APPENDIX B
SUMMARY OF FOREIGN TECHNICAL REPORTS

B.1 INTRODUCTION

This appendix summarizes foreign technical reports related to BPL implementation. NTIA reviewed these reports in the course of designing and refining its technical approach. Citation and summarization of a report herein does not, in itself, signify NTIA concurrence with any aspect of the report and inclusion or exclusion of a report has no significance. In this appendix, the acronyms BPL (for Broadband on Power Line), PLC (for Power Line Communications), and PLT (for Power Line Telecommunications or Technologies) are synonymous and will be used in accordance with each original report.

B.2 IMPLEMENTATION REPORTS

Several telecom equipment manufacturers have teamed up with utility companies to build BPL systems in order to test the technical and economical feasibility of BPL. Results of some of these implementation efforts are presented in Table B-1.

Table B-1: BPL Implementation Results

Company / Nation	Result	Source of Information
SIEMENS / Germany	SIEMENS decided in March 2001to leave the PLC business. Power companies which were due to use SIEMENS equipments are now supplied by ASCOM.	http://www.darc.de/referate/emv/plc/PLC-in-Germany-3-2001-Press-release.pdf
NUON / Netherlands	NUON stops offering digital services through the power lines in the beginning of July, 2003.	http://www.webwereld.nl/nieuws/14920.phtml (in Dutch)
ASCOM / Switzerland	According to DARC, ASCOM has declared that it was unable to supply all PLC main outlets with sufficient low failure rate because it can not be supported by the NB30 requirement.	http://www.darc.de/referate/emv/plc/c3.4-rev1-PLC5RPRT.pdf
ASCOM: Swiss PLC equipment supplier NUON: Dutch energy company SIEMENS: German PLC equipment supplier		

B.3 MEASUREMENT REPORTS

Many EMC measurements conducted by government agencies and private groups have been reported. Some of these reports are presented in Table B-2.

Table B-2: Measurement Reports

Country or Agency	Report or Result	Source of Information
OVSV / Austria	Video Showing Effect of PLC in Tirol, Austria	http://www.darc.de/referate/emv/plc/plc_video_tirol.rm
OVSV / Austria	Video Showing Effect of PLC in Linz, Austria	http://www.darc.de/referate/emv/plc/plc_video_linz.rm
Austria	During an emergency exercise of the Austrian Red Cross in May 2003, communication was massively disturbed by PLC, with interference levels exceeding the limits by a factor 10,000.	http://futurezone.orf.at/futurezone.orf?read=detail&id=205693&tmp=4659
Finland	In October 2001, FICORA measured disturbance levels in the PLC test network in a residential area. The measurements revealed that data transmission caused a significant rise in disturbance levels inside buildings, and outside near buildings and underground cables. The measured levels were significantly higher than NB30.	http://www.ficora.fi/2001/VV_vsk2001.pdf
Germany	"PLT, DSL, cable communications (including cable TV), LANs and other effect on radio services"	ECC Report 24, Section 8.1.2
Germany	"PLT, DSL, cable communications (including cable TV), LANs and other effect on radio services"	ECC Report 24, Section 8.1.3
Germany	"PLT, DSL, cable communications (including cable TV), LANs and other effect on radio services"	ECC Report 24, Section 8.1.4
JARL / Japan	"On Radio Interference Assessments of Access PLC System"	http://www.qsl.net/jh5esm/PLC/isplc2003/isplc2003a2-3.pdf
JARL / Japan	"On Radio Interference Assessments of Access PLC System – Presentation Material"	http://www.qsl.net/jh5esm/PLC/isplc2003/isplc2003a2-3presentation.pdf

