Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Amendment of Part 15 regarding new requirements and measurement guidelines for Access Broadband over Power Line Systems	)	ET Docket No. 04-37
	)	
Carrier Current Systems, including Broadband over Power Line Systems	)	ET Docket No. 03-104
	)	

SECOND REPORT AND ORDER

Adopted: October 20, 2011 **Released: October 24, 2011**

By the Commission:

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I. INTRODUCTION

1. In this Second Report and Order (Second Order), we fundamentally affirm our rules for Access Broadband over Power Line (Access BPL) systems. We also make certain minor modifications to improve and clarify the rules. These rules provide an appropriate balance between the dual objectives of providing for Access BPL technology that has potential applications for broadband and Smart Grid while protecting incumbent radio services against harmful interference.[1]

2. The Commission adopted rules for Access BPL systems in 2004[2] and affirmed those rules in 2006.[3] The BPL rules were challenged by the national association for amateur radio, formally known as the American Radio Relay League (ARRL) in the United States Court of Appeals for the District of Columbia in *ARRL v. FCC*.[4] In *ARRL v. FCC*, the court directed the Commission to: 1) make part of the rulemaking record unredacted versions of several staff technical studies which the Commission considered in promulgating the rules, 2) provide a reasonable opportunity for public comment on those studies, and 3) provide a reasoned explanation of its choice of the extrapolation factor[5] for use in measuring radiated emissions from Access BPL systems. In response, the Commission issued a *Request for Further Comment and Further Notice of Proposed Rulemaking* in this proceeding (*RFC/FNPRM*).[6] In the *RFC/FNPRM*, the Commission took its first step in responding to the directives of the court in *ARRL v. FCC* and also took that opportunity to review the Access BPL extrapolation factor and propose certain changes to the BPL technical rules that appeared appropriate in view of new information and further consideration of this matter. In this Second Order, we complete our action addressing the court's concerns and our proposals in the *RFC/FNPRM*. We find that the information submitted in response to the *RFC/FNPRM* does not warrant any changes to the emissions standards or the extrapolation factor. We are, however, making several refinements to our Access BPL rules. In particular, we are: 1) modifying the rules to increase the required notch filtering capability for systems operating below 30 MHz from 20 dB to 25 dB; 2) establishing a new alternative procedure for determining site-specific extrapolation factors generally as described in the

[1] A "smart grid" electricity network includes an intelligent monitoring system that keeps track of all electricity flowing in the system from suppliers to consumers providing real-time or near-real-time load information to permit improved transmission management. It also can utilize two-way digital technology to control appliances at consumers' homes to reduce peaks and even out demand, to save energy, to reduce cost, and to increase reliability and transparency.

[2] *Report and Order* in ET Docket Nos. 04-37, 03-104 *(Amendment of Part 15 Regarding New Requirements and Measurement Guidelines for Access Broadband Over Power Line Systems, Carrier Current Systems)*, 19 FCC Rcd 21265 (2004) (*BPL Order*).

[3] *Memorandum Opinion and Order* in ET Docket Nos. 04-37, 03-104 *(Amendment of Part 15 Regarding New Requirements and Measurement Guidelines for Access Broadband Over Power Line Systems; Carrier Current Systems, including Broadband over Power Line Systems)*, 21 FCC Rcd 9308 (2006) (*BPL Reconsideration Order)*.

[4] *American Radio Relay League, Incorporated, v. Federal Communications Commission (ARRL v. FCC)* 524 F.3d 227 (D.C. Cir. 2008).

[5] Because the field strength of radiated emissions decreases with increasing distance from the emitter due to propagation loss, an "extrapolation" factor is used to adjust the measurement results to account for the difference in attenuation, when measurements are made at a distance other than the specified distance in the rules.

[6] *Request for Further Comment and Further Notice of Proposed Rulemaking* in ET Dockets No. 04-37 and 03-104 *(Amendment of Part 15 Regarding New Requirements and Measurement Guidelines for Access Broadband Over Power Line Systems; Carrier Current Systems, including Broadband over Power Line Systems)*, 24 FCC Rcd 9669 (2009) (*RFC/FNPRM*).

RFC/FNPRM, and 3) adopting a definition for the "slant-range distance" used in the BPL measurement guidelines to further clarify its application.[7] We find that the benefits of the above changes to the rules outweigh their regulatory costs, as discussed herein.

3. Throughout this proceeding and in its appeal to the court, the ARRL has argued that more restrictive technical standards are needed to protect the amateur radio service from interference caused by leakage of radiofrequency (RF) emissions from Access BPL systems. We initially crafted rules for BPL systems that were based on our existing emission standards for carrier current communications systems – narrow-band devices that couple RF energy onto power line wiring for communication purposes – with a number of additional requirements to promote avoidance and resolution of harmful interference to licensed services that might occur in the context of BPL operations.[8] We subsequently affirmed those rules in response to petitions for reconsideration by various parties, including ARRL.[9] In this process, we have specifically rejected as unnecessary repeated requests by ARRL for tighter emissions controls on Access BPL operations. In response to the court's direction, we provided opportunity in the *RFC/FNPRM* for interested parties to address the BPL technical rules and the information developed by our staff that we considered in establishing those rules, explained our rationale for the extrapolation factor used in measuring BPL emissions, expressed our tentative satisfaction with the extrapolation factor adopted, while soliciting comment on whether another value would be more appropriate, and proposed a procedure for determining site-specific extrapolation factors. Herein, we complete our response to issues raised under the court's directive.

II. BACKGROUND

4. In the *BPL Order*, the Commission adopted rules to regulate the operation of Access BPL systems as unlicensed, unintentional radiators.[10] These BPL systems, which are a form of carrier current system,[11] deliver high speed Internet and other broadband services over the utilities' medium-voltage delivery power lines to homes and businesses; electric utility companies also use Access BPL devices to monitor and manage various elements of their electric power distribution operations as part of "Smart Grid" applications. In adopting the rules for these devices and systems, the Commission observed that BPL could provide a means to expedite the availability of broadband Internet service to consumers and businesses in rural and other underserved areas, introduce additional competition to existing broadband services, promote continued U.S. leadership in

[7] Because Access BPL devices are mounted on overhead power lines and the measurement antenna is at a lower distance closer to the ground, the actual distance from the power line to the measurement antenna is greater than the horizontal distance from the pole on which the BPL device is mounted to the measurement antenna. The correct distance for measurement is therefore the "slant range" diagonal distance measured from the center of the measurement antenna to the nearest point of the overhead power line carrying the Access BPL signal being measured.

[8] *BPL Order*, 19 FCC Rcd 21265 (2004).

[9] *BPL Reconsideration Order,* 21 FCC Rcd 9308 (2006).

[10] An unintentional radiator is defined in the rules as a device that intentionally generates radio frequency energy for use within the device, or that sends radio frequency signals by conduction to associated equipment via connecting wiring, but which is not intended to emit RF energy by radiation or induction. *See* 47 C.F.R. § 15.3(z). The Access BPL regulations are set forth in Sections 15.601-15.615 of the Commission's rules, 47 C.F.R. §§15.601-15.615.

[11] Carrier current systems transmit radio frequency energy by conduction over electric power lines, *see* 47 C.F.R. §15.3(f). These systems have been operating successfully as unlicensed campus radio stations in the AM Broadcast band for over fifty years in the United States at many universities.

broadband technology, and bring important benefits to the American public.[12] At the same time, it recognized the need to ensure that BPL operations do not cause harmful interference to licensed radio services.[13] Accordingly, the Commission established technical standards, operating restrictions and measurement guidelines for Access BPL to minimize instances of interference to licensed services and to facilitate resolution of such interference where it might occur.[14] These provisions for managing interference include: 1) application of the existing emission limits for carrier current systems in Section 15.109(e) to Access BPL;[15] 2) requirements that Access BPL devices employ adaptive interference mitigation techniques to promote avoidance and resolution of harmful interference; 3) requirements that Access BPL system operators provide information on the areas where their systems are installed and other technical parameters in a central data base that is accessible by the public; and 4) specific measurement guidelines and certification requirements for both Access BPL and other carrier current systems to ensure accurate and repeatable evaluations of emissions from Access BPL and all other carrier current systems. The rules also include specific provisions (not relevant here) for certain critical Federal Government and other services in the form of coordination requirements, exclusion zones and excluded frequency bands.[16] The Commission did not find that the amateur radio service warrants additional protections particular to that service; rather, it concluded that the general Part 15 rules and the additional specific provisions being adopted for Access BPL operations are sufficient to protect amateur operations.

5. Following the issuance of the *BPL Order*, ARRL filed a Freedom of Information Act (FOIA) request, seeking disclosure of Commission studies of emissions generated by Access BPL systems. In response to that request, the Commission released five staff presentations in redacted form and added them to the record in December 2004. ARRL, among others, sought reconsideration of the *BPL Order* on February 7, 2005.[17] The Commission on reconsideration amended its rules in part but generally denied ARRL's petition, making one clarification.[18] It reiterated the need to ensure that BPL operations do not cause harmful interference to licensed radio services and recognized that the substantial benefits of this technology might not be realized if BPL devices were to cause interference to licensed services and other important radio operations.[19]

6. Subsequently, ARRL challenged the Commission's Access BPL decisions in the United States Court of Appeals for the District of Columbia. In its petition for judicial review, ARRL challenged the Access BPL rules on four grounds, alleging that: 1) the Commission ignored long-standing precedent by authorizing the operation of unlicensed devices that could interfere with licensed services and by no longer requiring that operators cease using the unlicensed devices if they actually cause interference; 2) the Commission did not adequately consider an alternative proposal for

[12] *BPL Order* at 21266 and 21271.

[13] *Id.* at 21266.

[14] *See* 47 C.F.R. §§ 15.601-15.615.

[15] *See* 47 C.F.R. §§ 15.109(e) and 15.209; these limits are codified for Access BPL systems at Section 15.611(b).

[16] *See* 47 C.F.R. §§ 15.615(e)-(f).

[17] *See* ARRL Petition for Reconsideration (filed Feb. 7, 2005 in ET Docket 04-37). *See also*, ARRL Petition for Issuance of Further Notice of Proposed Rule Making and for Amendments of Regulations (filed Oct. 18, 2005) in ET Docket No. 04-37.

[18] On reconsideration, the Commission clarified rule section 47 C.F.R. § 15.611(c)(1), as requested by ARRL. *BPL Reconsideration Order* at 9320 and 9338.

[19] *BPL Order* at 21266.

reducing harmful interference that would have limited Access BPL systems to the frequency band between 30 MHz and 50 MHz, rather than between 1.7 MHz and 80 MHz; 3) the Commission violated the Administrative Procedure Act (APA) by failing to disclose in unredacted form certain technical studies prepared by the Commission's engineers that were relied upon in adopting the rules;[20] and 4) the empirical evidence does not support the Commission's decision to retain the existing 40 dB per decade (40 dB/decade) extrapolation factor to measure Access BPL radiated emissions at frequencies below 30 MHz, which contain several bands used by amateur licensees.[21]

7. The court denied in part and granted in part ARRL's petition and remanded the rules to the Commission for further action.[22] It found unpersuasive ARRL's arguments with respect to the first two points. However, the court found that the Commission failed to satisfy the notice and comment requirements of the APA by redacting staff studies which it considered in promulgating the rules and by failing to make a reasoned explanation for its choice of the extrapolation factor for measuring Access BPL emissions. The court therefore directed the Commission to make the unredacted staff studies part of the rulemaking record and provide an opportunity for notice and comment.[23] With respect to the extrapolation factor, the court found that the Commission has not adequately explained its decision and directed the Commission to "either provide a reasoned justification for retaining an extrapolation factor of 40 dB/decade for Access BPL systems sufficient to indicate that it has grappled with the 2005 studies [which ARRL submitted in *ex parte* comments supporting its petition for reconsideration from the 2004 Order], or adopt another factor and provide a reasoned explanation for it."[24] The court did not suspend the Commission's Access BPL rules pending further actions by the Commission and the rules have remained in effect.[25]

8. As directed by the court, the Commission placed into the record of the above proceeding unredacted versions of five technical staff presentations[26] that it had previously submitted in redacted

[20] In pertinent part, the APA requires administrative agencies to publish "notice" of "either the terms or substance of the proposed rule or a description of the subjects and issues involved," in order to "give interested persons an opportunity to participate in the rule making through submission of written data, views, or arguments," and then, "[a]fter consideration of the relevant matter presented, the agency shall incorporate in the rules adopted a concise general statement of their basis and purpose." 5 U.S.C. §§ 553(b), (c). In order to provide sufficient notice, the agency must disclose any technical studies and staff reports on which it relies. *ARRL v. FCC*, 524 F.3d at 236, *citing*, *e.g.*, *NARUC v. FCC*, 737 F.2d 1095, 1121 (D.C.Cir.1984).

