Broadband Powerline Communications
– Where Are We Now, February 2006.

Background

Broadband over Power Line communications, BPL, (aka Power Line Communications – PLC, or Power Line telecommunications -PLT), is a method of injecting and carrying high speed data over the electricity distribution network, or the transmission grid. BPL promises a broadband signal at every power connection, without the need for additional cabling.

Communications over power lines is not new, it has been used for communications and network control functions for many years. Recent availability of low cost semiconductor chipsets, together with increasing community demand for broadband services and improved access, especially in fringe and regional areas, has encouraged development of BPL technologies to meet perceived consumer needs.

Two basic types of BPL have emerged:

"In-House BPL" carries in-house data within a building typically using "Home Plug" standard modems at each access point. In-House BPL competes with Wi-Fi and conventional wired networks.

"Access BPL" provides broadband access into a building for services such as internet, VOIP telephone services, entertainment, gaming, video, remote meter reading, and other services typically provided by a service provider. The broadband signal is coupled (inductive or capacitive coupling) into the mains distribution wiring typically up to a hundred meters from the customer.

Access BPL may be carried on the local low voltage or medium voltage (LV or MV) distribution network or on the high voltage (HV) transmission network. Often, injection points are located at the medium voltage to low voltage transformer, and a series of repeaters used to increase the range from each injection point to the customer premises.

BPL systems inject multiple carriers on to the power line about every 1 kHz over a very broad frequency range (many MHz bandwidth segmented over the range 3-80MHz). Each carrier is modulated by the broadband data. Data speeds of around 200Mb/s are claimed achievable with the second generation (DS2) chipset. First generation chipsets achieve 45Mb/s. However, due to the 'branch and twig architecture' and inherent difficulties of using a largely unsuitable transmission medium, this speed is greatly reduced in real world networks, with 10Mb/s probably being more a realistic maximum data rate achievable at the customers premises.

Trials of BPL technology are occurring worldwide. Currently there are 23 active trials in the United States and 7 in Australia, http://www.acma.gov.au/ACMAINTER.65640:STANDARD:1047299885:pc=PC_2846

In NSW Country Energy has trialed 45Mb/s technology and in Tasmania Aurora Energy and its telecommunications subsidiary Tastel has the first Australian commercial trial, using 200Mb/s technology.

The Pro's and Con's

At first glance a broadband power line delivery system appears socially beneficial. The last hundred metre connection into customer premises is often the most expensive element in any service delivery. By 'illuminating' the power network, BPL proponents claim to be able to provide quality broadband services quickly and economically, especially in areas not currently well served, (city fringe and regional towns). Further, utilities can lever off existing infrastructure and 'bundle' broadband and telecommunications services along with electricity and gas.

Command and control of the power network, automatic load shedding, dynamic pricing, and remote meter reading are increasingly seen as important applications for BPL technologies, especially as energy costs increase and nations attempt to reduce carbon emissions.

However, many believe the potential social benefits of BPL are outweighed by external costs. Power lines were never designed to carry the high frequency signals used by BPL, and they certainly don't do it very well, being full of discontinuities and connected to notorious sources of electromagnetic noise. In fact they do it so badly that significant energy must be coupled into the line in order to achieve any useful transmission distance, causing high unnecessary and unintentional emissions across the entire spectrum occupied by BPL system carriers.

The interference potential from BPL to HF radio communications users is continuous, broadband, uniform across the frequency band used by the BPL system, very high level, and geographically widespread. The entire mains distribution system within the service area radiates the BPL signal, and the signal is always on regardless of traffic levels.

The potential for interference to a diverse range of radio communications users is very high, including FM broadcasting and television.

The UK regulator OFCOM performed measurements at Crieff UK, including interference regression with distance. "Below 30MHz the magnetic field regression, measured at 10, 30, 100 and 300 metres from the overhead line, was approximately 27dB/decade and the electric field regression, over the same path, varied between approximately 16 and 21dB/decade".

"Above 30MHz the electric field regression, measured at 10; 30; 100; 300; 1000 and 3000 metres from the overhead line, varied between 10 and 20 dB/decade."
http://p1k.arrl.org/~ehare/bpl/OfCom/OfCom_Summary_All.htm
http://www.ofcom.org.uk/research/technology/cet/powerline/

Interference from BPL systems exceeds the background noise levels at considerable distances from the BPL enabled area.

