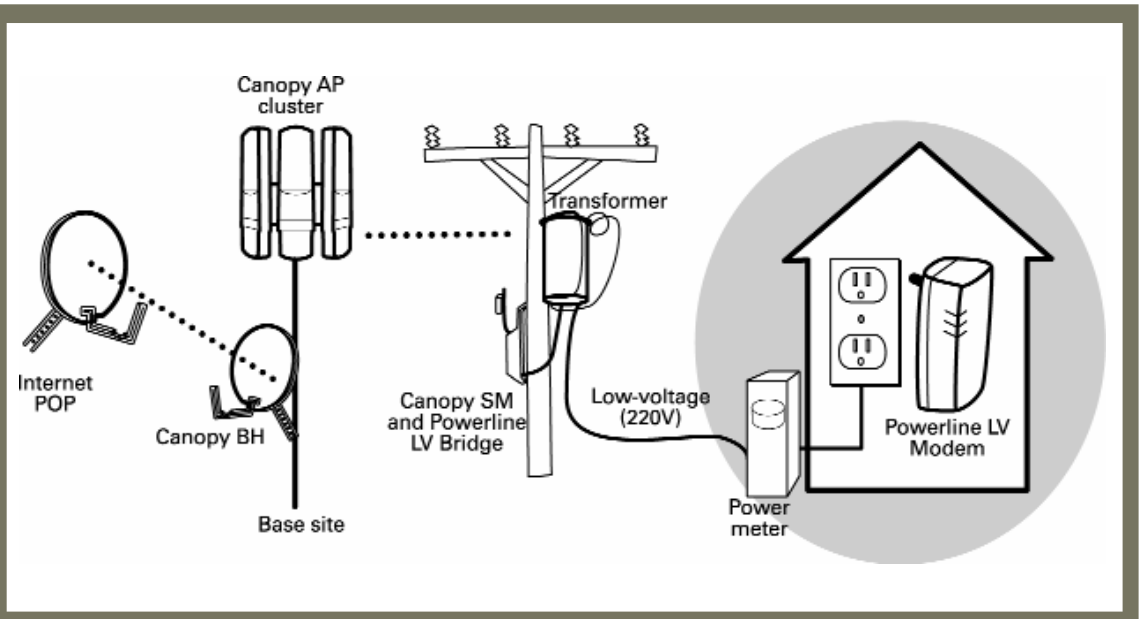

FIGURE 1. The Powerline LV solution takes the signal from the Internet POP and delivers it to the customer's network connection. The Canopy Subscriber Module is connected to the Powerline LV Bridge on the low-voltage side (120/240-Volt AC) of the transformers on the distribution grid. The Subscriber Modules use the 2.4 GHz, 5.2 GHz, 5.7 GHz, or 900 MHz frequency bands depending on line of sight, aesthetics, and environmental needs.

Cost Justification for Utilities

Other BPL solutions have been widely perceived as expensive and risky. In most cases, vendors are planning to deal with interference and other issues as they arise. Moreover, medium-voltage BPL solutions can lack scalability and require infrastructure improvements that take months to install. As such, the utility must make a substantial commitment based on projections rather than actual commitments from customers.

Regarding specific, cost-related issues that concern utility executives, Powerline LV:

- Can be cost-justified at one customer per transformer. Typically, BPL deployments generally require two or more customers per transformer to break even.
- Requires no additional cabling or other wiring to bring the broadband signal to service areas, so start-up costs and equipment installation requirements are minimal.
- Has low set-up and maintenance costs. No truck roll or work on the customer's premises or along the medium voltage distribution lines. No repeaters are needed along the primary distribution lines to maintain the signal.
- Installation can be performed by any qualified electrician approved by the utility, because the work is done on the low-voltage side of the transformer. This is a significant advantage, as medium-voltage systems necessitate highly skilled line crews for installation.
- Leverages Canopy's point-to-multipoint broadband technology, which enables utilities to create a wireless broadband network of virtually any size. Utilities can target specific areas for service delivery and can build out incrementally because costs are incurred only as customers are added to the system.
- By way of the Canopy backbone infrastructure, may be cost-justified for core utility applications (i.e., SCADA, Automatic Meter Reading, substation monitoring, etc.) alone.
- Operates in the unlicensed spectrum bands, so there is no need for spectrum acquisition or site licensing.
- With the MiBAS™ system, enables the rapid provisioning of broadband services while providing a billing system together with self-care capabilities. The MiBAS can help reduce costs, ease call-center traffic, and meet business challenges.

