Broadband Powerline Communications Systems

A Background Brief

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Contents

Introduction

This paper provides an introduction to broadband powerline communications systems and the potential issues relating to their widespread use in Australia. It examines the current status of technology development and reports on the regulatory arrangements currently in place and being developed overseas to cope with the issues raised by the use of these systems. Current Australian arrangements are also reported.

This paper was prepared following concerns raised in Australia about the risk of interference to HF radiocommunications services from broadband powerline communications systems. It is has been prepared to assist with further deliberation on these systems.

What are Broadband Powerline Communications Systems?

Broadband powerline communications systems, also known as powerline telecommunications (PLT) systems or broadband powerline (BPL) systems, are a new type of powerline communications (PLC) system capable of providing significantly higher data rates than previous PLC systems. They have the potential to provide simplified in-house interconnection of computers and peripherals, and cost effective last-mile delivery of broadband data services.

PLC systems consist of terminal devices that are plugged into or attached to the electrical power supply network and allow data to be transmitted via the network to other terminal devices plugged into or attached to the network. The use of the existing electrical power supply network wiring reduces costs and provides convenient access to broadband interconnection between devices.

Historically, powerline communications systems had been limited to relatively low data rates - typically less than 500 kbit/s. These low data rate systems are still in use and are used in such applications as the remote control of switches in domestic installations and by power supply authorities. Examples include domestic appliance control systems, off-peak hot water supply control systems and power supply authority switch yard control and monitoring systems.

What makes these systems different from previous systems?

The speed of data transfer and the frequencies used to transfer the data across the electrical supply network are what make these new systems different to previous systems. These new broadband systems provide significantly higher data rates of 4 - 20 Mbit/s, some ten to forty times faster than earlier PLC systems.

These data rates are comparable with early Ethernet (a common wired local area network) systems used to interconnect computers; the growth of information technology and multimedia in particular has created a need for broadband data transfer between many different devices.

Technology

The Wiring

The wiring in place to supply electrical power to, and within, homes and offices was not designed to carry high-speed data at high frequencies. It was designed to carry large currents at high voltages alternating at 50 or 60 Hertz so that significant amounts of energy could be delivered conveniently to consumers, at one primary very low frequency. Powerline communications systems can "piggyback" on this wiring – subject to various limitations – to provide connections between their terminals. As this wiring is not shielded, radiofrequency signals passing along it are in part, and unavoidably, radiated from it. One issue then is whether these radiated signals might interfere with radiocommunications.

The frequent uncontrolled connection of appliances and other loads to this network means that, unlike other wire based telecommunications networks, the electrical supply network does not have well defined physical or electrical characteristics relevant to the data rates used.

Impedance mismatching of devices connected to the network can result in significant signal loss (nulls) at particular frequencies, which will inhibit the use of those frequencies for communications. The location and depth of these nulls will change depending on both where a terminal device is plugged into the network and where and what other devices (appliances, etc) are connected to the network. See the example in Figure 1 below.

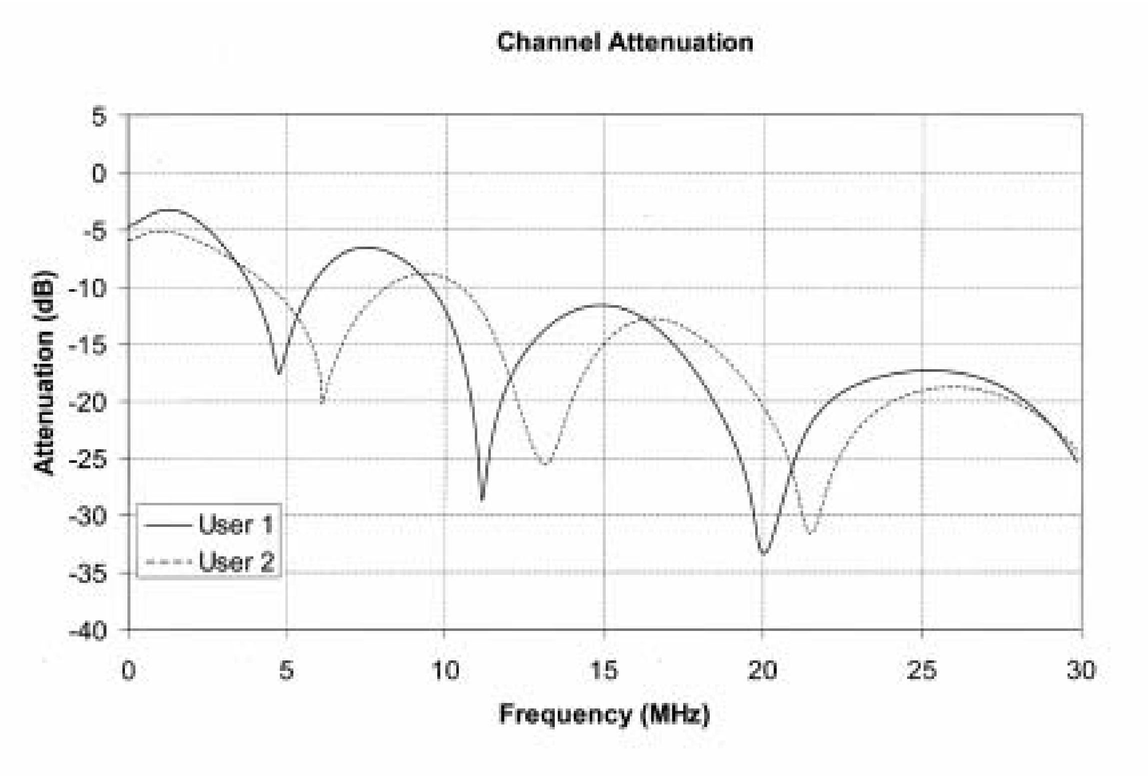

Figure 1

These network characteristics place a need on the terminal devices used in powerline communications systems to be adaptive in how they interact with the network.