International Regulations

The International Telecommunications Union (ITU) is the world body for the co ordination and regulation of telecommunications. The Constitution of the International Telecommunications Union, is the basic instrument of the Union and, together with the Convention and the Radio Regulations, forms a binding treaty to which Australia is party.

Article 15.12 of the ITU Radio Regulations provides as follows:

15.12 Administrations shall take all practicable and necessary steps to ensure that the operation of electrical apparatus or installations of any kind, including power and telecommunication distribution networks, but excluding equipment used for industrial, scientific and medical applications, does not cause harmful interference to a radiocommunication service and, in particular, to a radionavigation or any other safety service operating in accordance with the provisions of these Regulations.
(Note that Article 15.13 imposes a similar requirement with respect to ISM equipment.)

The amateur service is a radiocommunications service as defined in the treaty.

The Radiocommunications Act, 1992, is the Australian instrument which gives effect to the ITU agreements. Section 197 of the Act prohibits a person from knowingly or recklessly causing interference to radiocommunications.

The ACMA Position

The Australian Communications and Media Authority (ACMA), formerly the Australian Communications Authority, (the ACA) is charged with administering the various instruments relating to radiocommunications, telecommunications, broadcasting, and electromagnetic compatibility and susceptibility, in Australia.

The (then) acting ACA chair commented, “the challenge for the ACA is to set regulatory arrangements that do not unnecessarily inhibit the adoption of BPL technology but at the same time protect radiocommunications services from harmful interference”.

The ACA published BPL trial guidelines through a web information portal in order to assist with minimising the potential impact of BPL trials. In April 2005, ACMA released a BPL Discussion Paper which attracted 275 responses from a wide range of organisations.

The majority of the submissions show a high level of concern regarding BPL interference and its management. The lion's share of the submissions--222 in all--came from radio amateurs, including a significant submission from the amateur radio peak body, the Wireless Institute of Australia (WIA).

Others were from telecommunications companies, broadcasters and government agencies. One commenter, telecoms provider Optus, recommended a "cautious approach" and expressed concern over potential BPL interference to its cable services as well as over the issue of regulatory and competition certainty. Broadband cable and DSL provider Telstra worried about interference to its broadband and HF radio services saying its calculations indicate "ubiquitous BPL could have serious consequences for cable modem networks" and could lead to "significant degradation of VDSL in cases where power and telecommunications lines are in close proximity." Commenting through their industry association--the Personal Emergency Response Services Association (PERSA), medical alarm providers concluded that electromagnetic interference from BPL to PERS is potentially severe, continuous and widespread. "BPL interference could prevent a call for assistance in a life-threatening situation, resulting in death or injury," PERSA asserted. Not surprisingly, submissions from the BPL industry recommend less-onerous management techniques.

ACMA have indicated they will review the BPL trial guidelines in response to submissions received, have consulted stakeholders, and embarked on a comprehensive examination of the communications regulatory issues.

Clearly ACMA are taking a light handed approach to BPL, not wanting to prevent a potentially beneficial technology from being trialed and further developed, while on the other hand attempting to administer their responsibility under the Radiocommunications Act to licensed radio communications users.