Japan	"Interference measurements in HF and UHF bands caused by extension of power line communication bandwidth for astronomical purpose"	http://www.qsl.net/jh5esm/PLC/isplc2003/isplc2003a7-1.pdf
VERON / Netherlands	"The Radio Amateur and the Effects of the Use of the 230-Volt Power Line for Broadband Data Communications"	http://www.darc.de/referate/emv/plc/VERON_PLC_Report.pdf
VERON / Netherlands	"HF radio reception compatibility test of an in-house PLC system using two brands of modems"	http://www.arrl.org/tis/info/HTML/plc/files/ModemRPRTVeron11-04-03.pdf
Netherlands	"Current Situation on the Field Trials and Other Tests Performed in the Netherlands" (in Dutch)	http://www.agentschap-telecom.nl/informatie/plc/Position_NL_PLC_C..pdf (special access required)
Netherlands	"Information on radiating properties of mains networks" (in Dutch)	http://www.agentschap-telecom.nl/informatie/plc/NL_versie 6_final.pdf (special access required)
Norway	"PLT, DSL, cable communications (including cable TV), LANs and other effect on radio services"	ECC Report 24, Section 8.1.1
Switzerland	"Power Line Communication at Fribourg" (study report in French only)	http://www.bakom.ch/en/funk/elektromagnetisch/plc_freiburg/index.html
BBC/U.K.	In October 2002, the Technical Working Group completed final report on the "Compatibility of VDSL and PLT with radio services in the range 1.6 MHz to 30 MHz", in which Appendix M contains emission limit proposed by BBC.	http://www.radio.gov.uk/topics/interference/documents/dslplt.htm
RA / U.K.	RA Technical Working Group Final Report "Compatibility of VDSL and PLT with radio services in the range 1.6 MHz to 30 MHz" (Sections 7.2 & 7.3, Appendices P, Q)	http://www.radio.gov.uk/topics/interference/documents/dslplt.htm
RSGB / U.K.	"Notes on RSGB Observations of HF Ambient Noise Floor"	http://www.qsl.net/rsgb_emc/RSGBMeasurements_1b.pdf
RSGB / U.K.	"A paper on the difficulty of measuring broadband interference emissions from cables and the problem of assessing the results with respect to interference to radio reception. Tests and experiences from an installed PLT system"	http://www.qsl.net/rsgb_emc/PLTREP.pdf
RSGB / U.K.	"Background noise on HF bands"	http://www.qsl.net/rsgb_emc/emcslides.html

RSGB / U.K.	"Notes on the RSGB investigation of PLT systems in Crieff"	http://www.qsl.net/rsgb_emc/CRIEFF%20Notes%20Version_1.html
White Box Solutions / U.K.	"Some Practical Measurements of Far Field Radiated Emissions from a PLT Cell and an Estimation of the Cumulative Ground-Wave Effects of PLT Deployment on a Sensitive HF Surveillance Site protected by a Non-Deployment Area of Radius 1500m", Appendix X of the RA Technical Working Group Final Report "Compatibility of VDSL and PLT with radio services in the range 1.6 MHz to 30 MHz"	http://www.radio.gov.uk/topics/interference/documents/dslplt.htm
ARRL / U.S.	"Home Phone Networking Alliance Testing"	http://www.arrl.org/tis/info/HTML/plc/files/hpnatests.html
ARRL / U.S.	"HomePlug and ARRL Joint Test Report", January 24, 2001	http://www.arrl.org/tis/info/HTML/plc/files/HomePlug_ARRL_Dec_2000.pdf
ECC: Electronic Communications Committer (within CEPT) JARL: Japan Amateur Radio League, Inc. OVSV: Austrian Amateur Radio Society RSGB: Radio Society of Great Britain VERON: Vereniging voor Experimenteel Radio Onderzoek Nederland		

Abstracts of some of the reports are presented as follows.

"Measurement results from PLT field trials – Germany, System A," ECC Report 24, Section 8.1.2. The section presented the measurement result of the radiated noise level from a PLT system. System A is designed for outdoor and indoor communication in several frequency bands. The outdoor portion begins at a transformer station and ends in the cellar of several houses, mostly in front of the power meter. At the same location the indoor portion begins using another frequency range and ends at the plugs in the rooms. The characteristics of a PLT signal is determined by switching off the PLT system, then comparing the scans made with the system on and off. The measurement results showed that the PLT signal in the field trial exceeded the NB 30 limit with an injected power level of +10 dBm. It was noted that the field trial was based on two examples of cabling and using PLT equipment which is still under development, and it covered only one injection point (outdoor master) and only less than three households, hence the result was not representative.

"Measurement results from PLT field trials – Germany, System B," ECC Report 24, Section 8.1.3. The section presented the measurement result of the radiated noise level from a PLT system. System B is designed for outdoor and indoor communication in the same frequency bands. The outdoor portion begins at a transformer station and ends in the cellar of several houses, mostly in front of the power meter. The indoor portion begins at the same location using the same frequency range and ends at the plugs in the rooms. A filter is inserted between outdoor slave and indoor master devices to suppress influence. The characteristics of a PLT signal were determined by switching off the PLT system, and comparing the scans made with the system on and off. The measurement results showed the PLT signal in the field trial exceeded the NB 30 limit with an injected power level of +17 dBm. It was noted that the trial was based on one example of cabling and using PLT equipment which was still under development, and covered only one injection point and only three households, hence the result was not representative.