[21] *See ARRL v. FCC*, at 233. "Decade," a 10 to 1 range, refers to the ratio of the specified measurement distance to the actual measurement distance. An extrapolation factor of 20 dB per decade treats field strength emissions as if they attenuate at a rate inversely proportional to the distance from the emitter (1/R), whereas an extrapolation factor of 40 dB per decade treats emissions as if they attenuate at a rate inversely proportional to the square of the distance from the emitter ($1/R^2$). If the extrapolation factor is 20 dB per decade instead of 40 dB per decade, the correction factor would be significantly smaller, thus resulting in lower permitted values for the transmitted emission levels at the same distance from the emitter. *See* 47 C.F.R. § 15.31(f)(1) and (2).

[22] *Id.,* at 231.

[23] *Id.,* at 240.

[24] *Id.,* at 241.

[25] *Id.*

[26] We note that the use of the term "study" or "report" used for these informal presentations of scientifically collected data, staff notes and observations may imply a greater degree of completion, finality, consideration and conclusion than is the case here. These presentations of information, impressions, and ideas were just that, – informal presentations by staff engineers to other staff engineers and OET managers. A "study" or "report" prepared as information or for consideration would normally be in a formal written format for publication and (continued….)

form.[27] The staff presentations included information regarding measured emissions from various experimental Access BPL systems at locations in Pennsylvania, Maryland, New York, and North Carolina, that were used to familiarize the Commission and its staff with this new technology.[28] These presentations were considered in the decision-making process along with studies submitted by commenters such as ARRL and the National Telecommunications and Information Administration (NTIA). The first two presentations, included in a single file entitled *BPL Measurements in Allentown, PA*, contain data collected on the Amperion BPL system and on the Main.Net BPL system, both in Allentown, PA.[29] The third presentation, *Emissions Measurements on CURRENT Technologies Medium Voltage BPL System*, contains data collected on the CURRENT Technologies (CURRENT) BPL system in Potomac, MD.[30] The fourth presentation, *BPL Summary After Briarcliff Manor, NY Test*, contains data collected on the Ambient BPL system in Briarcliff, NY, and some staff observations.[31] The fifth presentation, *BPL Emission Test Near Raleigh, NC*, contains data collected on the Amperion/Progress Energy BPL system in Raleigh, NC.[32] The Commission observed that the redacted pages mostly contain information regarding specific test notes and test set-up recommendations with respect to the BPL systems at the various test sites,[33] certain requests from third parties,[34] and preliminary and partial data

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reviewed and vetted by agency staff and management, which was not the case in these instances. No formal peer review was conducted. Thus, while there is much useful scientific information in those presentations that was considered in our BPL decisions, other content therein is more properly viewed as discussion materials and options rather than settled conclusions. Accordingly, we will hereinafter refer to these documents as presentations to differentiate them from the more formal and considered findings of a study or report.

[27] *See* Letter dated April 29, 2009 to ARRL from Julius Knapp, Chief, Office of Engineering and Technology.

[28] Two presentations measured emissions from systems marketed by two specific Access BPL manufacturers (Amperion and Main.Net BPL systems in Allentown, Pennsylvania), and three others measured location-specific emissions in pilot Access BPL areas in Maryland (CURRENT Technologies BPL system in Potomac), New York (Ambient BPL system in Briarcliff Manor) and North Carolina (Amperion/Progress Energy BPL system in Raleigh.) *ARRL v. FCC*, *supra* at 237.

[29] *BPL Measurements in Allentown, PA* at
http://fjallfoss.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6520215595,
http://fjallfoss.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6520215596, and
http://fjallfoss.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6520215597.

[30] *Emissions Measurements on CURRENT Technologies Medium Voltage BPL System,* at
http://fjallfoss.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6520215597 and
http://fjallfoss.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6520215598.

[31] *BPL Summary After Briarcliff Manor, NY Test***,** at
http://fjallfoss.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6520215598 and
http://fjallfoss.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6520215599.

[32] *BPL Emission Test Near Raleigh, NC* **,** at
http://fjallfoss.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6520215599 and
http://fjallfoss.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6520215600.

[33] *BPL Measurements in Allentown, PA,* slide 6, labeled "Conclusions Regarding Amperion" and slide 7, labeled "Recommendations for Amperion"; *Emissions Measurements on CURRENT Technologies Medium Voltage BPL System,* slide 36, labeled "Recommended Future FCC Tests (to understand technology)".

[34] *BPL Measurements in Allentown, PA*, slide 48, labeled "Conclusions Regarding Main.Net" and slide 52, labeled "Other Issues".

with respect to the noise floor[35] and attenuation rate of the signal strength downline at the test sites[36] as well as the opinions of one staff member as to whether BPL systems are point-source systems[37] and that staff member's opinion on possible ways to treat these systems.[38] In the *RFC/FNPRM*, the Commission requested comment on the information in those unredacted presentations as it pertains to its BPL decisions.

9. On July 17, 2009, concurrent with its release of the *RFC/FNPRM*, the Commission also placed into the record some additional materials that contain preliminary staff research and educational information (preliminary research materials) and were not previously available therein and invited comment on those materials. These materials consist of several working papers and video files that were used in preparing the staff presentations and for staff education. The Commission stated that these are materials that it would not routinely, and in this case did not previously, place in the record. However, the Commission indicated that it now believes it is important to make available all potentially relevant research and information materials in order to fully and most efficaciously conclude its examination of the BPL issues. A list of these additional materials is provided in Appendix F.

10. The Commission also provided an explanation of its reasons for selecting 40 dB/decade as the measurement distance extrapolation factor for frequencies below 30 MHz. The Commission further explained why it believes the studies and technical proposal submitted earlier by ARRL do not provide convincing information that it should use an extrapolation factor that is different from that which it adopted.[39] The Commission also noted the existence of more recent studies that verify the correctness of its determination, although it did not rely on those studies as *ex post facto* rationale or justification for its decision.

11. Consistent with the opportunity provided by the court's remand and its stated intention in the *BPL Order* to review the decision on the extrapolation factor if new information becomes available, the Commission also indicated in the *RFC/FNPRM* that it would re-examine the current extrapolation factor in light of the recently issued technical studies addressing the attenuation of BPL emissions with distance and the efforts by the Institute of Electrical and Electronics Engineers (IEEE) to develop BPL measurement standards. The Commission stated that as the several studies now available show and as it has observed previously, there can be considerable variability in the attenuation of emissions from BPL systems across individual measurement sites that is not captured in the use of a uniform 40 dB/decade

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[35] *BPL Summary After Briarcliff Manor, NY Test*, slide 9, labeled "Raleigh Received Levels at 23.2 MHz from One Overhead Injector" and slide 13, labeled "NTIA Results"; *BPL Emission Test Near Raleigh, NC*, slide 16, labeled "Test Description for Mobile Radio Measurements" and slide 23, labeled "Notch Depth".

[36] *BPL Measurements in Allentown, PA*, slide 40, labeled "Summary of Relative Average Levels".

[37] *BPL Measurements in Allentown, PA*, slide 3, labeled "Major Conclusions", slide 17, labeled "Under-Line Field Strength vs. Distance Down Line" and slide 50, labeled "Conclusions Regarding Access BPL"; *BPL Summary After Briarcliff Manor, NY Test*, slide 17, labeled "New Information Arguing for Caution on HF BPL"; *Emissions Measurements on CURRENT Technologies Medium Voltage BPL System,* slide 35, labeled "Conclusions".

[38] *BPL Summary After Briarcliff Manor, NY Test*, slide 13, labeled "NTIA Results", slide 16, labeled "Skywave (<30 MHz)", slide 19, labeled "HF Issues and Options", slide 20, labeled "Low VHF Options", and slide 21, labeled "BPL Spectrum Tradeoffs and Proposals".

[39] This explanation of the insufficiencies of the OFCOM studies and of ARRL proposal for a sliding scale extrapolation factor responded to the Court's directive in *ARRL v. FCC* that the Commission provide a reasoned justification for retaining an extrapolation factor of 40 dB/decade for Access BPL systems sufficient to indicate that it has grappled with the . . . [empirical data] …"; *see RFC/FNPRM* at 9679-9680.

standard. To address this variability, it requested comment on whether it should amend the BPL rules to 1) adjust the extrapolation factor downward to 30 dB or some other fixed value and, 2) as an alternative, also allow use of a special procedure for determining site-specific BPL extrapolation values using *in situ* measurements. The *in situ* procedure it proposed was based on a concept that was under consideration at that time by the IEEE working group on power line communications technology electromagnetic compatibility (EMC) in its draft standard P1775/D2.[40]

12. In addition, the Commission clarified that parties testing BPL equipment and systems for compliance with emissions limits in the rules may measure at the standard 30-meter distance rather than the shorter distances recommended in the BPL measurement guidelines. It requested comments on the unredacted staff presentations, its selection of an extrapolation factor for BPL systems based on the slant-range method and the explanation provided therein, and its proposal to allow use of site-specific extrapolation factors as an alternative to the standard extrapolation factor. The Commission stated that in the interim, as justified therein, it would continue to apply the extrapolation factor as adopted in the *BPL Order*.

13. Thirty parties submitted comments and nine parties submitted replies in response to the *RFC/FNPRM*.[41] ARRL submitted a detailed presentation requesting rule changes to further protect the amateur radio service from harmful interference from Access BPL operations while permitting BPL systems to operate in the 3 MHz to 80 MHz range without significant constraint. It specifically asks that we achieve these objectives by requiring that BPL systems employ 1) full-time notching (frequency avoidance) of all amateur frequency allocations and 2) notch depths of 35 dB below the standard BPL emissions limit.[42] Nine of the commenting parties are parties with interests in the Access BPL industry who oppose ARRL's requested rule changes or provide other responses to its submissions. The remaining parties are individual amateur radio licensees who generally support ARRL's position.

III. DISCUSSION

14. In this proceeding, we have established a regime of rules for Access BPL systems that will provide a robust environment for the development and deployment of this important new technology option for delivery of broadband internet/data services while at the same time minimizing the potential for interference to licensed services caused by leakage from power lines of the RF energy used by BPL transmissions. As we observed in the *BPL Order*, there is some potential for increased harmful interference from BPL operations, particularly in locations within a short distance of the power lines used by this technology.[43] Consistent with our responsibilities for managing the interference potential of devices which can interfere with radio under Section 302 of the Communications Act, we have developed

[40] IEEE incorporated the *in situ* concept for deriving distance extrapolation from its earlier draft into IEEE 1775-2010 *IEEE Standard for Power Line Communication Equipment – Electromagnetic Compatibility (EMC) Requirements, Testing and Measurement Methods*, published on Jan 7, 2011.

[41] A list of the parties submitting comments and/or replies is provided in Appendix A.

[42] On Nov 30, 2011, ARRL also submitted *ex parte* comments (November 2010 *ex parte* comments) reiterating its requests, with information from an ITU-R Report published in 2009 (ITU-R Report SM.2158 *Impact of Power Line Telecommunications Systems on Radiocommunications Systems operating in the LF, MF, HF and VHF bands below 80 MHz*), an ITU-T Recommendation published in 2009 (ITU-T G.9960 *Unified High-speed Wire-line based Home Networking Transceivers – Foundation*), an OFCOM Report on *The Likelihood and Extent of Radio Frequency Interference from In-Home PLT Devices* dated Jun 21, 2010, and an IEEE Standard published in 2010 (IEEE P1901-2010 *Standard for BPL Networks: Medium Access Control and Physical Layer Specifications*) that it contends supports its position.