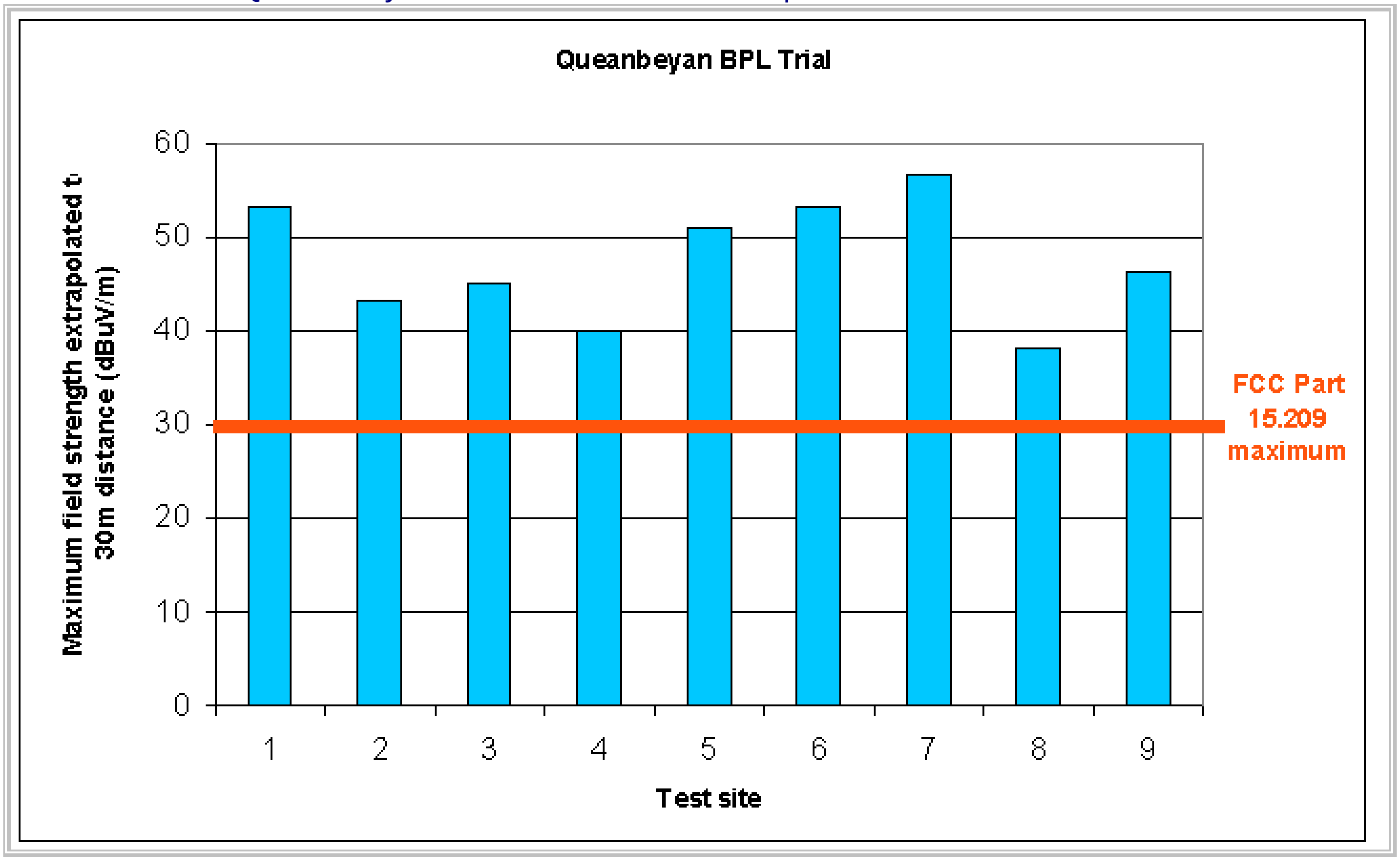
Some suggest ACMA is taking a more economic rationalist position than in the past and, in the absence of conclusive evidence of the economic viability of Access BPL, believe there is no need for immediate regulatory action - i.e. the problem may simply go away.

The Extent of the Interference Problem

ACMA measured interference unintentionally radiated emission levels at BPL trials in Queanbeyan and Moruya NSW. Their report "Queanbeyan BPL Trial Measurement February 2005" compares measured emission levels with the US FCC part 15 standards. All of the emissions were above the Part 15.209 maximum, and the range was 9dB to 27dB in excess, the average of 9 sites is 18dB in excess of the Part 15.209 maximum.

Telecommunications and IT consultant Owen Duffy, (VK1OD), published the measurement data of the Queanbeyan trial in graphical form, on his website. The chart, which is Duffy's presentation of the ACA's measurements documented in their published report, is reproduced below.

Queanbeyan BPL Trial emissions compared to FCC Part 15.209.



Duffy draws the conclusion, "An amateur radio station located in a residential environment where a similar BPL system was deployed would not be safely able to transmit at all on the 7MHz, 14MHz, and 21MHz bands because of the high risk of interference to possibly active stations that would not be heard through the BPL interference, effectively curtailing all activity on the band by such a station".