Powerline LV Passes Muster with Amateur Radio Operators

BPL technology has come up against serious, vocal opposition from ham radio operators, with good reason. Many existing BPL systems transmit digital content on medium-voltage power lines using the same frequencies as amateur radio operators. Some BPL vendors have attempted to rectify the situation with "notching" (turning off OFDM carriers), but problems persist.

Aware of the controversy and intent on setting Powerline LV apart from medium-voltage BPL technologies, Motorola contacted the national amateur radio association, the American Radio Relay League (ARRL), in Newington, Connecticut, and asked to install the Powerline LV solution at ARRL headquarters. Hoping to get as much firsthand information as possible about the performance of the Motorola system, and wanting to encourage non-interfering solutions, ARRL officials readily agreed.

Motorola's Powerline LV solution reduces the potential for widespread BPL interference by restricting the application of high-frequency RF to low-voltage (220-Volt AC) power lines. Powerline LV also features enhanced ham band-notching HomePlug technology. In addition, Motorola took the HomePlug Modem concept to the next level by adding tunable hardware filters to deepen the notches and improve the immunity of the system to nearby ham transmitters.

At the ARRL, a Motorola Canopy wireless link has been set up between ARRL headquarters and the W1AW building across the parking lot. The system is connected into the League's local area network on the headquarters side and into a 220-Volt AC power drop on the W1AW end.

ARRL laboratory manager Ed Hare was impressed with the results – using preliminary hardware. Working with Motorola principal staff engineer Dick Illman, Hare found only a few dB of BPL noise on one ham band using the highest-gain antenna at W1AW aimed directly at the W1AW building. Hare noted that on all other bands and antennas, the BPL noise did not change S-meter readings, nor did it affect readings on the Rohde and Schwarz analyzer and receiver used to make measurements. "This proactive step by Motorola has shown that they are serious about interference issues," said Hare. "More importantly, Motorola has shown that it is possible to achieve enough filtering to protect amateur radio under typical conditions."

The ARRL continues to praise the Powerline LV solution; and, in a recent petition for a BPL rule change, the ARRL spoke highly of it to the FCC.

MOTOROLA IS TAKING NOTCH FILTERING TO THE NEXT LEVEL

Motorola has demonstrated that it is technically and economically feasible to notch to a considerably greater depth than is required by present FCC rules. A state-of-the-art Digital Signal Processor (DSP) used to generate BPL signals offers notch depth of approximately 25 dB. However, the notch depth on the latest unfiltered radio transmitters is about the same, and the rules for virtually all radio services require additional filtering. The Federal Communications Commission could require BPL systems to operate at a minimum of -35 dB in any notched spectrum. This could only be achieved with additional hardware filters. The major benefit of the Powerline LV low-voltage BPL system, as demonstrated by Motorola at ARRL headquarters In Connecticut, is that the combination of OFDM notching of the amateur bands and additional filtering provided a remarkable degree of immunity of the BPL system to transmitted amateur radio signals in the same spectrum. Data rates were found to be unaffected when the W1AW station transmitted on a high-duty cycle at up to 1 kW of transmitter power output on 8 different amateur bands.

Why Motorola?

Motorola sees the big picture. We understand the potential that versatile, robust communications systems can bring to your enterprise, and to your customers. Our technological expertise, partnerships, and alliances allow us to deliver Powerline LV and other innovative, reliable solutions that set standards and help organizations maximize revenues while providing enhanced services. And then there's the quality of Motorola technologies and products. The company is a proud, two-time winner of the U.S. government's Malcolm Baldrige National Quality Award.

MOVING FORWARD

We are entering a new era of connectivity in which people and devices can exchange digital content and software programs effortlessly. It's what Motorola calls Seamless Mobility, and it encompasses easy, uninterrupted access to information, entertainment, communication, and monitoring and control across diverse environments, regardless of end-user or device location. Simply put, it is the delivery of business-critical information to you, when you want it, when you need it, to the device you are using.

But Seamless Mobility can only come about if broadband Internet access is ubiquitous. Powerline LV is the scalable, economical, flexible BPL solution that can reach populations that have yet to be introduced to the transformative power of broadband networks. It is the solution that utilities can use to expand their range of utility services to customers, while gaining real-time access to IP-based core management applications.

Security. Reliability. Flexibility. Scalability. They are all requirements of Seamless Mobility, and they are all attributes of Motorola's Powerline LV solution. And perhaps most important of all, Seamless Mobility and the Powerline LV solution represent something else: Opportunities. They remove barriers not only to communication and information exchange, but to the creation of strong new business models. We look forward to exploring those opportunities with you.

REFERENCES

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Motorola, Inc.
1301 E. Algonquin Road
Schaumburg, Illinois 60196
1-800-367-2346 x4821
Visit www.motorola.com/enterprise

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