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Internet Ready Connectivity for Classrooms: BPL Internal Connections Project

Internet Ready Connectivity for Classrooms: BPL Internal Connections Project

The Department of Education of Puerto Rico is the Government entity directly in charge of the management and operations of the elementary and secondary public education system in the island, which encompasses 1,523 schools, 41,263 teachers and 501,899 students island wide with a budget for approximately $4,040,075,000 for the year 2010. During recent years, several efforts to modernize schools have been undertaken with Federal funding which include the development of an Internet infrastructure within the schools. However, to date the most advanced schools in the public system only have networking and Internet capabilities in the school offices and library, even if they have the computer equipment available for use by the students and/or teachers in the classroom. There is a lack of internal connections within the schools to provide Internet connectivity to the classrooms.

The major problem the Department of Education faces to enable Internet connectivity across school facilities is the time and difficulty involved in the installation of internal connections and cabling infrastructure throughout facilities and the invasiveness of such a process during deployment. Schools operate over 85% of the year and all 1,523 of them commence and cease operations concurrently. This means that any invasive cabling infrastructure or internal connection project would be limited in its deployment to the summer vacation period, which makes it very difficult upgrade any significant number of schools yearly. Because of its invasive nature, cabling infrastructure cannot be deployed throughout the school year while classes are being held. Furthermore, because of the nature of construction in the island, which is all concrete and metal rod based, wireless connectivity is impractical because of the problems with signal propagation.

PowerNET is providing the Department of Education with an optimal solution to overcome the obstacles for the deployment of internal connections and provide Internet communications to the classrooms by using Grid2020's BPL technology as the Local Area Network architecture to connect all school facilities. There are several distinct advantages of this approach which makes it the only practical solution to provide internal connections within schools in Puerto Rico.

First, the installation of BPL equipment for internal connections is non-intrusive and non-invasive. In order to deploy BPL internal connections in a school, we only need to access the electric rooms and install a Broadband Regeneration Unit (BRU) and electrical couplers in the feeder lines of electric panel to propagate BPL signals across campus and provide IP connectivity throughout the school.

Secondly, the installation of BPL equipment for internal connections is very time effective. A typical school may have between 10 to 20 electrical panels rooms which would take at most two (2) days for the installation of the BRU's by a certified electrician and his assistant. Once this equipment is installed, configuration can be done either locally or remotely. Access across the school and to the Internet would only require plugging a BPL access modem in any wall outlet where connectivity is required to provide immediate LAN and Internet services to the classroom. Installing 100 Cat-6 drops throughout the campus would take an estimate of 20 to 30 days, including patch panel installation. Taking into consideration that this needs to be done in 1,523 school, BPL could be potentially deployed in all schools within 9 to 12 months to provide the necessary internal connections to all schools of the Department of Education, impossible to do with traditional cabling infrastructure.

Furthermore, the performance of the BPL network is not affected by noise, electrical fluctuations or other problems that may be currently affecting schools due to insufficient electrical capacity. BPL technology relies on the copper wiring as its transmission medium and does not require the same to be electrified. As this technology has been developed for carrier class telecommunications provisioning, it takes into consideration a number of typical sophisticated electrical problems which occur in the utilities power grids, such as weather, corrosion, induced RF noise, voltage and current fluctuations among others. Except for severe wiring problems, in-building application of the technology does not pose great challenges for implementation of BPL networking for internal connections within the school

Last but not least, using BPL for internal connections within schools is very cost effective compared to the installation of new cabling infrastructure. Once BPL is deployed, any and every electric outlet in campus becomes a potential Ethernet port for IP communications. The cost to enable a typical school with BPL technology will require approximately $20,000 of BPL equipment plus $10,000 of installation and configuration services. This would be equivalent to the cost of installation of approximately 100 Cat-6 drops to distribute across the schools entire campus, excluding the cost of time, effort and problems that may arise from such installation. However, BPL has the clear advantage of turning ANY electrical outlet as an Ethernet port, providing ubiquitous Internet availability across the school.

The new BPL networks would be fully integrated with the existing networks and/or IP communication facilities at the schools, including libraries, laboratories and administrative offices. Furthermore, the BPL network could provide support for other additional IP applications and services to be implemented now or in the future by the Department of Education, including VoIP telephony, video surveillance, physical security, access control and energy management among many others.

PowerNET will provide a full turn-key installation of BPL technology for use for the internal connections in each school, including all required BPL equipment, deployment services, remote management, network design, system configuration and network management and support services for the first year.

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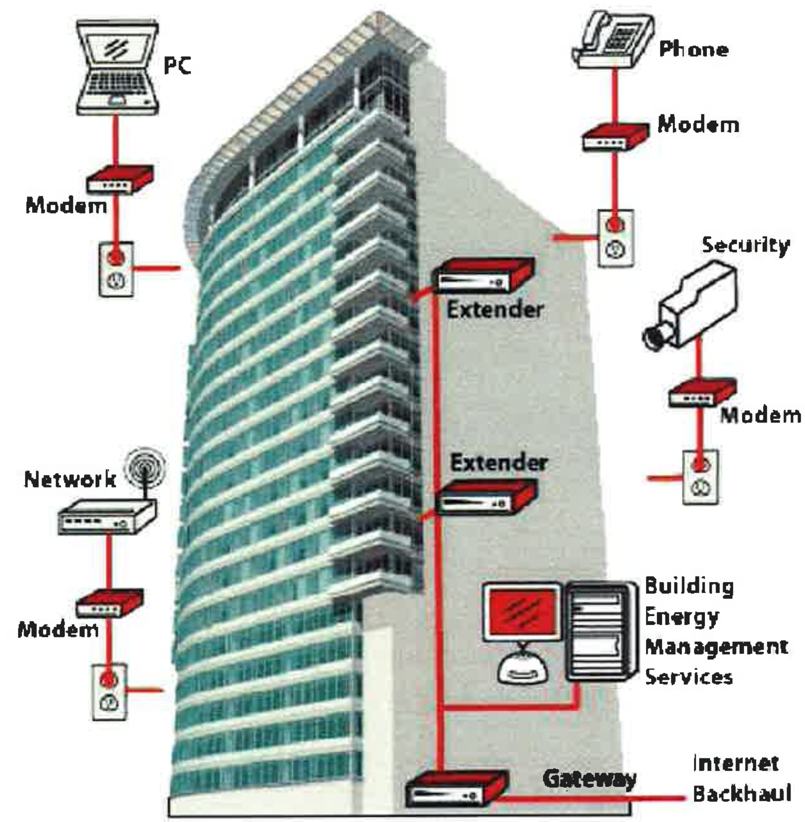
Using In-building Broadband over Power Line ("BPL") to provide Schools with Internet Ready Connectivity

- BPL ("Broadband over Power Lines") is the technology that allows the transmission of data through the electric power grid.
- Grid2020 has developed the only BPL technology capable of delivering cost-effective, high-speed communication services wherever electric power is available, especially to the rural space and geographically inaccessible areas as well as within buildings and campuses.



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- 100 Mbps symmetrical transmission speeds for in-building communications.
- Fully IP compliant, including IPv6, VLANs, QoS, etc.
- Ruggedized equipment built for exterior environments and harsh weather (power poles).
- Easy, unobtrusive, noninvasive installation for full school deployment in a matter of hours (8 hours per school).
- Transforms every power receptacle in school into an Ethernet port by just plugging in a CPE device.
- Integrates with existing networking equipment.
- Allows for central network management of school networks and service provisioning of individual users.
- Low cost of acquisition, installation and maintenance.