To date traceable interference measurements have not been published for the Aurora Energy trials in Tasmania using the new 200Mb/s technology. Aurora is continuing to make changes to the technology, and ACMA have indicated that they will not take measurements themselves while changes are likely to be made, (naturally, the results could easily be discounted).

Radio amateurs have made measurements at the Aurora Energy trial using a new technique for measuring field strength developed by Duffy and Hare. FSM (for Field Strength Meter) is a software application that extends a conventional SSB receiver to allow measurement and calculation of field strength of radio signals or interference.

FSM measurement data and observations by amateur radio operators suggest that the interference levels from the new technology Aurora Energy trial are also high, though possibly not as high as earlier 45Mb/s technology trials such as Queanbeyan. http://reast.asn.au/2006/Tasmanian%20BPL%20Trial%20Emissions%20Measurement%2020060202.pdf

One local Hobart radio amateur has filed an interference complaint with both Aurora Energy and ACMA.

Aurora claimed to have achieved a "90% reduction" in emissions after making modifications to the coupling method. Although a "90% reduction" might sound a lot to a lay person, it amounts to only a 10db power reduction and falls far short of what is required to ensure that interference is not caused to radiocommunications services.

The American Radio Relay League (ARRL) is the peak body representing 700,000 United States radio amateurs. The ARRL states; "Many, if not all, of the BPL designs that have been deployed to date suffer from a number of technological weaknesses. Perhaps the most critical of these is that BPL is seriously degraded by nearby transmissions from low-powered transmitters from sources like Amateur Radio or CB. In several BPL cities in the US, amateurs have done experimentation that shows that as little as 5 watts of power from a nearby radio transmitter can seriously degrade the performance of BPL. In some cases, the interference logged off a BPL user, requiring a reconnection to the network". http://www.arrl.org/tis/info/HTML/plc/degrade.html

Motorola released a new BPL delivery method which it claims greatly reduces the potential interference to (and from) amateur radio stations. Named "Powerline LV," it only uses the local low voltage LV line from the transformer to the home to deliver the BPL signal, using a "Home plug" type format. Motorola have also included proper RF level filtering for amateur radio frequencies at both the transformer injection point and the in-home modem. Unlike other access BPL technologies, the Motorola system only carries data when actually in use.

However, if the Motorola BPL system was used in Australia, unacceptably high levels of interference to HF users might still occur due to the greater length of line from the MV-LV transformer to the customer premises in our 240V system, and the likely necessity for higher injected power to enable the BPL signal to span that greater distance. However, the Motorola system appears to be a step in the right direction.

The Affect on Radio Amateurs

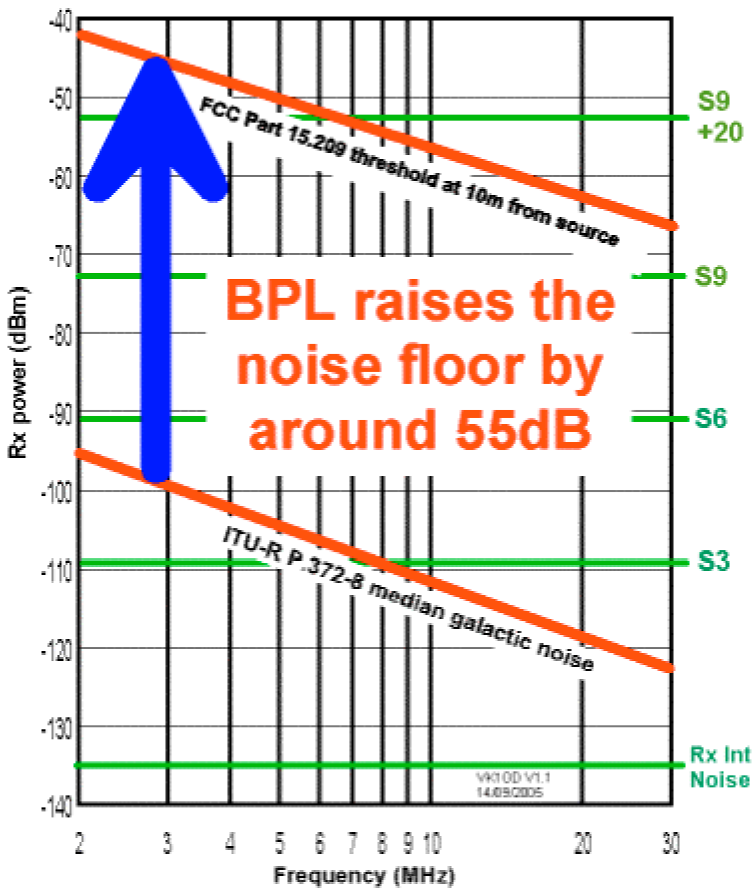
Amateur radio operators are particularly adversely affected by any interference, because they very often carry on communications using weak signals that are just above the local spectrum noise floor (RF noise background). Hence, signal-to-noise ratios are low – often considerably lower than those normally expected by other services. However, in sparsely settled rural areas, commercial and emergency service users are likely to also need to establish communications at similarly low signal to noise ratios.