"Measurement results from PLT field trials – Germany, System C," ECC Report 24, Section 8.1.4. The section presented the measurement result of the radiated noise level from a PLT system. System C was developed under the assumption that there would be no EMC problems if the system used low enough signal level such that the radiated noise met the threshold values specified in NB 30. The field strengths generated by the PLT signals, both inside and outside of buildings, were measured using the method in Measurement Specification 322MV05. The results showed that the radiated field strength at a distance of 3 meters from the injection point was close to the threshold values in NB 30, while the field strength at the "transformer station" exceeded the threshold.

"On Radio Interference Assessments of Access PLC System," JARL/Japan. Measurements were conducted to evaluate the impact of overhead access PLC to the amateur radio service and broadcasting service. Three cases were examined. First, the S/N of an AM signal and SINAD of a CW carrier were measured, and the results showed unacceptable degradation of HF broadcasting services from PLC interference. Second, observation using a spectrum analyzer showed that the HF broadcasting signal was completely jammed by the BPL modem operation. Third, measurement of the far-field component showed that short wave radio was jammed by the PLC signal at 156 meters away, and the PLC signal became undetectable at a distance of 200 to 400 meters. The experiment concluded that access PLC systems jam HF broadcasting and other radio communication services.

"Interference measurements in HF and UHF bands caused by extension of power line communication bandwidth for astronomical purpose," Japan. Two sets of modems, spread spectrum and OFDM, of the access PLC system were tested for the interference effect to radio astronomical observation. It was found that in the HF band, the PLC noise exceeds the level of the galactic noise by more than 30 dB when the two systems were 180 meters apart. In the UHF band, spurious emission near 327 MHz was observed at a 55 meter distance. In both cases, the interference noise exceeds the limit in ITU-R Rec. RA 769-1 for protection of radio astronomical observation. Safety separations to meet RA 769-1 limit are estimated to be 219 km and 12 km at 9.2 MHz and 327 MHz, respectively. The report concluded that PLC is harmful to radio astronomical observation in both the HF and UHF bands.

“The Radio Amateur and the Effects of the Use of the 230-Volt Power Line for Broadband Data Communications,” VERON/Netherlands. Measurement was conducted to evaluate the risks of interference from PLC to an amateur station. Both in-house and outside field strength measurements were taken and compared with the CEPT proposed radiation limits (NB 30, Norwegian Limit and BBC limit). The coupling between the mains wiring and the antennas of the amateur station was also determined. In the audio test, the level of interference in the HF amateur bands was evaluated using amateur antennas and receiver. The results showed that adequate protection can be provided against mains injected interference signals only in the BBC limit which was the strictest. Additional measurements were performed to find the “normal” interference levels on the mains wiring. The results showed that (1) it was apparent that the present interference levels in a quiet rural area are far below the CISPR 22 limits, and (2) injection of interference signals with a level equal to the CISPR 22 limit level causes harmful interference to the reception of signals in the amateur bands.

“HF radio reception compatibility test of an in-house PLC system using two brands of modems,” VERON/Netherlands. Tests were performed on the emissions of two types of in-house PLC modems developed to the HomePlug® standard. The measurements were done in a laboratory set-up, and in a residential house. The laboratory set-up, with many PCs running, was used to measure the mains disturbance voltage, field strength, and background noise; the residential house was used to measure the interference on an amateur radio receiving antenna, background signals, and noise on mains. The results show that one modem seems just to meet the mains disturbance limit in EN55022 for residential environment, and the other modem shows a level approximately 20 dB higher. Also, the following general observations were made: (1) interference from the modems is probably not a threat to the radio amateur service for a reasonably well constructed outdoor receive antenna, (2) interference may be harmful to the broadcasting services outside the spectrum notches, and (3) the background mains disturbance level is 30 dB or more below the EN55022 B limit in both the laboratory and residential environments.