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- BPL technology implements layer-1 (PHY) and layer-2 (DLL and MAC) of the OSI reference model.
- Operates in Layer 2 bridging mode, supporting transmission of any protocol compatible with Ethernet (ICMP, IP v4 and v6 packets, TCP, UDP, etc.).
- Integrates 802.1D-based switch supporting VLAN (802.1Q) and OVLAN (DS2's proprietary Optimized VLAN), traffic priorities for QoS policies, enhanced Spanning Tree Protocol and encryption assuring communications privacy.
- User Authentication and Authorization (free access, access lists, or RADIUS).
- Local and remote configuration and provisioning via DHCP and TFTP.
- Remote management and monitoring (via SNMP and CLI).
- Data encryption (DES and 3DES).
- Eight possible QoS priority levels. Traffic priorities can be computed based on IEEE 802.1p, IPv4, IPv6 or TCP fields (custom patterns can also be defined).
- Bandwidth allocation and limitation per node.

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Broadband Regenerator Unit (BRU)

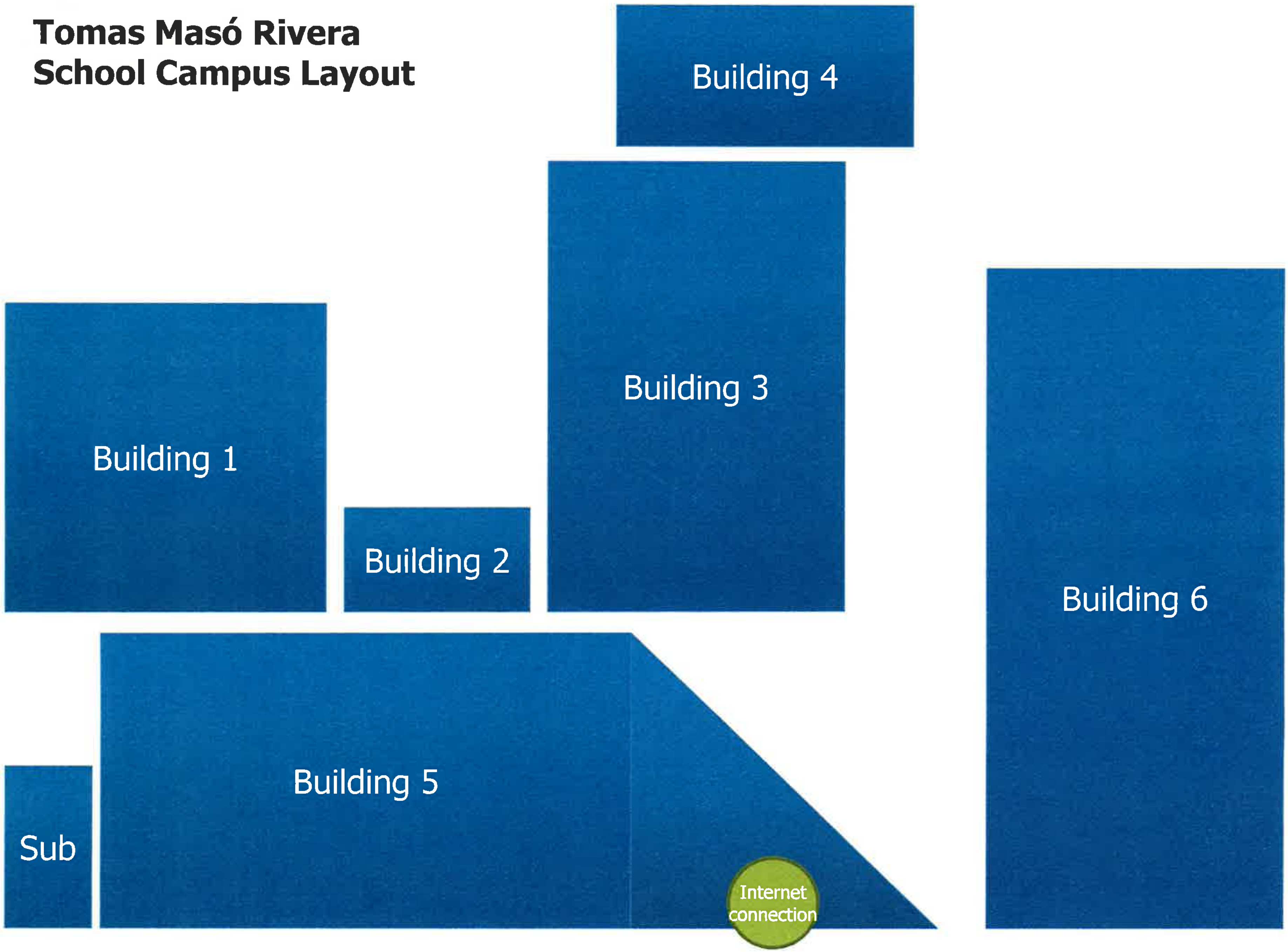
- Designed to digitally filter the accumulated noise in the communications signal
- Regenerates a full-strength, noise-free BPL signal
- Has built-in Wi-Fi capabilities and can be easily adapted for WiMax operation

Customer Premises Equipment (CPE)

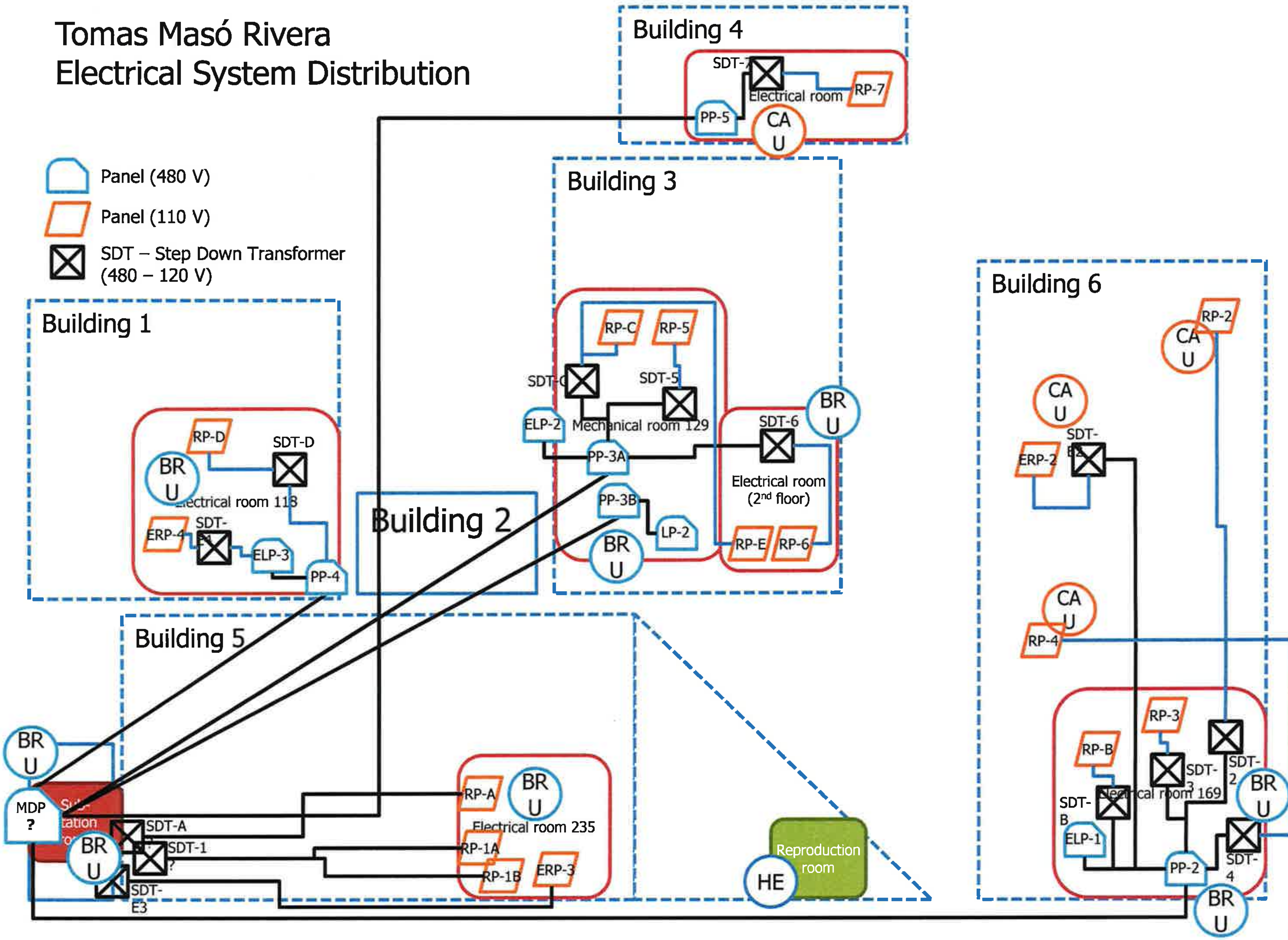
- Grid2020 modem plugs into any power outlet inside the customer premises convenient to a personal computer
- Connects to a computer via a standard Ethernet cable