[43] *BPL Order* at 21276.

a set of rules for BPL devices and systems that attempts to minimize instances of interference while allowing BPL systems to operate in a viable manner to serve the needs of the American public.[44] In this regard, we have stated and continue to hold that, on balance, the benefits of Access BPL for bringing broadband services to the public are sufficiently important and significant so as to outweigh the limited increase in potential for harmful interference that may arise. We also agreed with NTIA that while some cases of harmful interference may be possible from Access BPL emissions at levels at or below the Part 15 limits, the potential benefits of Access BPL service warrant acceptance of a negligible risk of harmful interference that can be managed and corrected as needed on a case-by-case basis.[45]

15. To minimize the potential for harmful interference, facilitate its resolution where it may occur, and address cases where its possible occurrence could impact critical services, we adopted additional regulatory measures beyond the emissions limits in the Part 15 rules. These additional measures generally require Access BPL operators to reduce emissions or avoid operation on certain frequencies or in certain locations in order to protect licensed services, to use equipment that can alter its operation by changing frequencies to eliminate harmful interference, to provide information that will assist the public in identifying locations where Access BPL operations are present and provide notice to radio users before commencing local BPL operations in a publicly accessible database. In this manner, the Access BPL rules provide an effective means for limiting harmful interference and ensuring that any instances of harmful interference that may occur can be quickly identified and resolved. As we emphasized in the *BPL Order,* Access BPL systems will continue to be treated as unlicensed Part 15 devices and as such will be subject to the conditions in Section 15.5(b) of the rules that they not cause harmful interference and that they cease operation if they do cause such interference, as required by our rules.[46] As discussed below, upon examination of the information and comments received in response to the *RFC/FNPRM*, we continue to believe that these measures are adequate and appropriate for managing the potential for harmful interference to all licensed radio services that operate on the bands used internally by BPL systems, including the amateur radio service.

16. The requests for comment, explanation of rationale, and proposals presented in the *RFC/FNPRM* were all raised to address further ARRL's concerns about the potential for BPL operations to cause interference to licensed services, and specifically to amateur radio operations. The record submitted in response to the *RFC/FNPRM* essentially consists of 1) a lengthy presentation by ARRL of the reasons and arguments as to why it believes the information in the unredacted presentations and the preliminary materials released in July 2009 show our rules for protection against BPL interference and the extrapolation factor are based on incorrect or inappropriate analysis, technical explanations supporting its positions, and requests for rule changes that it contends would "adequately protect" the amateur service; 2) statements from amateur licensees supporting ARRL's positions; 3) submissions from representatives of the BPL industry opposing ARRL's positions on interference potential and rule changes and 4) comments on our proposals for modifying the extrapolation factor and establishing a procedure for determining site-specific extrapolation factors. Inasmuch as ARRL is the principal proponent of changes to the BPL rules for interference protection and the extrapolation factor, and the principle respondent with regard to the information in the unredacted studies and preliminary materials released in July 2009, we focus the discussion on those subjects on its submissions and arguments.

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[44] 47 U.S.C. § 302. Section 302 states in relevant part that "[t]he Commission may, consistent with the public interest, convenience, and necessity, make reasonable regulations (1) governing the interference potential of devices which in their operation are capable of emitting radio frequency energy by radiation, conduction, or other means in sufficient degree to cause harmful interference to radio communications …."

[45] NTIA comments filed June 4, 2004 in ET Docket Nos. 03-104 and 04-37, 19 FCC Rcd 3335 (2004), at http://webapp01.fcc.gov/ecfs/document/view?id=6516212885, summary at iv.

[46] 47 C.F.R. § 15.5(b).

17. In its comments, ARRL argues in technical detail that BPL emissions propagate much farther than our assessment indicates and that BPL operations therefore pose a much greater threat of interference than that estimated by our analysis. It also asserts that the redacted portions of the staff presentations reveal information that BPL operations cause absolutely preclusive interference and that the Commission knew this information and ignored it.[47] ARRL essentially contends that the amateur service should be afforded protection against any possibility of interference occurring from BPL operations and demands that BPL operations not be allowed on frequencies allocated to the amateur service.[48] The commenting parties representing BPL interests oppose ARRL's demands and support maintaining our current rules. For example, CURRENT submits that "the record as a whole could plausibly have justified a range of regulatory responses…and that the Commission's approach in the *BPL Order* – enabling BPL to go forward subject to unprecedented notching and shut-down requirements, as well as the 40 dB/decade extrapolation factor – all come well within that range." It argues that nothing in the new materials calls those positions into question.[49]

18. We are not persuaded by ARRL's newest technical submissions, including the reports/standards referenced in its November 2010 and June 2011 *ex parte* comments, or its assertions regarding the information in the unredacted presentations and in the additional information we recently introduced into the record in July 2009 that our assessment of the interference potential from BPL operations was incorrect or inappropriate, or that modifications to the BPL emissions limits and other technical rules to provide additional protection for the amateur service are warranted. While there is much valuable and valid information and analysis in ARRL's technical presentations, there are additional considerations that previously led us to draw different conclusions and still lead us to maintain those conclusions now.

19. With regard to the redacted portions of the staff presentations and the preliminary information from early staff work that was released in July 2009, we were, of course, aware of that content and we were also aware of other considerations and facts that bear on the various BPL technical issues. Notwithstanding ARRL's apparent belief that the full content of the staff presentations should have led us to the conclusion it prefers, we found, and continue to find, differently with respect to the regulatory measures that are needed to protect the amateur service from interference from BPL operations. The presentations in those informally conducted experiments were part of our initial internal investigation of BPL and, while there is value in them, they are not the sole source of our information on BPL performance. In this regard, we considered all of the available information on BPL systems and their performance, submissions in the comments and other publicly available information. We also observe that some of the staff presentations on which ARRL focuses were of experimental systems that used early implementations of BPL equipment, developed before the *BPL Order*, that do not appear to have complied with the new rules; additionally, information on other system implementations, particularly our work with the Manassas, VA system, showed different performance characteristics than the systems ARRL criticized. In some cases, ARRL simply (and incorrectly) draws different conclusions from those presentations than we do. Also, the assessments and recommendations in the redacted portions of the presentations merely reflect the views of the Laboratory engineers who performed the testing and analysis; they do not necessarily reflect the consensus view of other engineers, the management of the Laboratory or of OET. Indeed, individual views are often conflicting, but are encouraged in the interest of producing vigorous debate to lead to a thoroughly considered recommendation and decision.

[47] ARRL comments, summary at 1.

[48] *Id.* at 1.

[49] CURRENT comments at 3.

20. In the two sections of the discussion that follows, we address the potential for interference and the measurement distance extrapolation factor, examining ARRL's arguments on each of the issues it raises on those subjects and the responses of others in the comments. These issues concern: 1) the potential for interference from Access BPL emissions to amateur communications, including the rate at which the level of BPL emissions decline with distance from a power line as informed by the unredacted technical presentations and preliminary materials released in July 2009; 2) the level of notching necessary to protect amateur radio operations and whether to make notching mandatory on all amateur frequencies; 3) the technical considerations underlying the proper, *i.e.*, "correct", value of the extrapolation factor used to adjust emissions measurements made at distances less than 30 meters and other aspects of the BPL measurement procedure and our request for comment on whether to reduce the extrapolation factor; and 4) establishing a procedure for determining site-specific extrapolation factors.

A. The Potential for Harmful Interference

21. *Overview*. In the *BPL Order*, the Commission, with concurrence from NTIA,[50] concluded that the current emission limits will restrict Access BPL systems to low emitted field strength levels in comparison to the signals of licensed radio operations. It found that the effect of these limits will be to constrain the harmful interference potential of these systems to relatively short distances from the power lines that carry the BPL signals. The Commission also recognized that some radio operations in the bands being used for Access BPL, such as those of amateur radio licensees, may occur at distances sufficiently close to power lines as to make harmful interference a possibility. The Commission stated that it believed those situations can be addressed through interference avoidance techniques by the Access BPL provider such as frequency band selection, notching, or judicious device placement, and it adopted rules to facilitate such solutions.[51]

22. The Commission agreed with ARRL that Access BPL on overhead lines is not a traditional point-source emitter, but not with its argument that Access BPL devices would cause power lines to act as miles of transmission lines all radiating RF energy along their full length. In this regard, the Commission observed that the Part 15 emission limits for carrier current systems have proven very effective at controlling interference from such systems. Also, it indicated that the design and configuration of Access BPL systems would be inconsistent with the development of cumulative emission effects for nearby receivers. The Commission further concluded that because the BPL emissions level decreases significantly with distance perpendicular from the line, the potential for interference also decays rapidly with distance from the line.[52]

23. Notwithstanding the above considerations, the Commission recognized that Access BPL systems present concerns for licensed users in the high frequency (HF) and lower portions of the very high frequency (VHF) bands, given the propagation characteristics of RF signals in the range of frequencies being used for these systems, the diversity of users of these frequencies, and the fact that Access BPL devices could be installed at many locations in an area.[53] While it concluded that there is

[50] NTIA undertook a significant effort to both study Access BPL technology, including its operating characteristics and interference potential, and to make specific recommendations to the Commission for policies to encourage its implementation and to manage its interference potential in this proceeding. The Commission staff worked closely with NTIA on this matter and the policy decisions and rules adopted for Access BPL reflect this cooperation and embody many of NTIA's recommendations. *BPL Order supra* at 21266.

[51] *BPL Order* at 21282.

[52] *Id.,* at 21282-21283.

[53] The HF band covers frequencies from 3 to 30 MHz. The VHF band covers frequencies from 30 MHz to 300 MHz.

little likelihood that harmful interference would occur from Access BPL operations at the signal levels allowed under the current Part 15 emission limits, it acknowledged that such interference could occur in limited situations despite the intentions of BPL operators. To address this interference potential, the Commission required BPL operators to comply with additional interference mitigation techniques. It stated that such steps should be taken particularly in those cases where the occurrence of interference would affect critical services[54] or where interference could be anticipated to occur. The interference mitigation measures for critical services include exclusion from operating on certain frequency bands and exclusion from operation in certain areas.[55] For all services, the interference mitigation provisions require that BPL system operators have the ability to remotely cease operation or apply frequency avoidance (notching) on bands where licensed services are receiving interference. BPL operators were required to be able to notch their operations on affected bands to a level 20 dB below the Part 15 emissions limit for frequencies below 30 MHz (*i.e.*, 1/100th of the emissions limits for other unlicensed unintentional radiators).[56]

24. In the *BPL Reconsideration Order*, the Commission affirmed its selection of 20 dB below the Part 15 emissions limit as the minimum notching capability for frequencies below 30 MHz.[57] It also revised the rules to specify that where an Access BPL operator implements such notching, the operator need not provide further protection to mobile operations, nor will the operator be required to resolve complaints of harmful interference to mobile operations by taking steps over and above implementing the "notch." The Commission found that, while this level may be above the noise floor, reception of signals in mobile operating conditions is generally not reliable at levels at or below that level and thus does not warrant protection.

25. *Comments*/*Discussion*. In its comments, ARRL argues that recently released documents and materials graphically and aurally reveal that Access BPL causes preclusive interference over very large areas when such systems operate under current rules.[58] It contends that, without substantial technical limits that are not in the current BPL rules, Access BPL is incompatible with normal licensed amateur radio communications. It asserts that all of the Commission's 2003 and 2004 presentations, including both the unredacted presentations and the preliminary research materials released in July 2009, directly controvert the conclusions that the Commission reached in the *BPL Order* and in the *BPL Reconsideration Order* and show that Access BPL has a significant harmful interference potential to normal residential amateur radio operation.[59] In this regard, it states that the presentations show that the

[54] Some of these critical services include national defense, maritime distress and safety, aeronautical navigation and communications, emergency response, and radioastronomy that provide important safety of life and research services. *See BPL Order* at 21287.

[55] For these services, *ex post facto* interference mitigation would not avoid potentially catastrophic results.

[56] 47 C.F.R. § 15.611(c)(1)(i).