“Measurement results from PLT field trials – Norway,” ECC Report 24, Section 8.1.1. The Norwegian Post and Telecommunications Authority conducted measurement tests on all experimental PLT systems in Norway in order to obtain information on unwanted radiation to other spectrally collocated radio systems in the HF band. The EMC requirement of PLT equipment for the mains port in wood buildings, a worst-case scenario, is 20 dBμV/m quasi-peak measured at a distance of 3 meters from the cable structure. The measured data are combined with a coupling factor to give the extent of field emission from equipment for the mains port. The measurement results show EM field levels 20–40 dB higher than 20 dBμV/m. This clearly indicates the need for a significant reduction in the spectral power density of the PLT signal to achieve compliance with existing EMC standards. Moreover, the report asserts that the field emission requirements for PLT should be somewhat more restrictive than the 20 dBμV/m limit because the PLT signal might be an ”always on” signal, and the geographical concentration of PLT units within a certain area might be fairly high.

“Power Line Communication at Fribourg,” Switzerland. A PLC network had been installed at the Swiss city of Fribourg. The Swiss Federal Office of Communication (OFCOM) accomplished extensive interference measurements on site with the goal to find out if and to what extent radio services in the short wave range would be disturbed. The already existent man-made noise at urban and rural areas has been analyzed and accounted for as well. The statistical interpretation of measurement data shows that PLC interference below 10 MHz is of little impact at urban areas because of already existent interference from other sources. However, at frequencies above 10MHz, PLC emissions are clearly the predominant cause for interference. Furthermore it has been shown that the limit of the German standard NB30 is exceeded at all frequencies of interest between 2.4 MHz and 25.4 MHz at urban areas. This report is available only in French.

“Compatibility of VDSL and PLT with radio services in the range 1.6 MHz to 30 MHz,” RA Technical Working Group Final Report, RA/U.K., Sections 7.2 & 7.3. Measurements of radiated emission from access and in-house PLC systems were conducted and data were presented. There was no discussion on the interference effect.

“Notes on the RSGB investigation of PLT systems in Crieff”, RSGB/U.K. Two PLT systems, ACOM and MAINNET, were tested. The primary objective was to obtain information on levels of interference noise generated by PLT systems and how this will affect radio amateurs and short wave listeners. Interference noise was observed, but no quantitative data were reported. No analysis or conclusion was presented.

“Some Practical Measurements of Far Field Radiated Emissions from a PLT Cell and an Estimation of the Cumulative Ground-Wave Effects of PLT Deployment on a Sensitive HF Surveillance Site protected by a Non-Deployment Area of Radius 1500m,” White Box Solutions/U.K. Field strength measurements were undertaken in a suburban/rural area. The results of these measurements were applied to the scenario of a sensitive HF radio surveillance site. It was concluded that for a non-deployment zone of radius 1500m, the dominant source of noise remains atmospheric noise (including man-made) and that the cumulative contribution from the surrounding PLT interferers would, in a worst case scenario, have less than 0.1 dB impact on the noise floor.

“HomePlug and ARRL Joint Test Report,” ARRL/U.S. The experiment examined the interference effect from the BPL waveform and power spectral density (PSD) limits proposed by HomePlug to the amateur radio services. Tests showed in general that with moderate separation of the antenna from the structure containing the HomePlug signal that interference was barely perceptible. The cases of objectionable interference were noted for an antenna located close to the power lines, a configuration chosen to mimic the situation in which the HomePlug equipment was in one house and the amateur radio in another.

B.4 MODELING AND ANALYSIS REPORTS

Several studies have developed models to analyze the potential BPL EMC problems. Some of the reports are listed in Table B-3.

Table B-3: Modeling and Analysis Reports

Country or Agency	Report	Source of Information
CEPT	"Determination of limiting values for emissions from PLT to protect DRM"	ECC PT SE35
Japan	"Sharing studies between the radio astronomy telescopes and the power line communication systems in the HF region"	http://www.qsl.net/jh5esm/PLC/isplc2003/isplc2003a7-4.pdf
BBC / U.K.	"Cumulative Effects of Distributed Interferers", Appendix R of the RA Technical Working Group Final Report "Compatibility of VDSL and PLT with radio services in the range 1.6 MHz to 30 MHz"	http://www.radio.gov.uk/topics/interference/documents/dslplt.htm
White Box Solutions / U.K.	"Application of Power Control and Other Correction Factors to PLT Systems and their Subsequent Impact on the Cumulative Effects, via Space Wave Propagation, on Aircraft HF Receivers", Appendix Y of the RA Technical Working Group Final Report "Compatibility of VDSL and PLT with radio services in the range 1.6 MHz to 30 MHz"	http://www.radio.gov.uk/topics/interference/documents/dslplt.htm
ARRL / U.S.	"Calculated Impact of PLC on Stations Operating in the Amateur Radio Service" (p.9-13)	http://www.arrl.org/tis/info/HTML/plc/files/C63NovPLC.pdf

Abstracts of these reports are presented as follows.