Grid2020's BPL network can be managed like any other broadband IP communications network

Tomas Masó Rivera School Campus Layout



Tomas Masó Rivera
Electrical System Distribution



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Location	Transformers	Panels (480 V)	Panels (120 V)
Sub-station room - Building 5	3	3	1
Electrical room 118 - Building 1	2	2	2
Mechanical room 129 - Building 3	2	4	2
Electrical room (2nd floor) - Building 3	1	0	2
Electrical room - Building 4	1	1	1
Electrical room 235 - Building 5	0	0	4
Electrical room 169 - Building 6	4	2	2
Scattered - Building 6	1	1	3

- Network connection points:
  - 25 classrooms (1 CPE per classroom)
  - 10 additional CPEs for other areas
    - Note: considering 5 additional CPEs for spare parts and / or LV repeaters
- Type of services to be offered:
  - Internet sharing
  - LAN
  - IP Camera
- If possible, the network should work 'stand-alone', without remote management
  - We will assume using Jeizer (remote management) as in any Coop network at this stage
  - We will study the stand-alone alternative later

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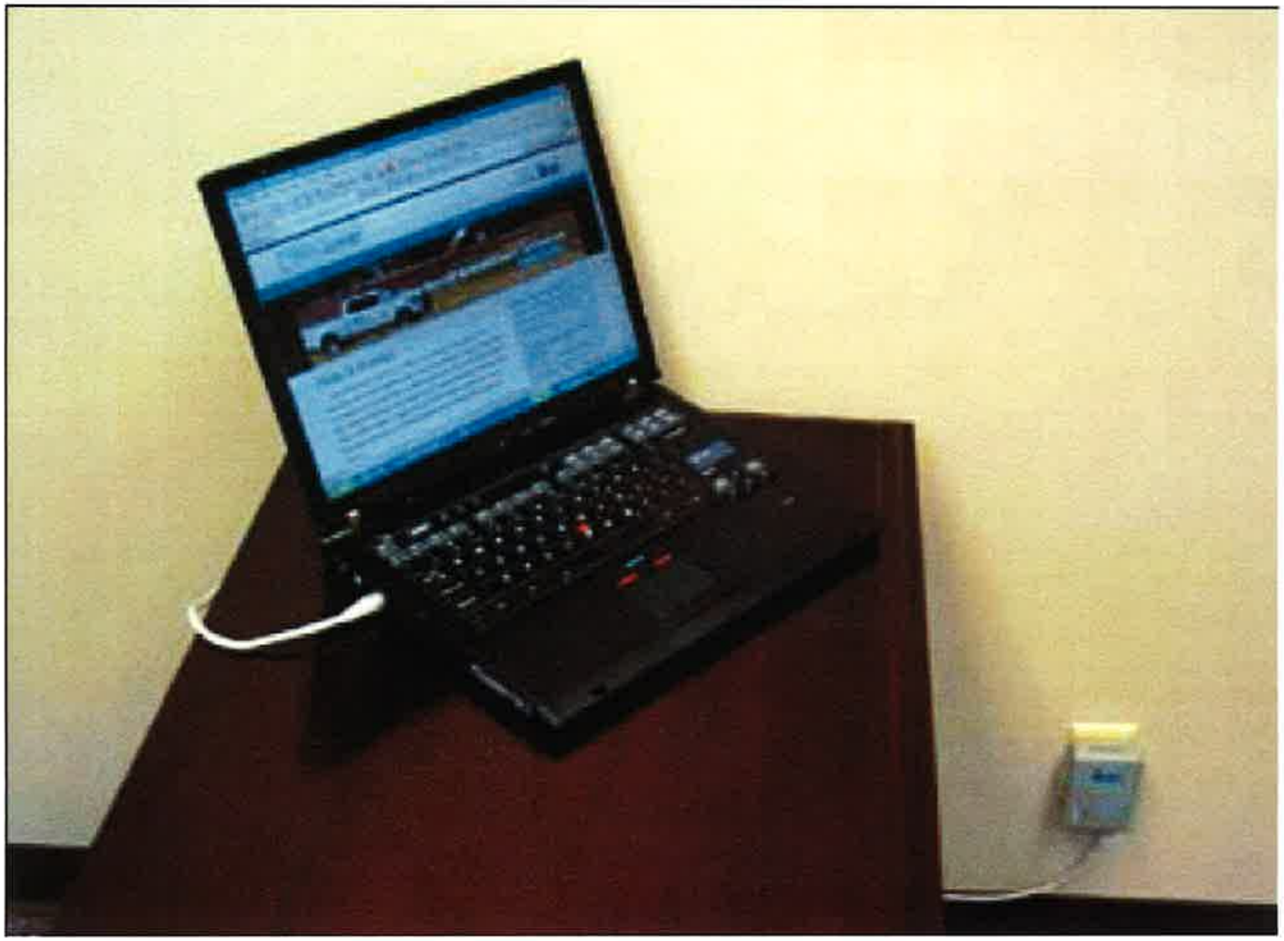
Installation time of less than 30 minutes provides IP communications to all receptacles in panel !!!

SESCO TECHNOLOGYSOLUTIONS



Just plug-in CPE to wall receptacle and attach patch cable to computer for IP network communications !!!