[57] *BPL Reconsideration Order* at 9319-9320. The Commission observed that when extrapolated to values for the typical distance of a mobile antenna from roadside power lines (approximately 6 meters horizontal distance and 8.5 meters vertical distance, for a slant range of 10.4 meters) and adjusted for the typical quasi-peak-to-average ratio of 4 dB for Access BPL devices operating at high duty factor, the Part 15 limit corresponds to a root-mean squared (RMS) field strength of 44 dBμV/m for frequencies at or below 30 MHz. A 20 dB reduction would limit emissions to 24 dBμV/m. *BPL Reconsideration Order* at 9318. *See* 47 C.F.R. § 15.209(a).

[58] ARRL comments, summary at 1.

[59] ARRL also submits that the unredacted versions of the Commission's presentations contain numerous anomalies and that it is not clear that the Commission has released the entirety of any of the presentations, because there are gaps in the slide numbers. In his April 28, 2009 response to ARRL's FOIA request, OET Chief Julius Knapp addressed this situation as follows: "Note that certain slide numbers and dates appear to be out of sequence, due to (continued….)

rules currently permit operation of BPL systems whose interference potential to amateur high-frequency operation from Access BPL is essentially 100 percent at substantial distances from the power lines.[60] In support of its argument that there is significant potential for interference, ARRL submits technical analyses describing why it believes the appropriate extrapolation factor for Access BPL emissions, which is a function of the rate at which emissions attenuate with distance, should be 20 dB/decade rather than the 40 dB/decade that has traditionally been used to extrapolate measurements of carrier current systems for frequencies below 30 MHz to determine compliance with the Commission's emissions limits. To avoid this interference, ARRL requests that the rules be amended to require mandatory notching of all amateur frequency bands at notch depths of at least 35 dB below the level permitted under the Part 15 emissions limits (*i.e.*, 1/5000th of the emissions limits for other unlicensed unintentional radiators).[61] On the other hand, the Utilities Telecom Council (UTC) contends that "the portions of the staff presentations that were previously redacted are largely opinions that make observations, explain 'caveats' in the data, and provide options for the Commission to take."[62] CURRENT states that "on the whole, the preliminary data released in July 2009 have no significant effect on the Commission's earlier conclusions."[63]

26. In its November 2010 *ex parte* comments, ARRL reiterates its request for a requirement for full-time mandatory notching of all amateur bands at a 35-dB notch depth, contending that this provision can be implemented as part of the rules without any adverse impact on the BPL industry. In this regard, it claims that the 35-dB notching capability is already a standard that is voluntarily in effect in most existing BPL system architectures and deployments.[64] ARRL cites a variety of recently published domestic and international standards/reports that specify a 35-dB notching capability.[65] However, in a May 2011 *ex parte* submission responding to this filing by the ARRL, UTC argues that contrary to ARRL's claims, 35-dB notching is not required by industry standards and requests that the Commission not impose such a requirement because it would adversely impact BPL performance.[66] It further states that one of the standards referenced by ARRL, the IEEE P1901-2010, only refers to 35-dB notching with respect to one type of BPL technology, wavelet OFDM.[67] UTC asserts that wavelet OFDM technology's capability to achieve notch depths of 35 dB is not representative of the performance of BPL systems in general. It therefore argues that it would be misleading to suggest that 35-dB notching is required at all, much less for BPL technologies in general. UTC further submits that a deeper notch depth generally requires wider notch width, which means less bandwidth and lower speeds in terms of performance.[68] UTC states that

(Continued from previous page)
repeat printing of files to generate unredacted versions of pages previously redacted." We would also point out that these are not presentations that were intended for release and they underwent various revisions and modifications. The versions provided in the record are the last drafts of those presentations and thus can be considered as the "final" versions.

[60] ARRL comments at 9, footnote 7.

[61] *Id*. at 10.

[62] UPLC comments at 2.

[63] CURRENT comments at 2.

[64] ARRL November 2010 *ex parte* comments at para. 3. As part of its comments, ARRL includes an Exhibit A titled *Rationale for Fixed 35-dB Notches for the Amateur Bands in Access and In-Premise Broadband over Power Line (BPL) Regulations*, in which it outlines the electromagnetic compatibility (EMC) practices and standards that the BPL industry has generally implemented to mitigate interference problems to the amateur radio service.

[65] *See* footnote 42, *supra.*

[66] *See* UTC *ex parte* comments (filed May 4, 2011) at 1.

[67] IEEE P1901-2010, *Standard for BPL Networks: Medium Access Control and Physical Layer Specifications*.

[68] *Id.* at 2.

for these reasons the Commission should continue the current rules, rather than impose 35-dB notching.

27. In a June 2011 *ex parte* rebuttal to UTC's May 2011 submission, ARRL argues that UTC's claims are in error because they are based on a selective interpretation and misstatement of the content of the standards discussed and of the content of other sources that ARRL described.[69] With respect to industry standards, ARRL states that it reported on the notching required in a number of industry standards, not just IEEE Standard 1901, and also reported on information published by or provided to ARRL by BPL manufacturers, and on numerous measurements of BPL systems made by ARRL, members of the BPL industry, regulators and other parties. It submits that in these sources, notch depth was described or measured at depths ranging from 30 to over 40 dB. It agrees that some of those standards and other sources cited in its November 2010 filing do not specifically mandate 35-dB notching, and that in some of the sources it cited the stated notch is instead informative, and demonstrative of the capability of the state of the art.[70] ARRL submits that whether 35 dB is chosen for the Commission's regulations, or 30 dB or 40 dB, is a secondary issue. It contends that the critical point is that the state of the art of BPL system notching is far better than the 10- or 20-dB notching mandated in the current BPL rules and that higher numbers – on the order of 35 dB – are achievable and can be implemented without adverse impact on the technology, and that full time, mandatory notching with substantially higher notch depths than are currently required by the Commission's rules are critical to interference avoidance.

28. In response to UTC's statement that the 35-db notching described in IEEE Standard 1901-2010 applies only to wavelet OFDM BPL technology, ARRL states that UTC fails to note that this standard applies to two BPL technologies, wavelet OFDM and FFT OFDM (HomePlug) and argues that UTC hides the fact that the standard's requirements for FFT OFDM (HomePlug) BPL are very specific, and normative, mandating a 30 dB spectral mask depth and normatively describing a "North America" mask that includes the frequencies for the US Amateur bands.[71] ARRL also disagrees with UTC that a deeper notch depth affects the performance of BPL systems. In this regard, the ARRL submits the findings of a study of In-House (in-building) BPL equipment by the European Telecommunications Standards Institute (ETSI) that indicates that with notching, the overall trend is for a slight reduction in data rate that is not harmful.[72] ARRL further argues that the Republic of Korea has developed rules requiring that the Amateur and aeronautical and marine safety bands be permanently notched and that BPL systems are being successfully deployed in that country.[73]

29. We disagree with ARRL that the recently released materials show interference potential from Access BPL systems to be significantly greater than that which we anticipated in the *BPL Order,* that such interference will be preclusive of amateur operations over large areas, or that the current rules

[69] ARRL *ex parte* comments filed Jun 24, 2011 (June 2011 *ex parte* comments).

[70] *See* the list of sources cited by ARRL in footnote 42, *supra.*

[71] ARRL June 2011 *ex parte* comments at p. 3-4. HomePlug is an industry standard for In-House BPL devices. *See* http://www.homeplug.org/home/.

[72] ARRL June 2011 *ex parte* comments at p. 9. ARRL cites ETSI technical report, ETSI TR102-616, *PLT Report from PlugTests 2007 on Coexistence between PLT and Short-wave Radio Broadcast; Test Cases and Results,* in which test results on in-building BPL devices show 1) the loss of data was not substantial; 2) in some cases, notching spectrum that is being affected by strong interference improved the data rate; 3) there is no consistency to the degree to which notching affects the data rate (in either direction) relative to other factors such as conductor losses and the physical architecture of the premise carrying the BPL signal; and 4) the data rate available to the end user is affected by other factors (primarily the physical architecture of the local wiring carrying the BPL signal).

[73] ARRL June 2011 *ex parte* comments at p. 10-11.

are not adequate to resolve any interference that might occur. Rather, ARRL's in-depth focus on that material is in some aspects consistent with our own assessments, in other aspects incorrect, and, importantly, in many aspects does not account for the real world conditions affecting the propagation of RF emissions at HF frequencies. While ARRL provides significant information on the standard engineering principles concerning the attenuation rate of emissions from line emitters, it is mistaken as to how the attenuation rate should be viewed for purposes of measuring BPL emissions. In this regard, we again conclude that 40 dB/decade is a best estimate of the expected attenuation rate/extrapolation factor in the conditions in which measurements are made under the Access BPL measurement guidelines. We find no information in the comments or the newly submitted information in ARRL's November 2010 and June 2011 *ex parte* submissions that would warrant modification of the Access BPL rules to require notching of all amateur bands at notch depths of at least 35 dB, or otherwise provide additional protection for the amateur service. However, in reviewing the requirement that Access BPL systems be capable of reducing their emissions by 20 dB in a given frequency band and current developments in BPL equipment, we now find that it would be appropriate to increase this required "notching" capability by 5 dB, to 25 dB for BPL systems operating below 30 MHz. We respond to the comments with respect to each of these sets of materials sequentially below.

1. Unredacted Staff Presentations and Newly Submitted Materials

30. In its comments, ARRL argues that the unredacted staff presentations show that:

1) Access BPL is not a point-source emitter; it is a distributive system that has significant interference potential over a wide area at significant distances from (and along) the power line carrying BPL signals. It contends that the Commission's measurements show that there is virtually no signal decay along the power line 230 meters from the coupler.

2) The proper distance extrapolation factor for assumed signal decay with distance from the power line is much closer to 20 dB/decade of distance (20 log R) than to the 40 dB/decade of distance (40 log R) adopted by the Commission for frequencies below 30 MHz.

3) Access BPL has a considerably higher interference potential to licensed radio services than the Commission concluded in the *BPL Order* if operated at the maximum radiated emission levels permitted by the Commission's Part 15 rules (and the BPL rules adopted in the *BPL Order*). Specifically, interference to licensed mobile radio receivers is very likely for very long distances along a power line. The presentations also show that systems operating at the Part 15 emission limits will be at least 25-35 dB stronger than the median values of man-made noise at 30-meters distance. Extrapolating this to a mobile antenna closer to the lines results in an even higher noise level.

4) The Commission erred in concluding that mobile Amateur stations would be protected from interference if, in response to an interference complaint, the BPL operator reduced the BPL radiated emission level from the offending portion(s) of the BPL system by 20 dB below the maximum radiated emission level permitted for Part 15 devices generally. That remedy falls far short of reducing BPL noise to the level of ambient noise in residential environments found by Commission's technical staff, and falls far short of reducing BPL wideband noise levels to the point that mobile communications can be conducted in areas substantial distances from the power line.

5) Measurement of BPL radiated emissions should be done at heights not lower than in the same horizontal plane as the overhead power line.

31. First, we agree with ARRL that a BPL system does not behave as a point-source emitter. Neither, however, can it be analyzed as a line emitter. Analysis and prediction of RF propagation in the HF frequency region is extremely complex and difficult, and particularly at locations close to the ground,

as the Commission, ARRL and many other commenters have acknowledged throughout this proceeding.[74] Our intent in the *BPL Order* was not to say that power lines are point-source radiators, but rather simply that the interference potential lessens with distance down the line from the coupler — though this occurs at rates that can vary significantly with power line topology.