"Determination of limiting values for emissions from PLT to protect DRM," CEPT/ECC PT SE35. This report presents measurement result for determining PLT emission limits to protect DRM transmission. The DRM system uses either 9 or 10 kHz channels or multiples thereof, QAM/OFDM modulation with channel coding, time interleaving, and FEC. The PLT system has neither defined bandwidth nor standardized modulation. The measurements were conducted in the HF band. The DRM reference field strength is 40 dBμV/m, which is the minimum sensitivity of an average AM receiver; this level is about 10 to 20 dB above the minimum usable field strength of DRM receivers. The PLT signal was transmitted with a mains power supply cable connecting two PLT modems. It was observed that the PLT signal in file transfer mode affects noticeably the DRM receiver sensitivity threshold by 7 to 15 dB. Moreover, the DRM receiver threshold is affected even when the PLT was switched on but not transferring files. It was also observed that when the PLT signal level reaches the NB30 limit (32 dBµV/m), the DRM receiver sensitivity threshold is 3 dB higher than the protected minimum field strength in mode 1 (43 dBµV/m instead of 40 dBµV/m), and 9 dB higher in mode 2. Therefore, the limiting value for emissions from a radiating PLT source to protect DRM receiver at less than 3-meter distance shall be equal to or less than 16 dBµV/m in the HF band. This value is 16 dB more stringent than the NB30 limit defined at 3-meter distance. The results clearly show that the NB30 limits are not sufficient to protect DRM receivers in presence of a PLT signal.

"Sharing studies between the radio astronomy telescopes and the power line communication systems in the HF region," Japan. The report develops a methodology to calculate the necessary distance between a radio astronomy antenna site and a metropolitan PLC system by using two equations in ITU-R P.525. First, it uses an equation for point-to-area links to calculate the radiation field strength at 30 meters. Then, it uses an equation for point-to-point links to calculate free space loss of the radiated field. Considering that 30-meter distance is likely in the near-field range for a BPL system, and that the BPL emission source may not be a point source, the accuracy of this model may be subject to examination.

"Cumulative Effects of Distributed Interferers," BBC/U.K. This model develops methodologies to estimate the aggregate interference power from a distribution of PLC sources. The receiver can be in either an aircraft or a ground-based system. This is a far-field model, and curvature of the Earth surface is being considered. The analysis indicates that the interference received by an aircraft is nearly independent of aircraft height when the entire visible earth is populated with the PLT systems. Limiting the area of distributed interferers from the visible earth to a smaller area representative of a major conurbation does not decrease the interference very greatly, unless the aircraft is very high. For ground receivers, the analysis indicates that sky-wave interference from widespread PLT systems to ground-based receivers may not always be negligible, even though it is less than that shown to be suffered by aircraft.

"Application of Power Control and Other Correction Factors to PLT Systems and their Subsequent Impact on the Cumulative Effects, via Space Wave Propagation, on Aircraft HF Receivers," White Box Solutions/U.K. This study utilizes the model in the report "Cumulative Effects of Distributed Interferers" to examine the possibility of using power control and other correction factors for the PLT systems to alleviate the impact from the distributed BPL systems to aircraft HF receivers. Its result indicates that practical PLT systems employing power control and power density less than -60dBm/Hz would not appear to raise the HF noise floor at an aircraft at any reasonable operational altitude.

"Calculated Impact of PLC on Stations Operating in the Amateur Radio Service," ARRL/U.S. ARRL uses EZNEC 3.1 with the NEC-4 engine to model a power line of 300 feet as an antenna. Its result shows that the emitted PLC signal at 30-meter distance is 275µV/m/9kHz, which exceeds the FCC limits by about 15 dB. ARRL claims that the data is supported by actual measurements made in Japan. Another message from this paper is that, by using a line source instead of a point source, the signal strength vs. distance relationship should be 20dB/decade instead of 40dB/decade.