DEPARTAMENTO DE EDUCACIÓN

Technical Description of BPL Network

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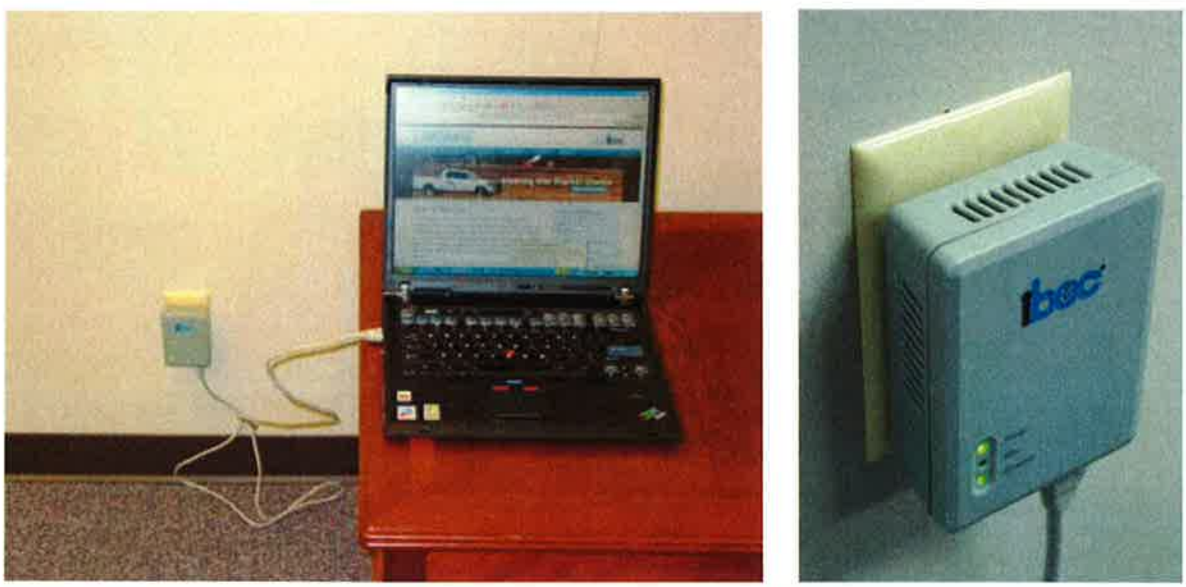
TECHNICAL DESCRIPTION OF BPL NETWORK

PowerNET provides a complete turnkey BPL solution based on IBEC's proven BPL technology. The IBEC solution is a fully Internet-Protocol (IP)-based approach to broadband-over-power lines, essentially turning the existing electric-line system into a broadband IP communications network. This approach provides the maximum flexibility possible, allowing virtually any IP-addressable device to be attached to the network. Since the established electric distribution system currently serves hundreds of millions of households and businesses throughout the U.S., the transmission medium for IBEC's voice, data, and video technology is already available without significant additional infrastructure installation cost. Indeed, this is also true internationally, where the power grid provides the one, universal infrastructure network, especially in underdeveloped and developing nations, presenting huge international opportunities for IBEC's BPL systems as well.

An advantage of BPL technology is that it instantly turns every power outlet in the premises into a broadband Internet access outlet, providing much more convenient and universal broadband networking within the premises than can be created with other wired broadband services, such as DSL and cable modem technology.



Customer BPL Internet Access Modem

IBEC's communication architecture allows for signal connections to be made independently of each power distribution circuit for delivery of broadband services and local-area network access to classrooms and other campus facilities.

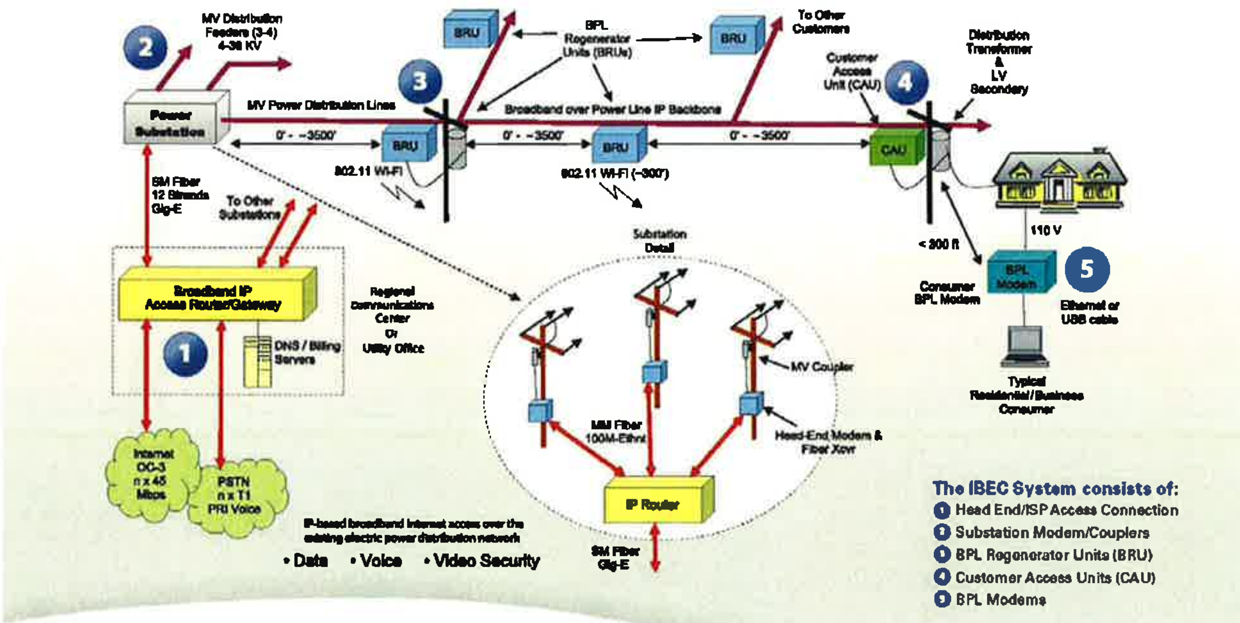
Numerous opportunities exist beyond providing broadband Internet access with a BPL network. With an established data network spanning a school's infrastructure, a new world of data gathering and sharing is opened up that can benefit not only students, but also the Department of Education itself. Services like Voice over Internet Protocol ("VoIP") and video monitoring for security can be provided on the BPL network. On the provider side, utilities have access to smart grid applications like

IBEC was the first to deploy a commercial BPL system in rural North America. It is also the only BPL firm that has received funding from the Rural Utilities Service (RUS), as no other BPL provider can profitably serve rural and underserved markets. IBEC has contractual commitments with 16 electric cooperatives encompassing over 325,000 customers and traversing over 38,000 power-line miles. To date, IBEC has received approval for loans totaling over $69.2 million. The RUS Telecommunication Program is a government entity that assists the private sector in developing, planning, and financing the construction of the telecommunications broadband infrastructure in rural America. In addition to providing an advantageous, low-cost funding source, the RUS backing is a significant validation of IBEC's business model and technology.

In addition, PowerNET and IBEC recently completed a proof-of-concept pilot project in Puerto Rico in conjunction with the Puerto Rico Electric Power Authority ("PREPA") whereby BPL technology was implemented throughout a sample area and various Internet and Smart Grid related technologies were tested, including Internet access services, Distribution Transformer Monitoring, Advanced Meter Infrastructure integrating Electric and Water metering, remote disconnect and video surveillance among others. The pilot project was a complete success and PREPA is currently in the initial phases of island-wide deployment of IBEC's BPL technology.

IBEC's proprietary technology solution has overcome the two largest impediments to BPL service: (i) cost efficiency, and (ii) transmission quality, which have stymied past network developments. Current BPL technology is predominantly utilized in densely populated areas where these factors are less of an issue. By utilizing and modifying existing powerline equipment, IBEC developed a proprietary and patented method to accurately transmit data over long distances at a fraction of the previous cost. Perhaps equally important, data transmission is accomplished with equipment that is very familiar and comfortable to deploy. This new technology changes the game for existing BPL deployment by enabling companies to efficiently offer IP communication services in areas and facilities previously difficult or impossible to provide.