32. ARRL points out that one of the video files in the staff materials released by the Commission in July 2009 shows interference to mobile reception of signals in the amateur 20-meter band (14.0-14.35 MHz). Specifically, it states that the video of the Briarcliff Manor system recorded on August 17, 2004 (Briarcliff Video #5) shows in a graphic, compelling manner the severe and constant interference caused by the BPL system to amateur reception over huge geographic areas which obviously precluded essentially all Amateur HF communications in the area. It submits that no objective observer of this video could possibly conclude that the level of BPL radiated emissions permitted by the Commission's Part 15 rules is acceptable. ARRL is correct that the interference that is apparent on Briarcliff Video #5 is not acceptable and would not be permissible under either our Part 15 rules or the system operator's experimental license.[75] However, while interference can occur from BPL operations along a stretch of power lines as shown in that and other videos in the preliminary materials released in July 2009, we did not and do not find this example to substantiate a need for more restrictive rules on BPL systems. First, it does not appear that any of the mitigating features that are required in the rules had

[74] Access BPL systems operating on overhead power lines do not act as point sources. The operation of these systems depends on injecting BPL-modulated radio-frequency (RF) energy that travels down the power lines for detection by subsequent BPL devices. The BPL RF current and voltage carried by the power lines cause RF emissions from the power lines — not just from the BPL couplers. The ARRL correctly notes that in some cases BPL emissions may exhibit relatively little decay 0.5 mile downline from the coupler, though in other cases the decay can be much more rapid, e.g., as shown on slide 8 of *BPL Summary After Briarcliff Manor, NY Test*. In general, one would expect those RF emissions to gradually diminish with distance downline from the coupler as energy is lost to resistance in the power line conductors and correspondingly to emissions from the power lines. In addition to this gradual decay with distance downline, a more abrupt drop in RF energy on the power line is expected to occur when the power line splits between two branches, e.g., continuing down the same street in addition to branching down a side street. Such a branch splits the RF energy between the two branches and also causes an impedance mismatch that reflects some of the energy back toward the BPL coupler. Both the splitting of energy between the branches and the reflection of some of the energy back toward the coupler cause an abrupt reduction in the RF current that continues down the power line away from the coupler. This reduction in current is accompanied by a reduction in emissions from the portions of the power line beyond the split. In addition, the energy directed back toward the coupler by reflection causes standing waves, which can cause the emissions from the power line to alternately increase and decrease at various points along the line. (Connection from an overhead line to feed an underground cable results in an even larger impedance mismatch and a larger reflection of the incident RF energy.) Consequently, one can expect that the RF emissions from the power line may alternately increase and decrease in moving down the power line, but with a gradual overall decline with distance downline from the coupler and with occasional step-change reductions in emissions caused by impedance mismatches and branches. These various effects contribute to a net — but erratic — reduction in RF signal level on the power line with distance downline from the coupler. These effects are the cause of both the need for repeaters to boost the level of BPL signals in order to enable the systems to function properly and the decay in interference potential of BPL emissions with distance downline.

[75] The Briarcliff Manor Access BPL system was operated under an experimental license and therefore not subject to the Section 15.209 emissions limit. It was, however, subject to a non-interference requirement. *See* 47 C.F.R. § 15.209. We also note that in its reply comments, CURRENT observes that ARRL, on the one hand, in a December 28, 2005 report of its measurements on the Briarcliff test, (http://www.arrl.org/tis/info/HTML/plc/filings/Briarcliff-Compliant-Engineering-0106.pdf) complains that the system was out-of-compliance with the rules. It submits that ARRL cannot both complain that a system is out-of-compliance and yet also use interference from that system as evidence that the rules are inadequate. CURRENT reply comments at 7. We agree and our assessment of the interference potential of a compliant system and the effectiveness of the Part 15 emissions limit in controlling interference is not based on the performance of the Briarcliff Manor system.

been applied to this system.[76] In addition, our staff did contact the licensee about interference from that system several times over the course of its operation and the operator took steps first to cease operation on the amateur frequencies and then to install new equipment that had notching capability.[77] Subsequent examination of that system by field agents of our Enforcement Bureau found no interference, which substantiates the effectiveness of our rules when properly observed.[78] Also, as indicated by the primary and secondary title screens of Briarcliff Video #5, the system was notched only in the 20-meter amateur band, and not in the 15-meter amateur band, for which that video was recorded.[79] Thus, we did not and do not consider the interference that appears in Briarcliff Video #5 to be representative of the performance of a system operating in accordance with the set of rules we set forth for Access BPL systems.

33. We also see no merit in ARRL's argument that statements on the same presentation slide concerning an interference problem from the Phonex carrier current system to ARINC aeronautical communications and opining that compliant Access BPL "may be worse" should have served as a factor in our decision on protection for the amateur service. In the *BPL Order*, we recognized the critical nature of aeronautical communications and, given the free space propagation path from a power line to an aircraft, excluded Access BPL systems from operating on frequencies used by that service.[80] With respect to the Phonex case, we also observe that the Phonex system at issue might not have been the source of the interference with ARINC's communications and its performance therefore cannot be used as an empirical basis for establishing any benchmarks with respect to the interference potential of BPL systems.[81]

34. ARRL next observes that another presentation slide in the Briarcliff Manor presentation recommends that the Commission "impose [a] 5 dB height correction [factor]" on measurements and a "20 log R extrapolation factor" if it is going to allow BPL on medium voltage (MV) overhead power lines and should use a 20 dB/decade extrapolation factor for signal decay with distance from the power line.[82] It observes that the presentation states that this "reduces interference [from BPL] to fixed stations." Basing the BPL emissions limits and measurement procedures on an attenuation rate of 1/R, *i.e.*, 20 dB/decade would, of course, reduce signal levels and thereby provide additional protection to licensed services against interference. We note that the slide in question does not provide a "recommendation" as claimed by ARRL, rather, it only presented several options for other staff and management to consider in its deliberations. Further, as we concluded previously, we do not believe that such additional protection is needed or warranted, but rather hold that the Part 15 "no interference requirement", the Part 15 emissions limit for carrier current systems, and the interference mitigation measures we adopted in the *BPL Order*

[76] Note that at the time of all of the testing recorded in the recently released documents, the Commission had not yet adopted any of the interference mitigation requirements on Access BPL systems, such as dynamic notching and remote shut-down.

[77] *See* Letter dated February 10, 2005 from Bruce Franca, Deputy Chief, Office of Engineering and Technology, to Christopher Imlay, ARRL.

[78] *Id.*

[79] *See also* the "Briarcliff Manor BPL Video Files" description in the preliminary materials released in ET Docket No. 04-37 on July 17, 2009.

[80] *See BPL Order* at 21287.

[81] *See* Memorandum from Joseph Casey, Chief, Spectrum Enforcement Division, Enforcement Bureau, to Bruce Franca, Deputy Chief, Office of Engineering and Technology, dated January 27, 2004, in ET Docket Nos. 03-104 and 04-37, at http://fjallfoss.fcc.gov/ecfs2/document/view?id=6516083908; *see also,* comments of Phonex Broadband Corporation on this subject at http://fjallfoss.fcc.gov/ecfs2/document/view?id=6515683343.

[82] ARRL comments at 28; Briarcliff Manor presentation summary at slide 19.

collectively provide sufficient protection to licensed services from the potential for harmful interference from Access BPL operations. As discussed below, we also continue to find that the attenuation rate of emissions from power lines is typically higher than 20 dB/decade and varies with location. At distances within 30 meters of the power line and when using the slant-range measurement procedure prescribed in our measurement guidelines, $1/R^2$, *i.e.*, 40 dB/decade, properly describes the expected attenuation rate at frequencies below 30 MHz, and variability around that rate is also expected.

35. It is also important to understand, as we discussed in the *RFC/FNPRM* and ARRL largely ignores, that RF propagation in the lower frequencies ranges, and particularly at frequencies below 30 MHz, is greatly affected by environmental factors, so that there is significant variability in propagation from place to place. These include ground absorption and conductivity, terrain, vegetation, and the presence of structures and other man-made objects, including additional power lines arrayed on pole/towers in the near-field of emissions from a power line carrying Access BPL transmissions. In some cases, emissions from BPL systems that are expected to be compliant with the rules will attenuate with distance at relatively high rates and be well below the Part 15 limits while emissions from other systems, or even from the same system but at a different location, will attenuate at a relatively lower rate and exceed the Part 15 limits. We are aware of these variabilities in this complex operating environment and to account for it, we adopted the additional provisions for mitigating harmful interference that are set forth in the rules. In addition, recognizing this variability, we did not base our assessment of interference potential on any standard performance factor, such as an attenuation rate by itself, but rather on the successful past performance of our existing standards and the availability of suitable approaches for managing the potential for harmful interference and correcting any harmful interference that may occur.

36. We have also fully considered the issue of how to measure Access BPL emissions, including whether a 5 dB correction factor was needed for Access BPL measurements below 30 MHz. In the *BPL Order*, we concluded that the existing measurement procedure that provides for measurement of the magnetic field at 1-meter height with no correction factor was appropriate for measurements in that frequency region.[83] There is no additional information in the presentation summaries that leads us to find that this decision should be changed.

37. ARRL points out that slide 20 of the Briarcliff Manor presentation listed options of notching or mandatory advance coordination for protection of low-VHF public safety channels and that the

[83] *See BPL Order* at 21303-21310. In its May 2004 comments in this proceeding addressing the Commission's proposed measurement guidelines later adopted, ARRL supported a measurement height of 1 meter with the use of a loop antenna to measure magnetic fields, stating that "ARRL has done antenna modeling that shows that the magnetic field will typically vary approximately 3 dB with height…" *See* ARRL comments filed May 3, 2004, Exhibit D at page 28, at http://webapp01.fcc.gov/ecfs2/document/view?id=6516182983. According to this submission, the maximum value is found at power line heights of 18 meters above ground, a height much higher than typical power line heights of 10-12 meters. For example, Figure 5 of Exhibit D shows only a 1.4 dB difference in the H-field intensity between a measurement at 1 meter and a measurement at a power line height of 11 meters, for 14 MHz. Further, ARRL agrees that measurements at such height, or even at typical power line heights of 10-12 meters, are neither practical nor safe. However, in its subsequent reply comments in the same time frame (filed June 2004), ARRL then agreed with NTIA's suggestion for a 5-dB height correction for measurements below 30 MHz (which NTIA itself later dropped based on subsequent studies, *see* NTIA supplemental comments filed Sep 24, 2004 at 3). Nonetheless, ARRL did not submit any data to the contrary to rebut its own previous submissions that the magnetic field does not vary much with height, especially at typical power line heights of 10-12 meters, obviating any need for a height correction factor for frequencies below 30 MHz. In its *ex parte* comments filed on January 11, 2010, ARRL again reiterated its demand for a height correction factor, stating that most standards require the use of a height-scanning antenna mast, but neglected to address that emission measurements below 30 MHz are made with a loop antenna and that its earlier modeling data and conclusions support the findings from NTIA and from the Commission that no height correction factor is necessary for frequencies below 30 MHz.

Commission did not adopt either of those options but instead put in place a notification requirement.[84] It also observes that the same slide listed the 50-54 MHz amateur band that is typically used for both mobile and fixed operations and the Commission did not acknowledge the interference potential to amateur operations in that band and offered no remedy for it. In the *BPL Order*, we determined that public safety systems, because of the often critical and/or safety-of-life nature of the communications they provide, merit the additional protection of advanced notice of BPL operations. We stated that an advance notification would provide a public safety operator with an opportunity to assess whether there are portions of its geographic area of responsibility about which it should make special arrangements with the Access BPL operator in order to avoid interference.[85] We did not address the frequencies used by the amateur service on an individual basis, but rather concluded that amateur radio frequencies generally do not warrant the special protection of frequency exclusion that was afforded frequencies reserved for international aeronautical and maritime safety operations.[86]

38. ARRL observes that slide 21 of the Briarcliff Manor presentation predicts the potential for BPL to cause interference to mobile operations to be "high" to "very high." It further observes that the same slide has a table indicating that the interference distance to fixed stations would be 62 meters at 2-8 MHz and 400 meters at 8-30 MHz in areas where the noise levels were at the International Telecommunication Union (ITU) "residential" level.[87] It contrasts these statements with our findings in the *BPL Order* that the potential of Access BPL systems was "low" and observes that in the case of mobile communications where a vehicle is close to the power lines, the potential for interference will indeed be higher. While we again recognize that at some locations (including where nearby antennas are located above the height of the power line) the attenuation rate of Access BPL emissions will be lower and at other locations it will be higher, these levels are consistent with our interpretations that the interference potential is low such that it can be managed adequately with the additional interference mitigation measures and the "no harmful interference provisions" of Part 15 that are also in our rules.[88] In this regard, the distances from a power line to an amateur fixed receiver will be sufficiently short that if harmful interference were to occur, the recipient could readily identify its source and request that it be resolved. We observe that International Broadband Electric Communications, Inc. (IBEC), a major operator of Access BPL systems, reports (with confirmation by ARRL in its comments) that it has been communicating with the local amateurs and emergency services in the areas it covers to implement a successful interference resolution process.[89] It states that it has been able to resolve interference complaints, as they arise, under the framework of the existing Access BPL rules. This information provides confirmation that the processes and requirements we established, when used in practice, are adequate to prevent most cases of harmful interference to licensed services, and to resolve quickly any instances of harmful interference that do occur.