Most amateur radio stations are located in suburban locations, where the spectrum noise floor encountered is generally tolerable for the majority of amateur radio activities and a proportion of radio amateurs are located in rural regions, where the spectrum noise floor is comparatively low, which permits operating with lower signal levels.

Amateur radio stations use antenna systems that are typically located within a suburban backyard and are not far from mains power lines. Even in rural areas, radio amateurs locate their antennas close to houses, not far from power lines.

The following graph by Duffy highlights the harmful effect of BPL operation at the FCC part 15 levels on HF radiocommunications. Australian BPL trials measured to date exceed FCC Part 15 levels. http://www.vk1od.net/bpl/AreYouReady.htm

The graph shows the expected receiver input power from the natural noise floor (galactic noise (from ITU-R P.372-8)); and the expected receiver input power from BPL that is of intensity sufficient to result in a maximum field strength of 30µV/m at 30m distance as specified by FCC Part 15.209. Duffy documents the assumptions underlying the model, and compares the model with measurements by Australia's communications regulator (ACA / ACMA) of an Australian BPL Trial of DS2 BPL. The graph's receiver power axis is scaled in both dBm and in "S-units".



Are you ready for BPL enablement of your home and neighourhood?

Notes:

The upper noise line is the noise at 10m from a radiator that is of intensity sufficient to result in a field strength of 30µV/m at 30m distance as specified by FCC Part 15.209. The interpolation uses the factor specified in 15.31(f)(2), and is done to reflect the realistic distance of an amateur receiving antenna from BPL excited power lines or power wiring. The assumption is that BPL operators will operate the system at the highest permitted power level to obtain the best speed / distance performance.

Many of the BPL systems trialed and measured in Australia and elsewhere have had emissions in excess of the FCC Part 15.209 specified limits (see below).

The lower noise line is the galactic noise level predicted by ITU-R P.372-8 formula (11). Galactic noise is the dominant source of noise above about 4MHz in quiet locations, and is unavoidable. At lower frequencies, galactic noise may fall off, but man made noise of similar intensity replaces galactic noise.

All predictions are for a receiver noise power bandwidth (NPB) of 2kHz. (Nominal 3kHz SSB voice receivers often have an NPB closer to 2kHz.)

Rx Int Noise is for a typical modern HF transceiver, older equipment might be up to 10dB to 15dB higher.

S values on the right axis are S-meter readings based on S9=50µV in 50O (-73dBm) and 6dB/S-unit.

BPL Standards Development

Standards development is largely a consensus driven process, and lack of progress towards the development of any meaningful international standard for BPL is a direct result of the huge gulf (some 50-60dB) between the unintentional emission levels that radio communications users can live with, and what BPL providers can make work. There seems little chance of arriving at any form of consensus anytime soon.