The Devices

Broadband powerline communications systems typically use a number of carrier frequencies in parallel in order to spread the data over a wider range of frequencies. This allows individual carriers to be turning on or off with less impact on the overall data rate of the system. This makes the communications less vulnerable to nulls, or interference from noise or other devices connected to the network.

Low data rate PLC systems utilised frequencies in the range 9 kHz and 525 kHz. In this frequency range the risk of emissions is low as the attenuation of the cable is low and the wavelengths used in the signalling are long with respect to the typical cable lengths in the system.

Broadband PLC systems use much higher data rates; these cannot be accommodated in the bandwidth available below 525 kHz. Instead, these systems typically use carrier frequencies in the range 2 - 30 MHz[1]. The use of higher frequencies leads to greater attenuation of the signals along the cable. The shorter wavelengths associated with these frequencies are now more typical of cable lengths found in the network and this increases the likelihood of nulls from open circuits occurring. These effects rapidly increase with frequency, effectively limiting the use of frequencies higher than the typical values indicated above. As well, the cables are becoming more effective radiators of electromagnetic waves.

The level of general electrical noise on the electrical power network requires PLC systems to utilise high levels of error protection coding and robust modulation techniques.

Broadband Powerline Communications System Applications

The applications for broadband powerline communications systems fall into two broad categories:

- in-house applications; and
- last-mile applications.

In-House Applications

These applications occur within a single building with both ends of the communications link within the same building. The building might be a house, an apartment block or an office building. The path over which the transfer of data occurs within these buildings is relatively short - typically it is less than 100 m between devices.

[1] Systems using higher carrier frequencies up to around 80 MHz have been discussed in the literature.

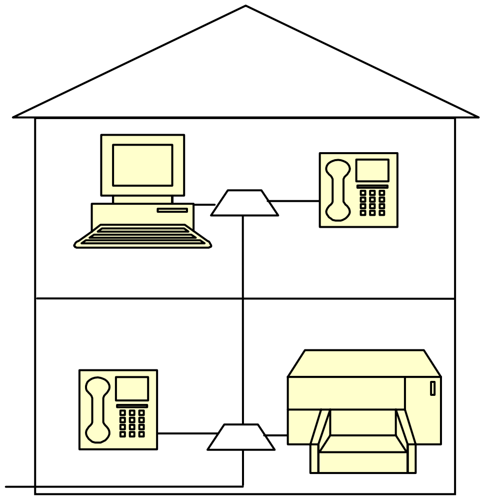

Figure 2

Broadband powerline communications systems are seen as an attractive means of retro-fitting of data services to existing buildings because no additional wiring is necessary. The networking of computers, printers and other telecommunications services by simply plugging into the existing AC supply wiring is attractive for both home use and small office systems[2].

Systems have been successfully developed overseas for these short distance in-house applications under existing Electromagnetic Compatibility (EMC) requirements for digital information technology (computer) equipment. This has been possible due to the relatively low power levels necessary to communicate over the comparatively short (cabling) distances within a building.

The development of technology for computer networking in-house applications is fairly advanced, with industry standards for terminal devices already in place allowing interoperability between devices from different manufacturers (eg, HomePlug 1.0). These devices, because of their relatively low cost (approximately AUS $250[3]) and ease of use, are now becoming available in Australia.

Other applications include the use of these systems for sound and video distribution, and appliance switching and control, within the home. To date, these opportunities have not been developed, or taken up by consumers, to the same degree.

Last-Mile Applications

These applications typically include the distribution to the home or office of Internet and other services by broadband service suppliers. In addition to broadband Internet connections, these broadband distribution systems are intended to also provide voice (IP telephony), video (VHS video quality), surveillance systems, entertainment (gaming) and utilities metering (electricity/water/gas) services.

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[2] In principle, the terminal devices used in these systems could potentially be used to link adjacent buildings as well.

[3] This market entry price is similar to the market entry price of 802.11b RLANs a few years ago, and suggests in-house broadband powerline communications solutions are likely to become a highly competitive alternative to wireless SOHO networking.

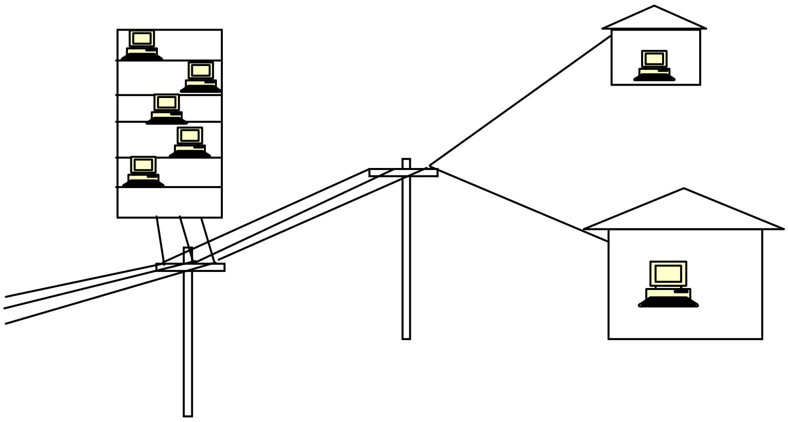

Figure 3

A significant proportion of the cost of providing broadband services to the public is associated with the so called last-mile connection between the network and the individual user. The provision of cabling to and into each building represents a significant cost and inconvenience due to the differences between buildings and the lack of an existing infrastructure within the building.

The technology for this category of application is less well developed, mainly due to the need for higher signal levels for the longer last-mile paths. Higher signal levels mean higher levels of emissions, and these have not been possible to contain within existing EMC requirements in most cases.

There are, however, some cities in overseas countries where the building density, the configuration of the AC power line network (eg, underground) and the existing broadband data network infrastructure have been such that it has only been necessary to use outdoor powerline communications systems over distances of a few hundred metres. This has allowed the use of devices with signal levels similar to in-house systems.