39. *Spectrum Notching.* The rules provide for mitigation of BPL interference where it may occur by notching. In the *BPL Order* and the *BPL Reconsideration Order,* the Commission found that, for frequencies below 30 MHz, a 20-dB notch would appropriately address any harmful interference that

[84] ARRL comments at 29-30.

[85] *BPL Order* at 21288-21289. Section 15.615(e) requires that notifications of Access BPL operations be provided to local public safety agencies at least 30 days prior to a system's initial operation.

[86] ARRL had requested that the Commission include the amateur HF and VHF allocations with other bands that NTIA determines require protection from BPL interference. *BPL Order* at 21289.

[87] *See* Briarcliff Manor presentation summary at slide 21.

[88] 47 C.F.R. § 15.5.

[89] IBEC comments at 2; *see also* ARRL reply comments at 3-4.

might occur to mobile operations, given both the low signal levels allowed under the Part 15 emission limits and the fact that a mobile transceiver is generally only in one place for a limited period and can readily be re-positioned to provide some separation from the Access BPL operation.[90]

40. In its comments, ARRL argues that slide 13 of the Briarcliff Manor presentation summary references predictions from the *NTIA Phase 1 Study* that show that the noise floor would rise by more than 20 dB at nearly all points, and by 30 dB at most points, along a 340-meter modeled power line. It also notes that the slide states that in NTIA's measurement activities, NTIA took occasional samples of noise power along the line with the Access BPL system turned off and found noise levels lower than predicted by the ITU for residential areas.[91] ARRL therefore contends that the 20-dB standard for the notching requirement is insufficient.[92] We initially note that NTIA's sampling of noise power was only at a very limited number of locations and not sufficient to serve as the basis for a conclusion that the noise floor is lower than the levels recognized by the ITU.[93] Further, as discussed below, there is not sufficient information in any of the submissions regarding changes in the noise floor to justify a change from our use of the well-established ITU-recommended levels for the noise floor in different environments.

41. In its November 2010 *ex parte* submission, ARRL provides additional comments[94] that reference several recent domestic and international industry and governmental reports/standards to support its request for a 35-dB notch of all the amateur frequency bands. These documents include: 1) ITU-R Report SM.2158;[95] 2) ITU-T G.9960;[96] 3) IEEE P1901-2010;[97] and 4) OFCOM Report on In-

[90] *BPL Order* at 21294 and *BPL Reconsideration Order* at 9318.

[91] The ITU's expected noise power levels are set forth in ITU-R Recommendation P.372-10 *Radio Noise*.

[92] ARRL comments at 36.

[93] We also note that in the same report, NTIA concludes that "the results for the vehicular mobile receiver predict that the received BPL signal power near the Earth surface falls off rapidly with distance from the lines. The distances within which these thresholds were exceeded at fifty percent of locations were modestly smaller at a third frequency (4 MHz) and much smaller at the fourth frequency (40 MHz). In all land vehicular cases considered, reductions in S/N were less than 3 dB and 10 dB beyond one-hundred-and-twenty-five meters and fifty-five meters, respectively." NTIA Report 04-413, "*Potential Interference From Broadband Over Power Line (BPL) Systems To Federal Government Radiocommunications at 1.7 - 80 MHz*," Phase 1 Study, Volume 1, April 2004 (*NTIA Phase 1 Study*), at 23.

[94] ARRL November 2010 *ex parte* comments at Exhibit A.

[95] *See Impact of Power Line Telecommunications Systems on Radiocommunications Systems operating in the LF, MF, HF and VHF bands below 80 MHz*, International Telecommunications Union (ITU) Report SM.2158, 2009. This report covers the use of the radio spectrum and associated interference protection requirements of radiocommunication services operating below 80 MHz with respect to the impact of BPL systems as part of the International Telecommunications Union studies on the compatibility between radiocommunication systems and high data rate telecommunication systems using electricity power supply or telephone distribution wiring. *See* http://www.itu.int/pub/R-REP-SM.2158/en.

[96] *See Unified High-speed Wire-line based Home Networking Transceivers – Foundation*, ITU-T G.9960, 2010. This ITU Recommendation specifies the system architecture and physical (PHY) layer for wireline-based home networking transceivers capable of operating over premises wiring including inside telephone wiring, coaxial cable, and power-line wiring. Transceivers defined by this Recommendation use OFDM-type modulation and are designed to provide EMC and spectral compatibility with other devices sharing the in-premises wiring. *See* http://www.itu.int/rec/T-REC-G.9960-201006-P.

[97] *See Standard for BPL Networks: Medium Access Control and Physical Layer Specifications*, IEEE P1901-2010. This standard provides specifications for several of the BPL existing OFDM protocols, essentially a multi-carrier (continued….)

Home PLT devices.[98] All of these documents mandate or recommend notching of the amateur frequencies.[99] ITU-R Report SM.2158 states that the maximum allowable increase in the noise floor[100] due to BPL emissions should not exceed 0.5 dB, based on the assumption that the fade margin[101] of the amateur service in long distance communications is less than 1 dB.[102] Based on this assumption, ARRL argues that a notch depth of 34 dB would be required if a 20-dB/decade extrapolation of the FCC emission limits is used and a notch depth of 43 dB would be needed if the existing extrapolation factor of 40-dB/decade is used.[103]

42. In re-examining all of the information pertaining to the depth of the notching requirement, we now find that it would be appropriate to increase the required notching capability to be 5 dB greater than the 20 dB specification we initially adopted. Previously, we observed that when operating with a 20-dB notch below 30 MHz, the maximum allowed emissions from an Access BPL system is 10 dBμV/m at the Part 15 measurement distance of 30 meters, a level which is at or only modestly above the noise

(Continued from previous page)
technique that spreads data among multiple carriers to allow a more robust operation in a noisy environment. *See* http://grouper.ieee.org/groups/1901/.

[98] *See The Likelihood and Extent of Radio Frequency Interference from In-Home PLT Devices*, OFCOM Report, June 21, 2010. This report focuses on In-House BPL devices in the United Kingdom, concluding that the notching of international amateur frequencies combined with interference mitigation features such as power control and smart notching would be sufficient to reduce interference to negligible levels. *See* ARRL November 2010 *ex parte* comments at Exhibit G.

[99] Concerning the level of notching needed, the ITU-T 9960 Recommendation specifies 30 dB notching of In-House BPL systems for compatibility with amateur radio services. The OFCOM Report, which focuses exclusively on In-House BPL devices, indicates that although smart notching capabilities (between 30 and 40 dB) are already part of the product roadmaps of the BPL vendors that were consulted as part of the study, it is recommended that where possible the introduction of these features be formalized. The IEEE P1901-2010 Standard provides for 35-dB notching for both In-House and Access BPL devices. The ITU-R Report SM.2158 does not specifically recommend a particular notch depth with respect to compatibility with amateur radio services, but states that "the maximum allowable increase in the total noise floor due to [BPL] emissions should be 0.5 dB." ITU-R Report SM.2158 at p. 35.

[100] ITU-R Report SM.2158 at p.36-37. The noise floor figures are derived from Recommendation ITU-R P.372-10 (2010) *Radio Noise*. *See* http://www.itu.int/rec/R-REC-P.372/en. In its June 2011 *ex parte* comments, ARRL also mentioned ITU Recommendation SM.1879 that refers to the SM.2158 report with respect to the increase in the noise floor.

[101] "Fade margin" refers to the amount by which a received signal level may be reduced without causing system performance to fall below a specified threshold value.

[102] ITU-R SM.2158 at p. 35.

[103] *See* ARRL November 2010 *ex parte* at Exhibit A, p. 29. ARRL also includes in this *ex parte* additional Exhibits B through G that show operation of BPL systems with 35-dB notching and certain other information relating to its position that BPL poses a threat of interference to amateur operations. Exhibit B is a copy of a joint report issued in 2001 by HomePlug and ARRL with respect to the cooperative tests and development of the HomePlug standard for In House BPL which incorporated 30 dB notches in amateur bands. Exhibit C is a copy of a news article released in 2006 discussing a demonstration at ARRL's headquarters of the notching efforts made by Spanish BPL chip manufacturer DS2 to avoid interference to amateur radio services. Exhibit D is a description of errors found in the BPL database maintained by UPLC, which ARRL has also identified in its comments (filed Sep 23, 2009). Exhibit E is a report commissioned by IBEC in 2004 to show that spectrum notches for the Amateur bands were implemented at an IBEC deployment in Cullman, AL. Exhibit F is a test report made by the Albermarle Amateur Radio Club in 2004 on another IBEC BPL system in Nelson County, VA, showing test results on spectrum notches in various amateur bands. Finally, Exhibit G reproduces an OFCOM report dated Jun 21, 2010 that studied the interference potential of In House BPL devices on radio services in the HF and VHF frequencies in the U.K.

floor in the HF bands at most locations.[104] That is, our intention was that Access BPL emissions in a notched bandwidth would not be significantly greater than the background noise at the distances normally used for protection against harmful interference from Part 15 unlicensed devices. We also evaluated the potential for interference at closer distances that can occur when conducting mobile communications while traveling adjacent to roadside power lines. We observed that when extrapolated to values for the typical closest distance of a mobile antenna in motion from roadside power lines (approximately 6 meters horizontal distance and 8.5 meters vertical distance, for a slant range of 10.4 meters) and adjusted for the typical quasi-peak to average ratio of 4 dB for BPL devices operating at high duty factor, the Part 15 limit corresponds to a root-mean-squared (RMS) field strength of 44 dBμV/m for frequencies at or below 30 MHz. A 20 dB reduction would limit emissions to 24 dBμV/m. We concluded that given the high variability of the noise floor at HF frequencies, where increases of as much as 20 dB or more are common, mobile reception of relatively weak signals under 24 dBμV/m is generally intermittent and not reliable because both the received signal and the ambient noise levels vary up and down (the received signal and noise energy levels generally do not rise and fall together) as the vehicle moves.

43. In carefully reviewing the record on this issue, we acknowledge ARRL's point that the modeling in the *NTIA Phase 1 Study* predicts that Access BPL emissions on frequencies below 30 MHz that are at the Part 15 limit would raise the mobile radio noise floor at 15 MHz and 25 MHz by 30 dB in 59% of residential locations.[105] After a 20-dB notch, the BPL remaining emissions would still produce a noise floor increase of about 10 dB for mobile operations in residential locations at those frequencies. As we observed in the *BPL Reconsideration Order*, there is considerable variability around the median noise level, such that increases of as much as 20 dB are common and reduce the reliability of signals at the margin of expected reception.[106] While we continue to believe that the significant variability in background noise levels limits the reliability of HF signals below 30 MHz such that BPL emissions at a level of 24 dBμV/m should not generally be considered harmful interference, we also understand that the 20 dB value for noise increases due to diurnal and seasonal factors is the maximum expected effect and that in many cases the daily variability in the noise floor levels will be somewhat less. We have no specific information on the distribution of the diurnal and seasonal variability of noise floor levels; however, we believe that an increase of 5 dB in the required notching capability, or half the 10-dB current margin of BPL emissions affecting mobile reception above the residential noise floor, according to NTIA's estimates as supported by ARRL, would take a more conservative approach and provide

[104] *BPL Order on Reconsideration* at 9319-9320. The nominal noise floor in the HF band, as recognized by the International Telecommunications Union, varies with frequency and population/commercial density (values are provided for business, residential, rural, and rural quiet areas). For reception with a short vertical monopole, the ITU median noise levels are 10 dBμV/m, 5 dBμV/m, 0 dBμV/m, and -7dBμV/m in business, residential, rural, and rural quiet areas, respectively, in a 9-kHz bandwidth at 30 MHz (at lower frequencies the ITU median noise levels increase on a sliding scale). The Part 15 radiated emission limit for Access BPL and other carrier current systems is 30 dBμV/m quasi-peak in a 9 kHz bandwidth at 30 meters for frequencies at or below 30 MHz, *see* 47 C.F.R. § 15.611(a).