A good overview of the development of a BPL standard is at:
http://www.iee.org/OnComms/PN/emc/Broadband%20RF%20Emission%20From%20Data%20Networks.pdf

The BPL Industry Response to Radio Amateurs Interference Claims

Stakeholders in this battle strongly defend their positions. Radio amateurs proclaim BPL providers are reckless spectrum polluters akin to technological carpetbagers, and BPL providers view radio amateurs as technological Luddites who would deny broadband to the masses rather than give up their quaint hobby. “We can not have people ‘back in the days of pulse dialing systems’ lobbying against technology that will bring this country into the 21st century!”

In the face of mounting evidence of BPL generated interference, The PLC Forum proclaims, …“Even if the promoters of competing alternative infrastructures may be disappointed... there are still no cases of proven harmful interference despite tens of thousands of users, hundred of thousands of connected properties, and a number of independent and comprehensive measurement campaigns! Moreover, would any local EMC (electromagnetic compatibility) troubles appear, current features of PLC technologies enable the removing of emission frequencies to avoid such troubles”.

BPL proponents continue to deny the harmful effects of BPL interference in the face of enormous evidence worldwide to the contrary. Denying the existence of harmful interference has been the ‘modus operandi’. In the beginning, there was no interference, then there was some interference, and now it has become "who needs HAM radio?"

Ed Hare is the technical manager for the ARRL. Hare puts it this way:

"Assume you are a PSK-31 (slow digital mode) operator who has a 10-minute 'brag tape.' When you get on the air, a harmonic from your station blanks out your neighbor's TV. He complains. You switch to Morse CW, which "reduces" the interference to a steady on/off blinking. Will your neighbor think that the interference is improved?

"He complains some more, so you "notch" his spectrum by 20 dB. This "reduces" the interference from complete blanking to a strong herringbone. He can hear the sound now, but the picture blinks on and off with a herringbone under which one can just make out the picture.

"You then tell him that you have done all that you are going to do, but if he has interference on another channel, you will be willing to consider fixing it. You then tell all of your neighbors that you have fixed his problem, but that he is pretending that you didn't and his complaints are not valid.

"He knows all this, and, having seen you lie, he knows that if he indicates in any way that the interference isn't quite as bad as it was, he can expect that you will tell all your neighbors that you admitted that he fixed it. And you know that if you do recognize this non-fix as the least bit improved, you will lessen the chances that anyone will require him to fix the remaining, serious interference.

"This is exactly what the City of Manassas (in the US) and COMTek (a US BPL provider) are doing. Any incremental improvements have not dropped the interference below the level of serious, ongoing, widespread harmful interference. Instead of S9+30 dB, it's now "only" S9. That is not a change in the interference status".

Is HF Radio Dead?

Another pro-BPL argument is that HF radio is mostly dead, and any services that still exist could be moved off HF onto satellite or the internet. However, HF radio is enjoying somewhat of a resurgence. New digital streaming techniques for HF broadcasting, such as Digital Radio Mondiale (DRM) can mostly overcome HF's disadvantages including annoying fading and noise, and also provide improved sound quality.

Cyclone Katrina and the tsunami in Asia proved beyond doubt the benefit of HF radio, being a simple, easy to deploy, long range communication system which does not rely on any infrastructure. In fact, amateur radio operators are routinely first on the scene at disasters providing critical first line communications until government and emergency communications systems are activated. http://www.rsgb.org/news/tsunami.htm

Australia relies heavily on HF radio. The ACMA licence register identifies 33,000 licensed HF radio users. Military, civilian, aviation, and emergency communications systems rely heavily on HF radio. HF radio is a valuable backup system to other long range communications systems used by many agencies including the Department of Defence.

Clearly, the success or otherwise of BPL depends largely on its economic viability and its ability to attract customers in the face of stiff competition from other broadband technologies. Experience in the US is mixed with some trials claiming success and others terminating for various reasons, including poor economic viability and competition from other technologies.

Many believe if BPL is to find a place it is likely to be in city fringe or regional towns which are not well served by other broadband technologies. Even in these areas, given recent initiatives by Telstra to speed their rollout of broadband optical fiber, the window of opportunity for BPL may be quite short. BPL may find its major application in niche markets such as security, industrial, or in-building applications.

Radio amateurs are not opposed to any technology which will improve access and competitiveness of any service, BPL included. Radio amateurs are strongly opposed any technology that causes such very high levels of electromagnetic interference they can no longer enjoy their hobby.