Mains Power Supply Networks across the World

Power supply networks are not the same around the world. For example, the obvious difference between Australia and the USA is the (nominally) 120 volts/60 Hz supply in the USA and 240 volts/50 Hz supply in Australia. There are also other differences such as network configuration and how the power is distributed to the average household.

The main characteristic of significance for last-mile broadband powerline communications systems is whether the power lines fed to the household are balanced[4]. If the broadband system can supply its signal on a pair of balanced wires, then the

[4] Communication over wires requires two lines to complete the circuit. A balanced wire circuit is one in which the two sides are electrically alike and symmetrical with respect to ground and other conductors. A common example of a balanced wire circuit is a twisted line-pair used in a telephone circuit. In an unbalanced wire circuit one line is typically grounded to earth. A common example of an unbalanced wire circuit is a coaxial cable connecting a TV antenna to a TV receiver - the outer shield is usually earthed and the signals are conducted from the antenna to the receiver via the central wire. In this case, note that the outer shield effectively prevents the signals from being radiated along the length of the cable – in an unbalanced powerline circuit there is no equivalent shielding so the signals on the unearthed line are free to radiate from that line.

emissions from the two wires tend to cancel each other out. Emissions from a balanced pair of wires tend to be less than from an unbalanced pair of wires.

A general description of the mains power supply networks in the USA, Japan, Europe, UK and Australia is available in Appendix B.

In the USA, Europe and Japan, signals are able to be introduced to the home using balanced power lines. In Australia and the UK, these signals must be introduced to the home on electrical infrastructure that uses unbalanced lines.

There are significant differences between in-house wiring and outdoor supply distribution networks in most parts of the world. Indoor wiring is generally bundled with the conductors in close proximity, which assists in limiting radiation from that wiring. Typically, outdoor supply distribution networks are made up of long runs of well spaced open aerial wiring. The location and the spacing of this open aerial wiring typically leads to higher levels of radio emissions from this type of cabling than is the case from closely bundled in-house cabling.

What Issues do these Systems Raise?

There are a number of issues raised by the introduction of broadband powerline communications systems. These issues can be categorised as falling into three areas:

- compatibility between private and public networks;
- telecommunications policy issues; and
- radiocommunications interference issues.

Compatibility Issues

The two application types, that is, in-house and last-mile, explored above are not necessarily compatible. The non-isolated electrical interconnection of private in-house networks and broadband data distribution supplier networks, both attempting communications over the same physical wiring, can lead to interference between systems. As well, separate in-house systems in high density areas such as apartment buildings are likely to suffer mutual interference that will lead to degraded performance even when using interoperable equipment.

Noting also that the last-mile powerline infrastructure is owned by a Utility, the Utility might be particularly concerned at the potential pollution of its infrastructure, or the diminished utility of that infrastructure, from signals introduced on it from private households.

There are other compatibility issues associated with existing supply authority systems and the electrical power supply network, for example, electrical safety requirements, protection of signalling needs of powerline authorities, and potential effects on other electrical devices.

Arguably, resolution of these aspects will need detailed consideration by all stakeholders, including manufacturers, Utilities and relevant regulatory bodies.

Telecommunications Issues

Last-mile broadband powerline communications systems have the potential to provide an alternate means of delivering broadband telecommunications services to the public. The electrical power distribution network is, however, unlike other guided public telecommunications networks. The communications characteristics of the network are less controlled with large numbers of non-telecommunications devices being constantly added and removed from the network.

The lack of isolation between private networks and public networks raises such questions as interference to public networks, compatibility of systems and carrier licensing requirements. The full extent of public telecommunications issues arising from widespread use of broadband powerline communications systems will need further investigation.

Radiocommunications Issues

The main radiocommunications issue raised by the widespread use of broadband powerline communications systems is the risk of interference to radiocommunications services caused by their generation of electromagnetic emissions from the powerlines over which they operate.

Open wire aerial powerlines in particular freely radiate high frequency signals being passed along their length. There are many case histories within the records of the Australian Communications Authority (ACA) and its predecessors of signals radiated from powerlines causing interference to radiocommunications services. The high frequency signals in these case histories have been typically generated by faults in the wired network such as arcing switch gear, coronal discharge and discharges across dirty insulators.

Similar experiences across the world experience have led many to believe that the deliberate placement of high frequency signals on powerlines by broadband powerline communications systems will lead to large scale interference problems for radiocommunications services particularly in the high frequency (HF) spectrum (3 to 30 MHz). Current radiocommunications uses of this spectrum include amateur radio, aeronautical and maritime communications and navigation services, broadcasting, and fixed and land mobile operations. HF communications is particularly important in Australia for long distance communications, and some of these services have defence or safety-of-life implications.

Radiocommunications services using frequencies above 30 MHz may also be at risk from some broadband powerline communications systems, though this does not seem to be as significant an issue, judging by current overseas concerns and developments.

Are these Devices Radiocommunications Transmitters?

Given the level of concern regarding the potential interference to radiocommunications services, it is useful to examine whether broadband powerline communications systems may be regulated under the Radiocommunications Act 1992 (the Act).

Broadband powerline communications systems consist of two of more terminal devices connected via the AC power supply network. Broadband powerline communications systems (that is, the system comprising the terminal devices and the connecting powerlines) fall under the definition of a “transmitter” as set out in subsection 8 (2) (b) of the Act because they give rise to radio emissions even though these emissions are not intentional. However, broadband powerline communications systems are not “radiocommunications transmitters” as the intended path of communications between the devices is through the wiring of the AC supply network, not by radio waves. The electromagnetic radiation from the wiring is an unintentional consequence of the communication along the wiring.