[105] *NTIA Phase 1 Study*, Volume I, Table 6-3. These predictions assume that mobile operations occur at a distance of 15 meters horizontal distance from the power lines. The increase in the noise floor is different at different frequencies below 30 MHz. For example, the same table in the NTIA *Phase 1 Study* shows that a 30 dB noise floor increase at 4 MHz only occurs in 6% of residential locations.

[106] See *e.g*., comments of NTIA in response to the *BPL Notice of Proposed Rule Making* (filed Sep 8, 2004), in which it states that "[p]ower line noise resulting from ingress of ambient radio noise can vary by upwards of 20 dB throughout the day and seasonally, especially at frequencies below 12 MHz." NTIA comments at 9. In addition, the ITU-R Rec. P.372-9 information on the values of decile deviations of man-made noise, showing combined variability with location and time of 19.4 dB, 16.4 dB and 16 dB in business, residential and rural environments, respectively. *See* ITU-R Recommendation P.372-9 (2007), *Radio Noise,* Table 2, at p. 15.

protection for amateur mobile operations in more instances, while continuing to recognize the variability in emissions that limit the service to mobile amateur receivers.[107] Given our understanding supported by the assertions in the record that most BPL operators are already using notches of at least 25 dB, we would expect the cost imposed by this requirement to be minimal or nil. We find that the benefits of providing additional protection for licensed services outweigh any potential additional costs to BPL providers. Such benefits include a more integrated environment where BPL devices may share spectrum with licensed users, with lesser concerns for potential harmful interference. BPL devices bring expanded benefits to electric utility companies by allowing them to monitor, and thereby more effectively manage their electric power distribution operations.[108] BPL also brings "last-mile" delivery of broadband services to some rural and underserved areas.[109]

44. With respect to the new information in ARRL's November 2010 *ex parte* submission, we first are not persuaded that a 0.5 dB increase in the noise floor as used in the ITU-R Report SM.2158 is a reasonable assumption for the numerous reasons we stated above with respect to the significant variability in background noise levels at HF frequencies.[110] Further, it appears that the 0.5 dB number was used in the ITU Report without any discussion, analysis or other explicit rationale. We further note that in its June 2011 *ex* parte submission, ARRL mentions that ITU-R Recommendation SM.1879,[111] which refers to the above report, does recommend that stations operating in the Amateur Service be protected to a level such that noise at the protected station is not increased by more than 0.5 dB.[112] Although ARRL provided calculations to relate the 0.5 dB increase in the noise floor with the Part 15 limits to arrive at its requested 35-dB notch number, it again did not provide a rationale for using a 0.5 dB increase in the noise floor as the protection criterion at HF frequencies. With the exception of ITU-R Report SM.2158, the reports/standards submitted by ARRL in its November 2010 *ex parte* comments do not include any analysis that shows that 35 dB or some other figure is the proper level of notching needed to protect amateur operations, but rather simply state as their recommendations/requirements a notching depth that existing BPL equipment can meet. We also recognize the ARRL's observation in its June 2011 *ex parte* submission that in the IEEE P1901-2010 standard there is a normative requirement for a 30-dB notch depth for the FFT OFDM (HomePlug) technology.[113] While this voluntary industry standard is apparently being used by manufacturers of HomePlug In-House BPL equipment, it is more stringent than

[107] In our previous decisions, we have assumed that mobile operations occur at a distance of 6 meters horizontal distance from the power lines. Following the analysis set forth in the *BPL Reconsideration Order*, at the shorter 6-meters distance, a 5-dB increase in an Access BPL notch will leave a margin of approximately 15 dB above the residential background noise level.

[108] *See* IBEC Smart Grid solutions at http://www.ibec.net/services.php; Amperion Smart Grid solutions at http://www.amperion.com/solutions.php.

[109] *See* IBEC High Speed Internet services to rural Americal at http://www.ibec.net/services.php.

[110] We note that ITU-R Recommendations are not binding on the Commission. *Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co- Frequency with GSO and Terrestrial Systems in the Ku- Band Frequency Range*, *Memorandum Opinion and Order and Second Report and Order*, ET Docket No. 98-206, 17 FCC Rcd 9614, 9631 (para. 41) (2002) ("[R]ecommendations resulting from ITU-R deliberations are not necessarily binding for purely domestic allocation decisions . . . ."). *See also Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems, Third Memorandum Opinion and Order*, ET Docket No. 98-153, 25 FCC Rcd 11390, 11393 n.16 (2010).

[111] *See* ITU-R Recommendation SM.1879, *The impact of Power Line High Data Rate Telecommunication Systems on Radiocommunication Systems below 30 MHz.*

[112] ARRL June 2011 *ex parte* comments at p. 4.

[113] *Id.*, at p. 3-4.

is necessary for our regulatory purposes as discussed above and in any case does not apply to the Access BPL applications at issue herein. We also do not find persuasive ARRL's argument that deeper notching can be implemented without adverse impact on the data rates of BPL technology. In this regard, the testing on which ARRL bases this claim was on In-House rather than Access BPL equipment and in any case our principal concern is with imposing regulation that is more restrictive than necessary rather than simply minimizing the impact that such regulation might have on some aspect of BPL equipment or its operation. While we duly note the Republic of Korea's decision to require permanent notching of the amateur bands, the relevance of that determination by that country's regulatory body at that time to our present consideration is not readily apparent, and ARRL provides no information regarding either the radio environment or the regulatory objectives and standards that informed that decision by which we might consider how those considerations might affect our own decision making.

45. We recognize that one of the documents referenced by ARRL, IEEE P1901-2010, is an industry standard for both Access and In-House BPL equipment authored by nearly a hundred entities that include BPL service and equipment providers and that this standard describes a 35-dB spectrum notching for compatibility with amateur radio services that can be supported by a type of BPL technology known as wavelet OFDM, as elucidated by UTC.[114] Further, as ARRL submits, its scrutiny of systems listed in the BPL database indicates that existing BPL systems in the U.S. are generally notching the entirety of the HF amateur allocations, using equipment capable of notch depths of at least 35 dB.[115] Thus, it appears that many BPL systems now in operation may be voluntarily observing the notch depth and band avoidances that ARRL is requesting. While those industry practices are consistent with the ARRL's goals in this matter, we nonetheless find they are more stringent than are justified from a regulatory standpoint.[116] In this regard, we do not find that an increase in the required notching capability to a level above 25 dB is needed to protect against interference to amateur or any other licensed services. To require that all systems adhere to a *de facto* industry 35-dB notching standard would unnecessarily constrain BPL operators, as stated by UTC, and equipment manufacturers who might choose to design for a different level of operation that would comply with the notching level we have determined will provide adequate protection.[117] Further, to require that all of the amateur bands be notched would unnecessarily restrict BPL operations in areas/locations where no amateur operations are present that could receive interference.

46. As indicated above, we see no statistically-valid support for ARRL's position that the ambient noise levels have become so low as to contradict our conclusion here that a 25-dB notch is generally sufficient to protect licensed services.[118] Further, for fixed stations, if a 25-dB notch is not sufficient to resolve observed harmful interference or other steps to resolve the interference are not successful, under Section 15.5(c) of the rules, the operator is then, upon notification by a representative of

[114] ARRL November 2010 *ex parte* comments at Exhibit A at 14 and UTC *ex parte* comments (filed May 4, 2011) at 2.

[115] ARRL November 2010 *ex parte* comments at para. 8 and Exhibit A.

[116] *See* discussion in para.42, *supra*.

[117] UTC *ex parte* comments (filed May 4, 2011) at 2.

[118] We disagree with ARRL that the single measurement by our staff of a noise level below 0 dBμV/m shows that noise levels are typically below the ITU residential noise floor. One observation is not a sufficient sample to statistically support any conclusion(s). *See also,* ARRL reply comments in which it agreed that the FCC Lab finding is not sufficient justification [that the noise floor has decreased], and that the ITU-recommend noise floor levels are indeed reasonable and typical and that even other competent bodies such as the North Atlantic Treaty Organization (NATO) believe that these ITU noise floor numbers are still valid today. ARRL reply comments at 8 and its Exhibit A at 7.

the Commission, required to cease operation until the interference is corrected. In such cases, the interference might perhaps be resolved by using new equipment that includes a filter with a notch capability greater than 25 dB. We believe, however, that the new 25-dB notching requirement will be sufficient to resolve the great majority of cases of harmful interference that might occur and therefore do not see a need to require that Access BPL systems routinely use equipment with greater notching capability.

47. In changing the notching level to 25 dB, we are aware that Access BPL operators have already installed equipment with 20-dB notching capability in compliance with the rules and that there is some inventory of equipment built to that standard which has not yet been installed. While we believe that the greater level of protection provided by our rule change is prudent in the long term, we have not observed any cases to date where the notching afforded by existing equipment has not been adequate to resolve interference. Accordingly, given the limited number of devices already deployed and manufactured, we will not require their replacement or prohibit their installation for replacement or in new constructions. In order to afford manufacturers time to redesign their equipment to comply with the new, more conservative 25-dB notching requirement, we will allow an 18-month period from the date this action is published in the Federal Register before the requirement becomes effective.

48. In its reply comments, ARRL submits that IBEC did not resolve interference complaints to amateur fixed stations by doing what the existing BPL rules require, other than compliance with the general Part 15 requirement to correct any harmful interference.[119] It states that instead, IBEC has avoided or resolved the interference by doing two of the things that ARRL has requested as modifications to the existing BPL rules: 1) IBEC avoided the use of Amateur bands in its installations, and 2) it has used state-of-the-art notch depths of 35 dB. We observe that avoiding a frequency band where interference could occur is certainly an option that is contemplated under the rules. Using a notching capability with attenuation of greater than that required in the rules where needed is also consistent with the general requirement in Part 15 rules that a device not cause harmful interference. We do not, however, find the fact that equipment which can provide 35-dB notching capability is now available and IBEC's choice to use such equipment to be indicative that we should require that level of notching capability in all instances. Rather, while the rules will now require a notching capability of at least 25 dB, that level of attenuation will only be deemed sufficient for resolving harmful interference in the case of mobile operations; the system operator is still responsible for resolving harmful interference to fixed operations if the 25-dB notch capability is used and the interference remains. Under the notching rules we are adopting, a BPL system operator has the flexibility to install a notching capability greater than 25 dB or to implement other measures for resolving harmful interference in cases where the 25-dB notch is not sufficient. In this regard, IBEC did, in fact, take the steps required under Section 15.611(c) of the rules – it configured its systems to be capable of remotely reducing power by 35 dB and adjusting operating frequencies to avoid site-specific, local use of the same frequencies by licensed radio operations.[120] A different operator might have chosen an alternative approach for complying with this rule.

2. Preliminary Documents released in July 2009

49. In its comments, ARRL addresses the three additional staff PowerPoint® presentations that were placed into the record on July 22, 2009 (three additional presentations).[121] It contends that these

[119] Reply comments of ARRL at 3.

[120] 47 C.F.R. § 15.611(c).