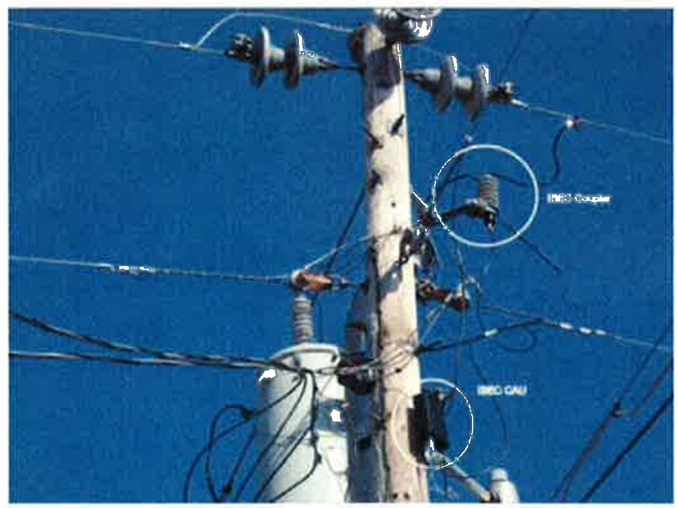
TECHNOLOGY, EQUIPMENT, AND NETWORK ARCHITECTURE



IBEC'S BPL Network Diagram

IBEC provides the most cost-effective BPL solution available in the power line industry due in part to proprietary technology. The Company's BPL system is comprised of an Internet backbone connection, substation coupling, line-conditioning and regeneration equipment, a CAU, network interface, and a broadband access device (CPE). IBEC's products are UPA (Universal Powerline Association) compatible and IEEE 802.11g-compliant (Wi–Fi), and are fully compliant with FCC Part 15G requirements for Access BPL equipment. The Company's power line access system and customer premise modems utilize the innovative orthogonal frequency division multiplexing modulation adopted by the UPA as well as the fast-growing wireless IEEE 802.11 standards. IBEC's solution has undergone extensive testing and has proven not to create harmful interference with existing, licensed radio services such as Amateur Radio. In fact, the American Radio Relay League ("ARRL"), the authoritative voice of Amateur Radio operators in the Unites States, recognized IBEC in public BPL-related filings to the FCC on October 18, 2005 and again on May 17, 2007, as an Amateur Radio-friendly BPL company. On August 15, 2007, IBEC Vice President of Engineering Brent Zitting, himself a long-time Amateur Radio operator, was named by the ARRL to its Electromagnetic Compatibility Committee as the BPL industry voice on the subject. IBEC maintains an excellent relationship and ongoing dialogue with ARRL regarding interference and noise mitigation and is considered by the ARRL to be the leading voice in ensuring the mutual compatibility of BPL systems and licensed radio services.

Access to the broadband signal and coupling take place at the power company substation or another suitable access point along the power line. An industry-standard fiber optic multiplexer or broadband termination from the high-voltage transmission line carries the broadband signal from the head-end at the regional communications center or broadband point-of-presence to the substation or other convenient coupling site. Coupling networks that are located on the load side of the substation circuit breakers then provide access to the high-voltage distribution circuits. IBEC's capacitive couplers provide both fault protection and impedance matching between the high-voltage line and a radio frequency (RF) hybrid circuit, which contains an RF power amplifier for driving either the single-phase or the three-phase power distribution line.



PATENTED COUPLER / CAPACITIVE COUPLER INSTALLATION

BPL signal regenerator units (BRUs) are utilized at various points along the medium-voltage energy distribution network to optimize the data-carrying capacity and extend the reach of the system. These regenerators are designed to digitally filter the accumulated noise in the communications signal, regenerate a full-strength, noise-free BPL signal, and place that signal back onto the medium voltage power line for transmission further along the electrical system. The spacing of regenerators is somewhat dependent upon the number of customers served and the types and number of power system devices attached to the medium-voltage lines; a BRU is typically required at intervals of 2,500 – 3,500 feet. Impedance-matching transformers are also utilized at the BRU to improve the signal strength as the signal is injected onto the power line. To further improve signal performance, isolation filters are sometimes placed at non-communication loads along the power line and at electric circuit breakers and reclosers to prevent the back-flow of broadband signals toward the substation transformers and along ancillary power circuits. Because of the unique nature of IBEC's network architecture and BPL regenerator design, regenerators can provide virtually unlimited distance coverage for rural BPL networks.

IBEC BPL REGENERATOR & CUSTOMER ACCESS UNIT

Customer Access Units are located on a power service pole or underground access point near the customer premises, and they serves as the means of decoupling broadband signals from the medium-voltage electrical distribution line, digitally amplifying the BPL signal, and sending it over the low-voltage power line into the customer premises. The decoupling apparatus consists of a bypass coupling network that routes the broadband signal around the transformer by using the existing, grounded lightning arrestor or a similar capacitive coupling device. Lightning suppression and over–voltage protection are included in the bypass process, working in concert with the unique IBEC patented coupler, to prohibit lightning or other electrical disturbances from entering the customer premises over the low-voltage BPL connection. This simple but effective BPL signal decoupling process reduces cost, improves reliability, durability and serviceability, and satisfies all FCC regulatory requirements.

IBEC's use of orthogonal frequency-division-multiplexing modulation and UPA-compliant Broadband Access Device modems at the customer premises is patterned after the existing, proven cable data infrastructure and the operation of cable modems on CATV systems, except that it uses the existing power line network. At the customer premises, the external broadband network interfaces with the home or business directly via the low-voltage power line into the premises, providing true "broadband to the power outlet" to *every* power outlet in the premises. A broad range of energy management and IP services will soon be available to connect all IP-enabled devices within the home or business to the broadband network, and this will allow the IBEC BPL network to become *the single* in-home device management path needed to monitor and control in-home appliances and HVAC systems as part of the evolving "Smart Home" concept. The IBEC CPE modem is plugged into any power outlet inside the customer premises convenient to a personal computer, providing easy connection to the computer at any electrical power outlet in the home or business. A Wi–Fi Internet connection directly from the pole outside the premises to the computer is also available. The IBEC BRAD is a FCC Part 15B-compliant (the residential consumer electronics product emissions standard) BPL modem which connects directly to the personal computer via a standard Ethernet cable.

Once the power network is broadband and Internet Protocol-based via BPL, it can be managed like any other broadband IP communications network.

- Assign individual and multiple IP addresses to track, identify, and manage unique devices at various locations throughout the power network
- Enable packet-based voice and data to flow symmetrically and bi-directionally throughout the network
- Perform enhanced and automated internal energy system functions that greatly improve the performance and reliability of the utility network

The open architecture of IBEC's IP BPL network makes it easy to add new and unique applications without "reinventing the wheel" of communications or necessitating large-scale equipment replacement when upgrading services or adding system features, so the individual needs of utility companies can be easily addressed and adapted in the future. Typical IP applications for utilities, beyond high-speed Internet services, include cost-saving services such as substation load monitoring and balancing, transformer and other component monitoring, Demand Response monitoring and control, and predictive maintenance applications that can prevent many system failures. Video monitoring over the power lines provides critical Homeland Security capabilities, especially in remote areas where no other means of broadband video surveillance is possible. IBEC is currently developing partnerships with leading suppliers of these applications and technologies.

BPL STANDARDIZATION

IBEC's products are fully compliant with existing UPA BPL standards and with IEEE 802.11 wireless access standards. To further establish recognized international standards for BPL, the IEEE is developing three new standards for the industry - IEEE P1675, addressing signal coupling, deployment practices, and safety; IEEE P1775, addressing processes and methods for measurement of interference and radio frequency compatibility; and IEEE P1901, addressing modulation and transmission methods for BPL modems and technology. While IBEC's utility contracts protect the Company against any other BPL vendors or service providers operating on a utility's power distribution network along with IBEC, the BPL industry recognizes the need for meaningful standardization to maximize technology compatibility and propel the industry forward in acceptance across the electric utility marketplace.