Applying the methodology set out in RALI MS 27 “*Determining the Applicability of Licensing and EMC Regimes to Transmitters*” leads to the conclusion that broadband powerline communications systems could in principle be regulated through the ACA’s EMC regime, if required. However, applying the Act to regulating a system where radiation from the interconnecting wires is the main interference source, rather than the terminal devices themselves, has yet to be tested.

Overseas Arrangements

There is significant interest in the use of broadband powerline communications systems around the world. This interest is fuelled by the demand for broadband data distribution systems and the development of a world market for this technology.

United States of America (USA)

The regulatory body for radiocommunications and telecommunications in the USA is the Federal Communications Commission (FCC)[5]. The FCC enforces mandatory requirements for telecommunications and radiocommunications systems. The USA is also home to at least one industry based standard (HomePlug) for broadband powerline communications systems.

Federal Communications Commission (FCC)

Powerline communications systems have developed in the USA under Part 15 of the FCC Rules and Regulations, which is equivalent to Australia’s class licensing regime. This part of the FCC Rules and Regulations relates to requirements for unlicensed low power radiocommunications devices and emissions from non-radiocommunications digital equipment that might otherwise cause electromagnetic interference (EMI) to radiocommunications services.

Powerline communications systems are treated in Part 15 as non-radiocommunications digital equipment. They are referred to in this Part as current carrier systems and specific arrangements are in place for systems operating on frequencies in the band 9 kHz to 30 MHz. The FCC Rules and Regulations specify limits for both conducted and radiated

[5] The National Telecommunications Information Administration (NTIA) has responsibility for federal government use of spectrum.

emissions[6] for current carrier systems. Section 15.107 sets out the conducted emission limits for all Part 15 devices connected to the AC power supply, including devices used in current carrier systems. It appears that these requirements apply to the terminal devices only.

The radiated emission limits for current carrier systems [15.107(c)(3)] [15.109(e)] are the general radiated emission limits for non-specified devices that radiate either intentionally or unintentionally. The limits for conducted emissions set out in FCC Rules and Regulations section 15.107 and the limits for radiated emissions set out in section 15.109 are reproduced in <u>Appendix A</u>. These limits are significantly higher (> 100 times) than limits found in the regulation of other countries for these devices at HF frequencies.

The FCC in April 2003 [ET docket No.03-104] initiated an enquiry into current carrier systems, including broadband-over-powerline systems, to obtain information on a variety of issues relating to these systems. The enquiry sought technical information and data to allow an evaluation of the current state of the technology and to determine whether changes to Part 15 are necessary to facilitate the deployment of this technology.

The closing date for comment was initially set as 7 July 2003 but was later extended to 20 August 2003 due to the large number of comments (filings) made. The period in which responses to the filings can be made is expected to close in late September 2003. The FCC initiated this enquiry as part of its statutory mandate to encourage new technologies. (Renewed world wide interest in powerline communications systems seems in part to be a consequence of these developments in the USA.)

A brief examination of some of the initial comment filings made to the FCC indicates that various respondents are concerned about the risk of interference from powerline communications systems to radiocommunications, including the NTIA and the amateur radio community. Concerns have also been expressed regarding possible interference to cable television services and digital subscriber line services using aerial cables in close proximity to powerlines.

HomePlug

The HomePlug power line alliance is an industry grouping in the USA consisting of seven sponsoring companies including Cogency, Panasonic, RadioShack Corp. and Sharp. The alliance has some twenty participating members including Motorola, Philips Electronics, Sony Corp. and France Telecom. The alliance has developed the HomePlug standard specifically for in-house systems and meets the current FCC Part 15 requirements for current carrier systems.

The HomePlug standard strives to provide interoperability between consumer devices by setting out a media access control protocol as well as the physical signalling techniques to be used by devices. The media access control allows multiple devices to be connected to the network within the building. The media access control specification includes data encryption levels, priority communications and latency control. The physical signalling uses a form of orthogonal frequency division multiplexing (OFDM) modulation using up to 76 carriers in the band 4.5 MHz to 21 MHz.

[6] "Conducted emissions" refers to guided electromagnetic energy that is generated within a device and travels out along the cables connected to the device, for example, on an AC power cord. "Radiated emissions" commonly refers to electromagnetic energy that is radiated directly from the case of a device.

The HomePlug standard provides for a typical throughput rate of 14 Mbit/s with the potential for up to 20 Mbit/s when all carriers are in use. The physical layer standard provides for carrier channel selection (channel adaptation) and carrier modulation selection (DBPSK/DQPSK)[7] in conjunction with variable levels of forward error coding to allow adaptation to the transmission path between devices. Devices complying with the HomePlug standard meet FCC Part 15 requirements.

Europe

The use of broadband powerline communications systems in Europe is in some ways more developed than in the USA. Last-mile systems are in use and growing in a number of European countries including Finland, Iceland, and Russia. The basic legal framework under which harmonised regulatory arrangements for these systems are being developed is that established to meet the requirements of European Economic Community EMC Directive 89/336/EEC.

European Conference of Postal and Telecommunications Administrations (CEPT)

The European Communications Committee (ECC) of CEPT has considered in ECC Report 24 (May 2003) the compatibility between cable communications systems, including powerline communications systems, and radio services. This report includes measurement results from PLT field trials held in Norway, Germany and Finland. The report also considers the compatibility of three other high data rate cable communications technologies including Digital Subscriber Line (DSL), cable TV and Local Area Network systems.

The report finds in its general conclusions that the electromagnetic spectrum below 30 MHz needs special protection and that “the risk of interference to radio services depends not only on compliance with a radiation limit but also on the different network structures and technologies as well as the frequencies used. For example, owing to the type and properties of cables installed, the structure of the network, the risk of interference caused by high frequency powerline systems is much higher than with DSL or cable TV systems.”

The report states that the European Commission has entrusted (Mandate 313) the European Committee for Electrotechnical Standardisation (CENELEC) and European Telecommunications Standards Institute (ETSI) with the task of developing a set of harmonised standards covering the electromagnetic compatibility (EMC) requirements for telecommunications networks using those using powerlines, coaxial cables or telephone wires.

European Telecommunications Standards Institute (ETSI)

The ETSI Technical Committee TC PLT has already produced standards for reference network architecture (TS 1010896) and coexistence (sharing) arrangements between in-house and last-mile systems (TS 101867). Other standards in development cover detailed in-house architecture and protocols. It should be noted that all of these standards

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[7] DBPSK Differential Binary Phase Shift Keying - a highly robust two bit per symbol modulation that allows for clock recovery. DQPSK Differential Quaternary Phase Shift Keying - a robust four bit per symbol modulation that provides higher data rates with only a small loss in robustness.

are dealing with telecommunications aspects and that none directly address potential interference issues for radiocommunications systems.

The Technical Committee is working through CENELEC with the International Electrotechnical Committee specialist body CISPR (the International Special Committee on Radio Interference), on EMC issues related to powerline systems. The CISPR standard for information technology equipment conducted limits at mains terminals and telecommunications ports (CISPR 22), together with its European counterpart EN 55022, are in the process of being updated to include changes clarifying their application to powerline systems.

Currently, several European countries have adopted their own requirements for powerline communications systems. These include: Germany, where limits for emissions from all cable systems are set out in NB30[8]; and the United Kingdom - covered by MPT 1570, which has been recently updated. There is also a limit proposed by Norway. See Appendix C for a comparison of these limits, as taken from ECC Report 24.

In summary, the European Communications Committee has identified a significant risk of interference to HF radiocommunications services (ECC Report 24). Based on these findings, Europe is currently developing a range of telecommunications and other harmonised standards specifically covering broadband powerline communications systems. There is, however, a growing number of systems already being deployed in Europe and surrounding countries to provide last-mile broadband services using devices compliant with EN 55022.

United Kingdom

The Radiocommunications Agency

The Radiocommunications Agency is an Executive Agency of the Department of Trade and Industry. This Agency is responsible for the management of the non-military radio spectrum in the UK. This role includes allocating spectrum and licensing its use, and preventing pollution of the radio spectrum.

The Minister for Small Business and E-Commerce in November 2000 announced a package of measures for the control of potential interference from the telecommunications systems digital subscriber line (DSL), power line technology (PLT) and home local area networks (LANs). One of the measures announced was the development of a new standard to limit interference from DSL and similar broadband technologies based on the specification MPT 1570.

When the document was first released it covered emissions from all cable systems using frequencies up to 300 MHz. After further consultation a revised specification MPT 1570 (2001) was released; this was further revised in January 2003 and the specification now covers emissions from all cable systems using frequencies up to 1.6 MHz.

[8] NB30 is a usage provision in that country's Frequency Band Allocation Ordinance (ie, a spectrum plan). The limits in NB30 are slightly higher than the effective limits derived from emissions in trials based on equipment meeting CISPR 22 requirements.

The British Broadcasting Corporation (BBC)

The BBC commissioned several reports (J.H. Stott, 1999 / J.H. Stott, 2000) into the potential effects of widespread use of cabled data services on HF radiocommunications services. Shortly after these reports were published the Radiocommunications Agency commenced its development work on MPT 1570. The BBC has proposed limits developed from these reports to protect HF radiocommunications services. These limits have been specifically developed to protect sensitive HF services from aggregated use of powerline and other data systems. These limits are the most conservative of the limits examined in ECC Report 24.

Japan

The Ministry of Telecommunications

The Japanese Ministry of Telecommunications is the regulator of the postal system, telecommunications systems and radio frequency usage in Japan. Currently, systems are limited to the use of systems with operating frequencies below 450 kHz.

Systems using frequencies below 10 kHz require permission from the Minister and systems operating on frequencies between 10 – 450 kHz require notification to be given the Ministry.

Efforts have been made by the Association of Radio Industries and Business (ARIB) over the last few years to gain access to frequencies between 2 and 30 MHz for broadband powerline systems in Japan. This has included trials in Akagi held in January 2002 and further trials held in June 2002. The Ministry currently considers the risk of interference to radiocommunications services from these systems too great to permit widespread use.

International

International Electrotechnical Commission (IEC)

The IEC is the leading global organisation that prepares and publishes international standards for all electrical, electronic and related technologies. Work related to broadband powerline communications systems is currently being undertaken by the IEC International Special Committee on Radio Interference (CISPR).

International Special Committee on Radio Interference (CISPR)

CISPR has developed a range of EMC standards for electronic equipment that have been widely adopted by regulatory authorities around the world, including Australia. CISPR Standard 22 on the limits and measurements of emissions from information technology equipment is currently in the process of being updated. The CISPR 22 work program includes a project to provide clarification of the application of CISPR 22 to PLC equipment (project number: CISPR 22 Amd.2 f9 Ed.3). This work was scheduled for completion in August 2003; however, due to the level of debate regarding the impact on radiocommunications services from powerline systems the work is still uncompleted.

The debate is centred on the appropriateness of the conducted signal measurement methods and limits in CISPR 22 (which are intended to limit the amount of radiofrequency energy finding its way from information technology equipment onto mains power networks). (The radiated signal limits and measurements methods would only be applicable to the cases of powerline communications terminal devices and radiation from the case of these terminal devices does not present a significant interference risk.)

PLCforum

PLCforum is an international industry association representing the interests of manufacturers, energy utilities and research organisations active in the field of last-mile and in-home power line type systems. PLCforum was established in early 2000 through the merger of two existing associations to lobby for satisfactory regulatory frameworks for PLC, to pursue coexistence and interoperability standardisation and support the marketing and financial models of its members.

The forum organised a world summit of PLC Associations in Brussels in June 2003 to discuss aspects of international standardisation and the need to lobby for a common regulatory approach by regulators.

Domestic Aspects

Broadband powerline communications system terminal devices for in-house applications have recently begun to be marketed in Australia[9], and an electrical supply authority has approached the ACA recently about conduct trials of equipment for last-mile applications.