IBEC participates fully in all three IEEE standards committees. As founding members of each committee, IBEC helps steer these standards toward completion, ensuring that IBEC's technology is both protected and included as appropriate and that any future standards are compatible with IBEC's investment in its existing product portfolio. For example, the draft IEEE P1675 standard specifically includes IBEC's unique capacitive coupling technique as a preferred method for coupling BPL signals onto power lines. At the present time, IEEE P1675 is an approved IEEE standard. IEEE P1775 has gone to formal ballot. IEEE P1901 is moving more slowly, but it is apparent that the OFDM technology and transmission methods adopted by IBEC in its BPL products will be fully included in the resulting standards. IEEE P1901 will likely be formalized and adopted as an international standard sometime in 2009 and incorporate the work going on in ITU G.hn.

FREQUENTLY ASKED QUESTIONS

How fast is BPL?

Theoretical Speed Limits (1 Gbps)

Several years ago, studies were performed by a professor at Penn State University to assess the potential real-world transmission capacity of existing medium-voltage overhead power-lines. In this paper, the conclusion was that in real-world settings, that data throughputs up to 1 Gbps were possible. This study illustrates the possibilities for the power-lines to carry significant data channels as technology continues to make it cost effective.

BPL technology today (200 Mbps)

Most BPL chipsets available today are of the "200 Mbps class" family, which is about four years old. This means that under ideal conditions, the raw data thruput can be 200 Mbps one direction or the other. Of this bandwidth, about 50% of it is used as overhead in assembling and disassembling Ethernet packets for transport over the bpl network, and to maintain connection information between devices. So, in a lab test, one could show actual Ethernet throughputs of 100 Mbps of TCP/IP traffic, fully utilizing a typical 100 Mbps ethernet connection.

All BPL chipsets on the market today are half-duplex devices, that is they either transmit or receive, but they don't do both simultaneously. The reason for this is the technical difficulty of designing echo-cancellers that would make full duplex possible. In order to meet market needs and achieving the desired cost targets, fullduplex BPL is not being used. Another factor that affects this decision is the treebranch architecture of most electrical distribution networks. Deploying BPL on these networks create inherent point-to-multipoint connections, which are better served using half-duplex methods

How fast are the next generation chipsets?

Next generation chipsets are in development with most BPL chipset providers. These devices will operate at the 400-500 Mbps speed levels, essentially doubling the previous capacities. These devices also promise improved error correction mechanisms to improve BPL performance in noisy environments.

What determines the capacity of a BPL network?

Access Architectures and Applications

For access applications, BPL networks may become more complex both in structure and size. In the rural MV grid in the United States , they resemble a tree-branch structure. (See figure 1 and 2)

BPL networks share backbone bandwidths similar to CATV broadband delivery systems. However, an important difference is that upstream and downstream bandwidth can be flexibly allocated in either direction dynamically, and based on the traffic requirement.

Access networks have attributes, which differ from network to network and are dependent upon the physical size and organization of links. These organization differences ultimately affect the data thruput capacity of the network as a whole. Below are the important attributes:

1. Length of Network – from Headend to CPE
   a. Short: 1 or 2 hops (50 - 80 Mbps design capacity)
   b. Medium: 3-5 hops (25 – 30 Mbps design capacity)
   c. Long: > 5 hops (10 – 15 Mbps design capacity)

2. Network Fanout – Number of Point to Multipoint connections
   a. Small: 1-2 units per master
   b. Medium: 2-6 units per master
   c. Large: >6 units per master

As the backbone network becomes longer, the backbone capacity is decreased when functional thresholds are crossed. Because of the need to re-use certain frequencies and the introduction of TD repeaters, there is a reduction in backbone capacity when going from short to medium and medium to long length networks. Further lengths beyond 5 hops will not further reduce the capacity of the backbone.

As network fanout increases, fixed backbone bandwidth resources are shared with more CPEs, which have to share the available time during which to pass data.

What kind of BPL network is IBEC deploying?

IBEC is employing architectures for its rural networks that may be as long as 25 hops from the head-end to the customer CPE. These networks may traverse up to 13 miles of distribution line, at the furthest extent, and in total may occupy 150 line-miles. In order to cover such long distances, IBEC has organized its equipment to operate in frequency bands and modes that optimize the reach of the network in exchange for backbone bandwidth. Backbone units, or BRUs operate as either Frequency Division Repeaters or as Time Division Repeaters. IBEC's rural networks are "Long" and the fanout of the network is small to medium. This architecture results in a backbone capacity of 10 – 15 Mbps, which works well for the rural customer densities which we encounter.

For geographically smaller networks, higher capacity backbones may be constructed if they are not as physically long. These networks may not use TD repeaters because of their short length, thus yielding an immediate x2 thruput improvement over long networks.

Can IBEC equipment deliver speeds greater than the services we sell?

Yes. These inherent speed limits are imposed upon the network at the customer CPE and may be dynamically changed or removed completely. Limiting the speed at the customer equipment ensures fair access to bandwidth for all customers along the network. The speeds offered must take into account the BPL backbone bandwidth, number of customers, and the oversubscription ratio (15:1 for IBEC).

What is IBEC working on to improve BPL technology?

The primary impairment for MV overhead lines with regards to BPL is impulsive sparking noise. The worst noises are detected and fixed during the "make-ready" part of network deployment, using RF equipment to scan the lines while the network design is verified.

IBEC is currently engineering additional performance improvements designed to increase thruput on links that are experiencing noise impairments. These improvements are based on monitoring bit error rates and adjusting bit-loading on the OFDM carriers to optimize thruput through the system. While these improvements do not increase the top-end speed available on a non-noisy installation, they will increase performance on lines that are noisy, and thus reduce the need for "make-ready" work. These improvements will be deployed in the next quarter.

IBEC is the industry leader in developing noise-resistant installation methods and equipment. Our BRU products come with native differential feed systems to enable balanced feeding of multi-phase MV lines without external splitters/combiners, and enhanced performance. BRUs also come with built-in balanced combiners to save the cost of two additional couplers in FD repeater applications, and soon will be available with dynamic impedance matching.

Because IBEC deploys and manages its own networks, our equipment has been optimized for fast and efficient deployment. From our network management system, headends, repeaters, and couplers to CPEs, each product runs custom IBEC firmware and software that enables efficient management of notching utilities, recovery of misconfigured units without truck-rolls, and additional instrumentation above and beyond that normally available in DS2-based products.

Over the last year, IBEC has developed with DS2 special noise-tolerant operational modes that create much more robust networks in harsh environment. IBEC also sells a special headend unit that allows full implementation of all VLAN and OVLAN features supported by DS2. This is only available from IBEC.