Arrangements in Australia for Existing Powerline Communications Technology

Some powerline communications systems terminal devices are currently regulated under the ACA EMC regime. Specifically, powerline communications systems using frequencies in the range 3 kHz - 525 kHz must meet the requirements of one of two standards:

- EN 50065-1 Signalling on low voltage electrical installations in the frequency range 3 kHz to 148.5 kHz- Part 1; or
- IEC 61000-3-8 Electromagnetic Compatibility (EMC) – Part 3: Limits, Section 8: Signalling on low voltage electrical installations using signals in the frequency range 3 kHz to 525 kHz.

These existing arrangements for powerline communications systems do not apply to broadband powerline communications systems, which utilise HF frequencies (3 MHz to 30 MHz) and above. The current ACA Fact Sheet on EMC requirements for powerline communications equipment[10] indicates that there are no mandatory standards for PLC equipment using frequencies above 525 kHz, and advises that penalties may apply in accordance with Section 197 of the Act to individuals or companies who knowingly or recklessly cause interference to radiocommunications.

[9] A Google search will reveal an amount of Australian based marketing information, including recent media announcements, promoting this technology solution for in-house LAN applications.
[10] http://www.aca.gov.au/consumer_info/fact_sheets/industry_fact_sheets/fsi23.pdf

Risk Management

There would appear to be a potential risk to HF radiocommunications services from the widespread use of broadband powerline communications systems; the risks appear to be associated with in-house applications as well as last-mile applications. This can be seen in the early filings to the FCC enquiry into powerline communications and the findings in ECC Report 24. There have now been broadband powerline communication trials held in the USA, Europe and Asia. The results of these trials have not alleviated concerns over the potential interference risk to radiocommunications.

Currently there are broadband powerline communications terminal devices being marketed in Australia. These devices are unlikely to comply with the conducted limits of CISPR 22, as signals are being intentionally injected into the electrical mains wiring. The interference impact on radiocommunications reception and the susceptibility of mains connected equipment to increased conducted emissions from broadband powerline communications equipment is unknown.

This uncertainty is due to two factors:

- the unknown emission efficiency of the connecting AC supply network which depends upon physical layout; and
- the differences between the conducted signal characteristics (level, bandwidth, duration, etc) of these devices in comparison to emissions currently limited by CISPR 22.

The Australian mains power distribution network is not identical to that in Europe or the USA[11]; this may lead to differences in the level of radiated emissions from broadband powerline communications systems.

The applicability of CISPR 22 as a standard for devices used in broadband powerline communications systems is currently being debated. The proposal is to amendment the scope of CISPR 22 to include PLCs and to prescribe conducted limits for these devices that are considerably higher than the current restrictions. This work may take some 2-3 years to complete.

While as a general principle, the ACA seeks where possible to align its management arrangements in Australia with those in place in other regions this is not always possible or appropriate. Europe and the USA have greater degrees of urbanisation than Australia and the weighting placed on the protection of HF services in those countries may well be less than that required in Australia.

[11] See Appendix B for a brief description of the AC power supply networks of several different countries mentioned in this paper.

General Summary

Electromagnetic Compatibility

Overseas and in Australia the spectrum polluting effects of some types of powerline communications systems are regulated under EMC regimes. Internationally, arrangements are still being developed to accommodate broadband powerline communications systems. A watching brief on current standards development work being carried out overseas should be maintained. The proposed changes to CISPR 22 are of particular interest – Australia has input into CISPR through Standards Australia (SA), and the ACA has representation on the relevant EMC committee in SA.

There may be some anomalies in local industry claims regarding compliance with existing ACA EMC standards – this falls under the ACA's regulatory powers to investigate, and to take appropriate regulatory action, as required.

Significantly, differences between the Australian powerline environment and overseas countries developing standards for broadband powerline communications systems might lead to "safe" limits in those countries being "unsafe" in the Australian context. This area would seem to need further investigation. In due course, developments in the UK might provide a valuable guide, because of the apparent similarities in the AC power supply networks of the two countries. However, there is a risk that overseas findings (and therefore standards' limits) might not be directly transferable into this country.

Public Telecommunications

There are potentially various public telecommunications issues raised by the introduction of broadband powerline systems. The sharing of lines that could be used for private and public communications suggests the need for pre-planned arrangements. Noting that powerline circuits have continually changing electrical characteristics arising from such things as changing electrical loads and faults, quality of service requirements and expectations on such networks might need addressing, along with carrier licensing requirements. Arguably, these areas will need further investigation.

Stakeholder Organisations

The analysis in this paper suggests that there is a range of issues falling across various parts of the telecommunications industry. Broad consultation will be necessary to develop an appropriate regulatory regime to facilitate the expected growth in this technology, whilst ensuring appropriate protection against interference to radiocommunications. Domestic stakeholders who are likely to have in interest would include:

Australian Broadcasting Authority – EMC
Australian Communications Authority – EMC and public telecommunications
Australian Communications Industry Forum - public telecommunications
Australian Maritime Safety Authority – EMC
AirServices Australia - EMC

Department of Defence - EMC
Electrical Supply Association of Australia (ESAA) – AC supply system issues
National EMC Forum – EMC
National Office of Information (NOIE) – Broadband issues
Wireless Institute of Australia - EMC

Bibliography

Australian Communications Authority, ACA, RALI MS 27, "DETERMINING THE APPLICABILITY OF LICENSING AND EMC REGIMES TO TRANSMITTERS", Australia, July 1998.

British Standard, BS EN 50065-1, "signalling on low-voltage electrical installations in the frequency range 3 to 148.5 kHz", Britain, 1992, with European amendments up to 1996.

CENELEC, EN 55011, "Radio disturbance characteristics of Industrial, and Scientific and Medical (ISM) equipment", 1998.