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Pilot Project:

Tomás Masó Rivera Morales Intermediate School

Toa Alta, Puerto Rico

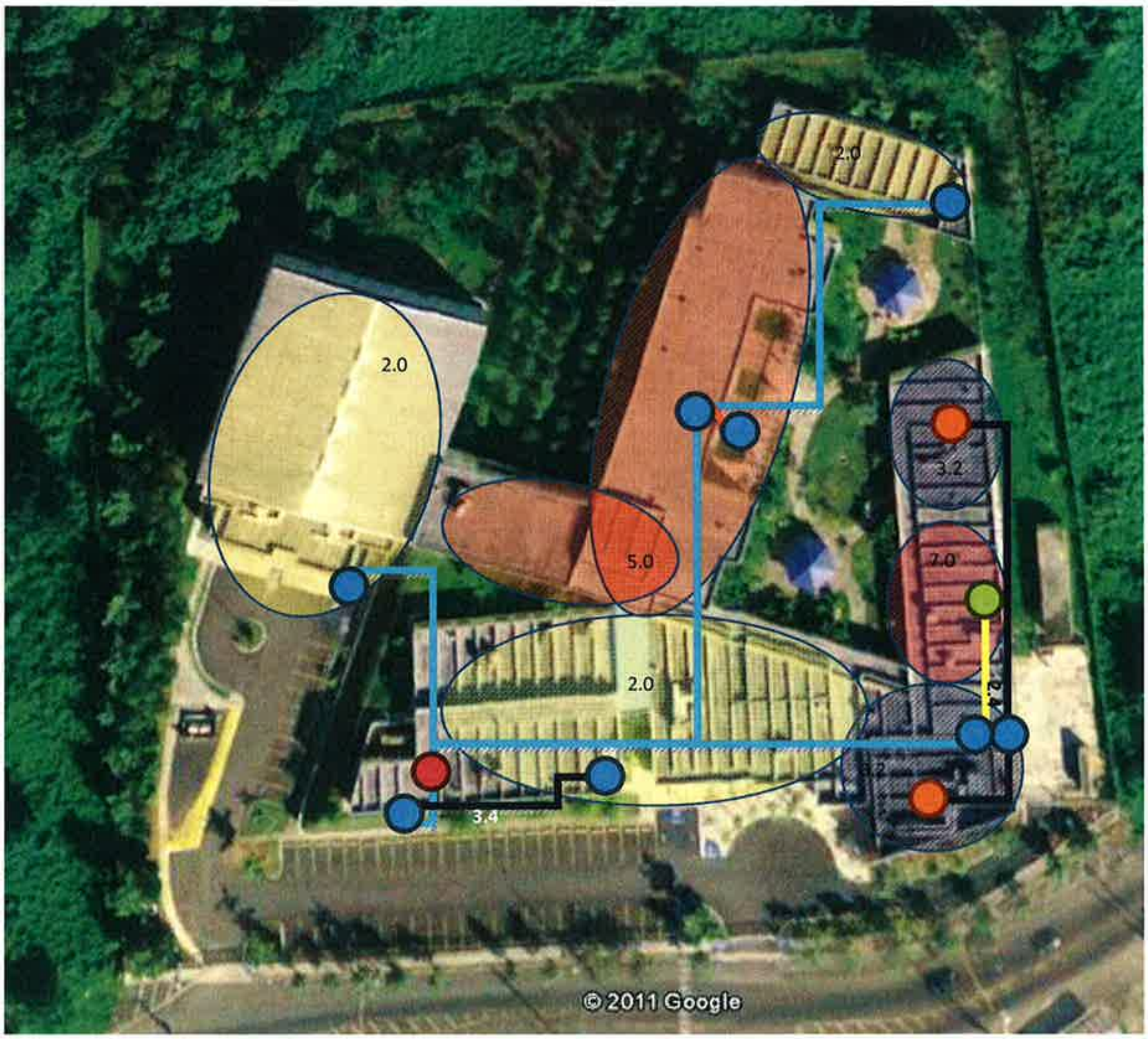
MDU BPL PILOT DEPLOYMENT

PROJECT NAME: TOMÁS MASO RIVERA SCHOOL BPL PILOT

This document presents the results of the MDU BPL pilot deployed in Tomas M. Rivera School.

Date: May 2011 | Deployment time: 1 week | Location: San Juan, PR

BPL NETWORK MAP



Legend	Quantity	Description
	1	Head End
	8	BRU
	1	CAU
	2	Repeater (PB-200 CPE)

Legend	Transmission Mode
	480 VAC - Mode 1
	110 VAC - Mode 2
	110 VAC - Mode 3
	110 VAC - Mode 5
	110 VAC - Mode 7

CPE LINK CERTIFICATION

PROCEDURE

For each point indicated in the map below, the following measurements were performed:

- Link level (Physical speed in transmission and reception).
- Speed test from Internet (Internet bandwidth).

CERTIFICATION TEST MAP

Note: Sky-blue squares denote second floor rooms.

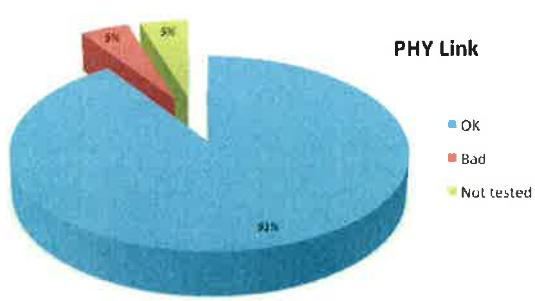
TEST RESULTS

Please refer to the following two tables for results.

I. CPE PHYSICAL LINK TEST RESULTS

No.	Building and Floor	Location (room)	PHY Tx	PHY Rx
1	B1-1	P.E.	52	67
2	B1-1	P.E. 2	49	69
3	B2-1	Hallway (NO KEY TO ACCESS ROOM)	50	93
4	B2-1	Empty Room	81	99
5	B2-2	Language Room	28	73
6	B2-2	NO KEY TO ACCESS ROOM		
7	B3-1	1	56	20
8	B3-1	2	105	107
9	B3-1	3	17	98
10	B3-1	4	42	82
11	B3-1	5	19	80
12	B3-1	NO KEY TO ACCESS ROOM		
13	B3-1	7	NO BPL LINK (Repeater Needed)	
14	B3-1	7-A	NO BPL LINK (Repeater Needed)	
15	B3-2	1	93	108
16	B3-2	2	64	109
17	B3-2	3	94	105
18	B3-2	4	54	77
19	B3-2	5	52	89
20	B3-2	6	23	87
21	B3-2	7	13	63
22	B3-2	7-A	11	39
23	B4-1	1	51	59
24	B4-1	2	50	55
25	B5-1	Library	48	16
26	B5-1	Library 2	42	37
27	B5-1	Library 3	43	30
28	B5-1	1-CIENCIA ROQUE	63	75
29	B5-1	2-MATEMATICA	30	33
30	B5-1	3-REPODUCCION	43	70
31	B5-1	4-CIENCIA RIVERA	34	33
32	B5-1	5-CIENCIA MENDEZ	52	34
33	B5-1	6-CIENCIA MELENDEZ	63	52
34	B5-1	Admin-Director	50	51
35	B5-1	Admin-Educación Especial	58	56
36	B5-1	Admin-Faculty Room	37	47
37	B5-1	Admin-Orientadora	46	65
38	B5-1	Admin-Recepción	39	37
39	B5-1	Admin-Secretaría	65	66
40	B5-1	Admin-Social Worker	35	46
41	B6-1	Industrial Arts Workshop	60	55
42	B6-1	Lunch Room	33	36
43	B3-1	Hallway	90	90

TEST RESULTS SUMMARY



II. INTERNET BANDWIDTH TEST RESULTS

	Upload	Download
School's Internet max. speed (baseline)	0.45 Mbps	1.75 Mbps
CPEs average results	0.41 Mbps	1.65 Mbps
CPE capacity as percentage of max speed	91%	94%

Download bandwidth tests were performed using the website www.speedtest.net[1].

A baseline for these tests was established by measuring the maximum Internet bandwidth directly at the school's router, before the BPL network (max Internet speed available at the school). The achieved speed at each CPE was compared with the baseline.

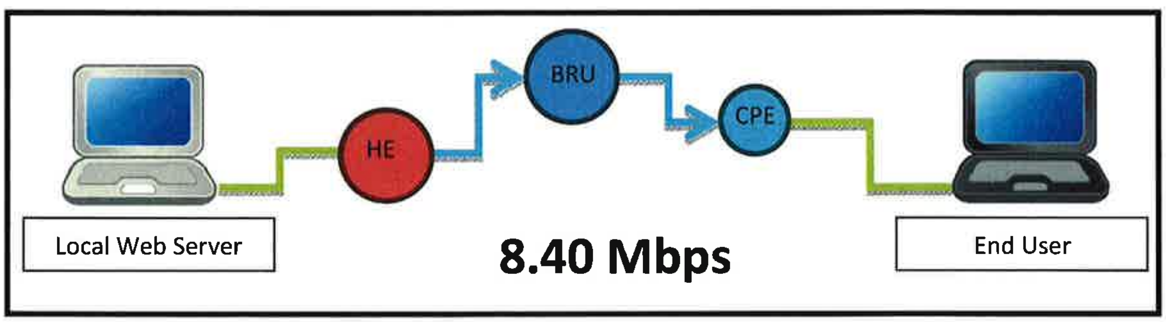
The tests results for all rooms with BPL link, were between 90% and 100% of the baseline.

These results prove successfully that certified BPL links are capable of good speeds on regular web-based navigation.

OTHER TESTS

An internal bandwidth test was also performed, from a local Web Server running on a computer directly connected to the HE to a computer connected to a CPE (on test point 43). This test result is strictly dependent on BPL links and network load, and independent from the school's Internet connection.

The download speed achieved was 8.40 Mbps.



NOTES

1. Achieved BPL link levels are good enough for regular Internet applications.
2. Blind spots (tests # 13-14): possible solutions include intermediate CPEs acting as repeaters, or hybrid networks (i.e. Wi-Fi).
3. A recommended idea is to identify with a colored dot sticker every certified receptacle, as there are some cases where two different receptacles provide very dissimilar signal levels – due to they don't belong to the same electrical circuit.
4. Additional considerations may be taken when connecting all the school's PCs to the network.

[1] Results are dependent on school's Internet connection and webserver's load capacity, not exclusively on BPL Backhaul.

DEPARTAMENTO DE EDUCACIÓN

BPL Equipment Technical Specifications

SESCO
TECHNOLOGY SOLUTIONS

IBEC BPL Products

PB-200 Consumer Modem

IBEC's Broadband over Power Line equipment has been specifically engineered to meet the needs of rural and underserved markets. Its cutting-edge BPL Headends, Regenerator Units, Customer Access Units, Couplers and Modems have been designed to cost effectively cover long distances with low population density, while working equally well in densely-populated areas.

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Empowering the World's Broadband®

ibec®
International Broadband Electric Communications

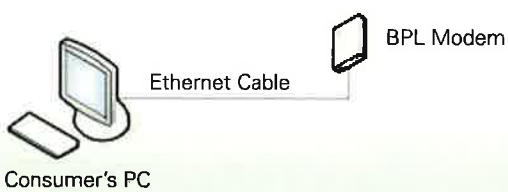
Technical Specifications

- Based on 200 Mbps DS2 technology DSS9001 chipset
- Alma backbone edition firmware
- IBEC access network optimized
- 10/100 Ethernet jack
- SNMP, telnet, web-managed
- Frequency: 2-32 MHz
- Output: -54 dBm/Hz, 10 MHz mode
- Operating temperature: 0 - 40°C
- Storage temperature: -30°C to +85°C
- Power: 100-240 VAC 50/60 Hz
- Power consumption: 4 Watts typ
- For US style outlets
- FCC part 15 class B, class G certification
- Approved to Ansi/UL 60950-1 and CSA C22.2#60950-1

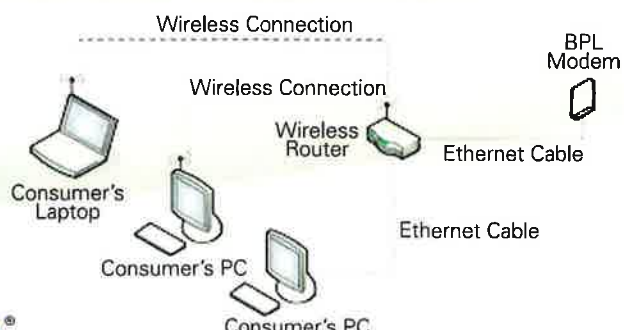
BPL Modem Installation

IBEC's BPL Modem plugs directly into a power outlet, then connects to the consumer's computer or router with a standard Ethernet cable.

Connecting Directly to a Computer



Connecting Through a Router



www.ibec.net

Empowering the World's Broadband®

IBEC BPL Products

Broadband Regenerator Unit (BRU)

(battery backup optional)

(Wireless optional)

IBEC's Broadband over Power Line equipment has been specifically engineered to meet the needs of rural and underserved markets. Its cutting-edge BPL Headends, Broadband Regenerator Units (BRU), Customer Access Units (CAU), Couplers and Modems have been designed to cost effectively cover long distances with low population density, while working equally well in densely-populated areas.

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the World's Broadband®

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International Broadband Electric Communications

Broadband Regenerator Unit (BRU) Technical Specifications

- Based on 200 Mbps DS2 technology, dual DSS9002 chipsets
- 10/100 Ethernet jack
- SNMP, telnet, or web-managed
- Per-modem integrated coexistence filters for modes 1, 2, 3, and bypass
- BPL output: 50 Ohms (F-type female), balanced or unbalanced
- Integrated IEEE 802.11 b/g wireless access point (optional)
- Operating temperature: -20°C to +60°C
- Storage temperature: -30°C to +85°C
- FCC part 15 class A, class G type certification
- EN61000-4-5 surge-compliant
- Designed to UL1950 requirements
- IEC IP67-compliant waterproof housing
- Power: 90-250 VAC, 50/60 Hz universal supply
- Sealed power connector
- 25 Watts power consumption

  Dimensions: 12 x 9 x 3.75 inches; .3 x .23 x .01 meters (LxWxD)
- Weight: 10 lbs; 4.5 Kg plus optional battery
- 2 hours of backup operation with included external battery
- Separate replaceable battery module, located outside of the BPL unit
- Ensures quick replacement and no network outage
- Ensures longer battery life by separating from internal electronics
- U.S. patents 5,864,284 6,040,759
- U.S. and International patents pending

Optional Battery Backup Specifications

- Operating Temp -20 to +60C
- 2 hour minimum backup operation
- Pole mounting or attach to BRU unit
- Proven sealed lead acid battery technology
- NEMA 4 rated housing and waterproof connections
- Easy battery access and replacement
- LED indicators to indicate status
- Network Monitoring via SNMP and Console commands
- Temperature compensation to maximize battery life
- Automatically tests and monitors battery conditions
- Typical battery life 3 to 5 years

Battery Backup Configurations

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This product has been tested and FCC-certified for use in the United States only with the IBEC coupler. FCC certification must be obtained before using this product in the United States with any other coupler.

IBEC BPL Products

BPL BRU-G3H Headend Injector Modem

IBEC's BRU-G3H Headends and BPL network fully support 802.1Q VLAN tagging which allows multiple bridged networks to transparently share the same physical network link without leakage of information between networks. IBEC's Broadband over Power Line equipment has been specifically engineered to meet the needs of rural and underserved markets. Its cutting-edge BPL Headends, Regenerator Units, Customer Access Units, Couplers and Modems have been designed to cost effectively cover long distances with low population density, while working equally well in densely-populated areas.

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