CENELEC, EN 55022, "Information Technology Equipment (ITE) – Radio disturbance characteristics – Limits and methods of measurement", 1998.

European Commission, "Standardisation Mandate Addressed To CEN, CENELEC and ETSI Concerning Electromagnetic Compatibility (EMC)", M 313 EN, Brussels August 2001.

European Committee for Electrotechnical Standardization (CENELEC), EN 50065-1, "signalling on low-voltage electrical installations in the frequency range 3 to 148.5 kHz", Belgium, 1992, with amendments up to 1996.

European Telecommunications Standards Institute, ETSI EN 300 386 v1.3.2 (2003-05), "Electromagnetic Compatibility and Radio spectrum Matters (ERM); Telecommunications network equipment; ElectroMagnetic Compatibility (EMC) requirements", France, May 2003.

European Telecommunications Standards Institute, ETSI TR 102 049 v1.1.1 (2002-05), "PowerLine Telecommunications (PLT); Quality of Service (QoS) requirements for in-house systems", France, May 2002.

European Telecommunications Standards Institute, ETSI TR 102 175 v1.1.1 (2003-03), "PowerLine Telecommunications (PLT); Channel characterization and measurement methods", France, March 2003.

European Telecommunications Standards Institute, ETSI TS 101 867 v1.1.1 (2000-11), "PowerLine Telecommunications (PLT); Coexistence of Access and In-House Powerline Systems", France, November 2000.

European Telecommunications Standards Institute, ETSI TS 101 896 v1.1.1 (2001-02), “PowerLine Telecommunications (PLT); Reference Network Architecture Model; PLT Phase 1”, France, February 2001.

HomePlug 1.0, USA.

International Electrotechnical Commission (IEC), IEC 61000-3-8, First Edition, “Part 3: Limits – Section 8: Signalling on low-voltage electrical installations – Emission levels, frequency bands and electromagnetic disturbance levels”, Switzerland, 1997.

International Special Committee on Radio Interference, CISPR 11, “Radio disturbance characteristics of Industrial, and Scientific and Medical (ISM) equipment”, Belgium.

International Special Committee on Radio Interference, CISPR 22, “Information Technology Equipment (ITE) – Radio disturbance characteristics – Limits and methods of measurement”, Belgium.

J. H. Stott, “The threat to New Radio Systems From distributed Wired-Communication Installations”, BBC R&D, 8th International Conference on HF Radio Systems & Techniques, 10-13 July 2000, IEE Conference Publication No. 474, pp. 385-389.

J.H. Stott, “Cumulative effects of distributed interferers”, BBC R&D, BBC R&D White Paper. Input to CEPT SE35; UK TWG on PLT, VDSL, etc.; EBU B/EIC; UK HF Users' Group. August 2001

J.H. Stott, “Protection of 'sensitive' receiving sites”, BBC R&D, Paper for RA Working Group on HF Mains Signalling, October 1999.

Radiocommunications Agency, “Radiation Limits and Measurement Specification - Electromagnetic radiation in the range 9 kHz to 1.6 MHz from material substances forming part of a telecommunication system”, MPT 1570, London, January 2003.

Reg TP, “Usage Provision 30 (NB 30)”, Germany, May 2001.

Reg TP MV 05, “Measurement of Interfering Fields at Telecommunication Systems and Conductors in the Frequency Band from 9 kHz to 3 GHz”, Germany, May 2001.

Standards Association of Australia, “Limits of Electromagnetic Interference from Overhead A.C. Power Lines”, Australian standard 2344-1980, Australia, 1980.

Part 15 of the FCC Rules applicable to Powerline Systems

Current Carrier Systems
15.107 Conducted Limits–
This section sets out the conducted limits of devices connected to the AC mains supply.
15.107(a) Limits for all devices except Class A digital devices and the current carrier systems in part (c).

Frequency (MHz)	Quasi-peak (dBmV)	Average (dBmV)
0.15-0.5	66 to 56	56 to 46
0.5-5	56	46
5-30	60	50

15.107(b) Limits for Class A digital devices

Frequency (MHz)	Quasi-peak (dBmV)	Average (dBmV)
0.15-0.5	79	66
0.5-30	73	60

15.107(c) Current Carrier Systems
The limits shown in paragraphs (a) and (b) of this section shall not apply to current carrier systems operating as unintentional radiators on frequencies below 30 MHz. In Lieu thereof, these current carrier systems shall be subject to the following standards:

(1) For current carrier systems intended to be received using a standard AM broadcast receiver (Not a PLC system as considered in this report.)
(2) For all other current carrier systems within the frequency band 535-1705 kHz 1000 mV.
(3) Carrier current systems are also subject to radiated emission limits.

15.107(d) Measurements to demonstrate compliance

15.109 Radiated Emission Limits
15.109(a) Limits for all devices except Class A digital above 30 MHz
15.109(b) Limits for Class A above 30 MHz
15.109(c) Band edge values
15.109(d) CB receivers
15.109(e) Current carrier systems are subject to the radiated limits in 15.209 between 9 kHz and 30 MHz.
15.109(f) Receiver terminals
15.109(g) Acceptance of devices which comply with CISPR 22

15.209 Radiated emission limits, general requirements

Frequency(MHz)	Field Strength(uV/m)	Measurement Distance
0.009-0.490	2400/ F(kHz)	300
0.490-1.705	24000/ F(kHz)	30
1.705-30.0	30	30
30-88	100	3

A Brief Description of Mains Power Distribution Systems

Power Supply in the USA

The power supply network in the USA has medium voltage (MV) lines running along every street. Low voltage (LV) lines run to the houses and are usually less than 300 metres with about 1 to 10 customers per MV/LV transformer. The primary side of the MV/LV transformer is fed with one phase and a neutral from the medium voltage lines. The secondary side then supplies three wires to the residential house, two at 120 V and one at 240 V (for high current devices like water heaters). Two options suggested for last-mile Current Carrier Systems in the USA is to feed the signal into the medium voltage lines or to run broadband coax cable or optical fibre to all the MV/LV transformers and feed the signal into the secondary low voltage power line. If the signal was fed into the medium voltage line then the signal would need to be fed between the phase and neutral lines. In this case a bridging transformer would need to be installed at the MV/LV transformer. If the signal was fed into the low voltage line then the signal could be feed between the two 120 volt lines. The second option means the signal would be carried by a balanced cable, which would reduce EMI levels.

The in-house current carrier systems feed the signal between the phase and neutral in the USA. This would be an unbalanced configuration.

Power Supply in Europe

In most of continental Europe a MV/LV transformer can service several hundred homes. Generally, all three phases and a neutral are supplied to the home. The LV windings are in a Y configuration with 400 volts between phases and 230 volts from phase to neutral. If there is a protective earth available then it is connected to the neutral. This structure allows the last-mile PLT signal to be supplied to the house between two phases. This means the signal would be carried by a balanced cable, which would reduce EMI levels.

In the UK however, typically only one phase is supplied to the house, which means that the last-mile PLT signal must be supplied between the phase and neutral (an unbalanced configuration). This would be a disadvantage with regard to EMI levels.

The in-house PLT systems feed the signal between the phase and neutral in both the UK and continental Europe. This would be an unbalanced configuration.

Power Supply in Japan

In Japan, MV/LV transformers is similar to the USA transformer with the secondary suppling two phases and a neutral. The MV/LV transformer supplies up to 30 houses, which is more than in the USA. Again the BPCS signal could be fed between the two phases; this would be a balanced configuration.

The in-house BPCS systems would feed the signal between the phase and neutral in Japan. This would be an unbalanced configuration.

Power Supply in Australia

In Australia the power supply network is similar to that in the UK in that only one phase is supplied to the house, and the ground and neutral are connected together. This means that the last-mile PLT signal must be supplied between the phase and neutral (an unbalanced configuration). This would be a disadvantage with regard to EMI levels.

The in-house BPCS systems would feed the signal between the phase and neutral in Australia. This would be an unbalanced configuration.

A Comparison of Different Proposed Standard Limits (extract from ECC Report 24)

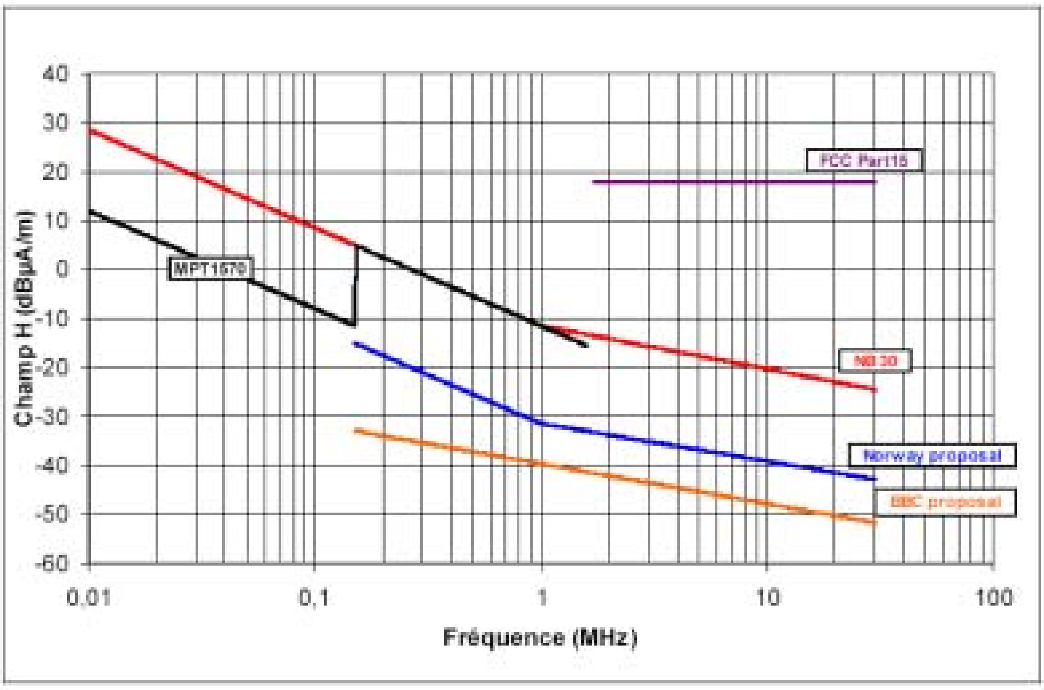

Figure 2: Comparison of the different standard limits at 3 meters

The different proposals are the following (bold fonts indicate that this limit is defined at 3 meters (sic) and not extrapolated from another distance):

- BBC: proposal n°4. The measurement distance is 1 meter in the CISPR 9 kHz resolution bandwidth (the proposed limit starts at 150 kHz). The basic limit is extrapolated here to a 3 meters distance assuming free space (20dB/decade) propagation conditions;
- **"Norway proposal": proposal n°2. The field is measured at 3 meters in a 9 kHz resolution bandwidth;**
- MPT 1570: proposal n°3. The measurement distance is 1 meter in the CISPR resolution bandwidth. The basic limit is extrapolated here to a 3 meters distance assuming free space (20dB/decade) propagation conditions;
- **NB30: proposal n°1. The field is measured at 3 meters (CISPR resolution bandwidth);**
- FCC: proposal n°5 limit defined at 30 meters in the CISPR resolution bandwidths. An extrapolation down to 3 meters assuming 40dB/decade fall off as defined by FCC is made here. Only values between 1.705 and 30 MHz are represented on the diagram, but higher limits (70 dBµV/m at 1.7 MHz at 3 meters; 94 dBµV/m at 3 meters; 130 dBµV/m at 9 kHz at 3 meters…) are defined by the FCC for lower frequencies that are not shown here for readability of the diagram.