[121] These presentations, as listed in Appendix F, are "Field Strength Measurements Relative to ARRL Concerns Regarding BPL," October 16, 2003; "Broadband Over Power Line (BPL) Test Results and Considerations," December 3, 2003; and "BPL Emission Tests in Briarcliff Manor, NY," August 17-19, 2004.

presentations are "most relevant" to the determination of the actual interference potential of BPL to licensed radio services, the proper radiated emission level for BPL systems at HF, the proper distance extrapolation factor for signal decay, and the necessity of full-time notching of all Amateur Radio allocations by BPL systems in order to avoid interference.[122] ARRL argues that, in the aggregate, these presentations show that the Commission's assumptions in the *BPL Order* with respect to the interference potential of BPL to the amateur service, both fixed and mobile stations, were wrong.[123]

50. ARRL first states that the three additional presentations collectively show that radiated noise from overhead power lines carrying Access BPL signals increases significantly above the ambient noise level when measured at ground level.[124] It alleges that the *BPL Order* improperly focused on mitigating interference to licensed services after the fact, rather than on preventing interference from BPL to licensed services *ex ante*.[125] ARRL contends that the Amateur Service is uniquely adversely affected by BPL interference and that the probability of harmful interference to amateur communications is virtually 100 percent in residential areas where there are overhead MV power lines. ARRL asserts that practical experience with BPL interference indicates that the information in the three staff presentations was absolutely correct: interference is not practically resolved *post hoc*, and BPL has a far higher likelihood of interference to the amateur service than other Part 15 devices, which are qualitatively different. It demands that the rules be revised in view of these facts just now coming to light.[126]

51. Notwithstanding ARRL's contentions, we did consider the information in these presentations in the *BPL Order* and in the formulation of our rules for regulating interference from Access BPL emissions. There are no new facts, information, or interpretations in these presentations or in ARRL's comments that are inconsistent with our previously stated understandings and findings. These presentations, as well as other information in this proceeding, show that Access BPL operations can raise the RF noise level to levels above the noise floor such that they can cause interference to amateur operations in the close vicinity of power lines on which the BPL signals are carried. As the presentations show, the area of interference is essentially limited to distances close to and along the power lines.[127] While some interference is possible at locations close to the power line, we believe that in the great majority of locations, interference will not occur to radio services because either propagation conditions limit the range of the Access BPL emissions or there is no licensed amateur station present and operating on the frequencies on which such emissions appear. We see no need to require an Access BPL operator to reduce emissions below the Part 15 limits where there is no potential for interference. In addition, we have required that a database of Access BPL systems be established to allow amateur operators to identify BPL operations in their area before the systems commence operation so that they have an opportunity to alert the BPL operator of their presence before the system is activated.[128] We address specific points in ARRL's arguments in the following paragraphs.

52. ARRL argues that the three additional presentations released in July 2009 show that in

[122] ARRL comments at 39.

[123] *Id.* at 45.

[124] *Id.* at 46.

[125] *Id*. at 45.

[126] ARRL comments at p. 45-46.

[127] *See* for example, "BPL Emission Tests in Briarcliff Manor, NY," slide 23 – "distance away from the power line, which exhibits a rapid drop-off with distance."

[128] The requirements for the Access BPL database are set forth in Section 15.615(a) of the rules, 47 C.F.R. § 15.615(a).

recent years, the ambient noise levels have decreased below the rural noise levels recognized by the ITU and that this reduction in the noise floor results in a greater potential for interference to amateur communications.[129] In particular, it observes that the first presentation, "Field Strength Measurements Relative to ARRL Concerns Regarding BPL," indicates that, according to a December 2001 report by NTIA (*2001 NTIA Report*), ambient noise levels measured at 137 MHz in the VHF band have decreased by 10 dB since the ITU noise models were adopted.[130] ARRL submits that this indicates that the actual residential noise floor is now 4 dB below the ITU rural curve. It also points to a (single) measurement by the staff at the FCC Laboratory of noise levels in the MF and HF bands used by the amateurs that showed the ambient noise to be 5-8 dB below the ITU rural curve.[131] It points to slides 11 and 12 of the above presentation and argues that with this reduction in the noise floor, BPL emissions can now be the source of a 25-35 dB increase from the noise floor at 30 meters from the power lines and that this will have a major impact on some amateurs.

53. IBEC states that to provide another data point on background noise levels, it made observations of the background noise level over the frequency range 2-30 MHz at two locations chosen at random, one residential and the other business.[132] IBEC's quasi-peak measurements at these locations show business noise levels 10 dB higher and residential noise levels 20 dB higher than the ITU levels. IBEC does, however, also acknowledge that further investigation is needed to describe the noise environment today.[133]

54. The presentations and measurements mentioned in the comments and in the three additional presentations do not provide a basis for any general conclusions regarding changes in the noise floor.[134] The study in the *2001 NTIA Report* only looked at VHF frequencies 137 MHz and above and this report is therefore not directly relevant to the noise levels on the medium frequencies (MF) or HF frequencies 30 MHz and below that are at issue here.[135] We therefore continue to believe that our reliance on the current noise levels recognized by the ITU is appropriate and that in this regard, the potential for interference from BPL emissions remains the same as we considered in the *BPL Order*. We acknowledge that a compliant BPL system will increase the noise floor within a relatively short distance of the power lines (typically ranging from less than 15 meters to 400 meters, depending on frequency, type of receive

[129] A lower noise floor would allow amateurs to receive signals at lower levels.

[130] ARRL comments at 39; *see also* NTIA Report No. 02-0390, "Man-Made Noise Power Measurements at VHF and UHF Frequencies," Robert J. Achatz and Roger A. Dalke, December 2001 (*2001 NTIA Report)* at 33; *see also* "Field Strength Measurements Relative to ARRL Concerns Regarding BPL" at slide 6.

[131] ARRL also notes that the noise measurements were made at a representative height for amateur radio antennas (10 meters high and 30 meters from the antenna).

[132] IBEC comments at 4-5.

[133] In its reply comments, ARRL argues that IBEC's measurements of the noise floor are flawed, because it appears that IBEC was measuring the noise level of its EMC instrumentation, not the actual noise floor. ARRL reply comments at 6-7.

[134] We further note that ARRL argued at length in its comments that the Commission had proof [from the result on these slides] that the noise floor has decreased and thus the amateur service would be subject to higher levels of interference in this lower noise floor environment. ARRL comments at p. 42. However, in its reply comments filed subsequently, ARRL agreed that the FCC Lab finding is not sufficient justification [that the noise floor has decreased], and that the ITU-recommend noise floor levels are indeed reasonable and typical and that even other competent bodies such as the North Atlantic Treaty Organization (NATO) believe that these ITU noise floor numbers are still valid today. ARRL reply comments at 8 and its Exhibit A at 7.

[135] The medium frequency (MF) region covers frequencies from 300 kHz to 3 MHz.

station and location-specific behavior of the BPL operation), and have determined that this increase is acceptable so long as the system's operation does not cause harmful interference.[136] Under the rules, the Access BPL operator is required to take steps, including using frequency notching or band avoidance as necessary (which amounts to shutting down operations in the affected band), to avoid any such harmful interference that might occur, and/or resolve it if it does occur.

55. ARRL next observes that slide 3 of the "Broadband Over Power Line (BPL) Test Results and Considerations" presentation contains statements that "resolving interference complaints will be difficult/impractical;" and that Part 15 radiated limits were "[a]dequate for most devices, but not for BPL."[137] ARRL states that the difference, as noted in the presentation, is that BPL has a broad bandwidth; it has high emissions over that wide bandwidth; it is exempt from conducted limits except in the AM broadcast band; it is in close proximity to neighboring residential antennas, including those used to receive amateur signals; there are no intervening walls to attenuate interference; and the radiators have a large spatial extent. It submits that these differences were each noted by ARRL in its comments in this proceeding before the *BPL Order*, but that the Commission claimed it believed otherwise. Contrary to ARRL's claim, we did, indeed, recognize all those factors (and others) and considered them in formulating our requirements for Access BPL systems that are in addition to those applied to carrier current systems.[138] We are, and were, aware that amateur receive sites are typically located outdoors in relatively close proximity to power lines and that BPL emissions are likely to be present over all or large portions of the amateur bands. These considerations, as well as similar considerations with respect to other services, led us to require that Access BPL operators be capable of remotely managing their facilities to reduce or eliminate emissions in locations where interference might occur and to require establishment of a database of BPL operations so that licensed radio users could contact the local BPL operator if interference were to occur. We also disagree that resolving complaints from BPL systems is particularly difficult or impractical, in that BPL emissions often create a very distinctive audio tone or pattern of broadband noise burst that is easily recognized and interference from a BPL system can be conclusively identified by simply having the system cease operation for a brief period of time on the affected frequencies.[139]

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[136] The amount of increase in the noise floor diminishes rapidly with distance from the power lines, but depends on a number of other factors as well. The impact of an increase in the noise floor will be greatest for sensitive receivers with antennas located well above the ground in locations with low ambient noise. Noise increases would be smaller if the receiver operates at a frequency at which the local BPL emissions are significantly below the emission limit or if ambient noise levels are higher — as might be expected in a business environment or where higher levels of RF noise are present from other sources. Noise increases would be larger if the receiver operates in a region with ambient noise levels typical of rural or quiet rural areas. We note generally that the consensus in the technical community is that the noise floor has been steadily increasing due to the ever growing proliferation of electronic and electrical equipment that are all capable of generating man-made radio noise. *See* for example, *Radiated and Conducted EMI Emissions in Switch Mode Power Supplies (SMPS): Sources, Causes and Predictions*, by Nagrial, M.H. and Hellany, A. IEEE INMIC 2001, Technology for the 21st Century Proceedings IEEE International, p. 54-61, at http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=995314; and *Indoor Noise Conditions in the FM Broadcast Band*, by Johnston, S. National Association of Broadcasters (NAB) Engineering Conference 2010 at http://m.core-apps.com/2010NAB/events/51f39223ab6d2bfd89cd88a156bd8b9b.

[137] ARRL comments at 41.

[138] *BPL Order* at 21275-21276.

[139] We also note that non-OFDM BPL systems and some OFDM BPL systems have been observed to sound like pulsed broadband noise, which may not be aurally distinctive from the surrounding white noise. However, a system using a noise-like modulation method would appear to create noise-like common power line emissions and could be readily evaluated as a possible source of any interference by briefly switching the signal off or activating the system's notching capability on the frequencies on which the interference was occurring.

56. ARRL raises issues with regard to the presentation "BPL Emission Tests in Briarcliff Manor, NY," arguing that the notches on amateur radio bands in that system were inadequate and that in one case a notched BPL device was filled in by noise from another device operating 0.7 miles away. It further observes that, as shown on slides 19 and 22 of that presentation, BPL audibility in a mobile receiver quickly ends when roads depart from the power lines but could be heard along the lines up to 1.7 miles from the nearest in-band BPL device.[140] ARRL argues that this information shows that localized notching of the amateur bands is not effective in resolving interference. However, it is quite plain from other information on slide 13 of this presentation that the notching feature implemented in the early models of BPL equipment used in the Briarcliff Manor experiment were not functioning properly. We therefore do not consider this information to be a representative example of the performance potential of the notching capabilities of BPL systems. Our staff has also made other observations of notched BPL signals, for example at the Manassas, VA system, where notching capability as required under the rules was implemented and was very successful in eliminating interference.[141]

57. We also note that throughout this proceeding and as new equipment that allows BPL operators to better manage their frequency use at specific locations has become available, we have observed BPL operators taking active steps to locate and avoid interference to amateur operators.[142] Given that identification and resolution of harmful interference can involve expenditures of staff time and resources for Access BPL providers and possibly the temporary disruption of service to their subscribers, these providers have a strong incentive to take *a priori* steps to ensure that they avoid causing interference to the local radio services, including amateurs. Notwithstanding the occasional interference that was found by amateurs from the trial systems that were operated during the early phases of BPL development such as those examined in the staff presentations (and which, in some cases, were operating with emissions levels that were found to exceed the Part 15 limits by amounts ranging from 1 to 4 dB), we have observed, as described by IBEC and CURRENT in their comments, that Access BPL operators are taking effective steps as contemplated in the *BPL Order* to avoid interference to amateur and other licensed services, including working with local amateur operators.[143] Moreover, our own internal records on enforcement matters show only one complaint of interference from Access BPL to fixed licensed operations; that complaint was submitted recently and is under investigation at this time.[144] In summary, we therefore see no new information or reasoning in ARRL's submissions or other information regarding the three additional staff presentations in the preliminary materials released in July 2009 that would warrant changing the current rules and, specifically, we see no need to further restrict the operations of

[140] ARRL comments at 45.

[141] *See* Letter dated March 2, 2007 from the Commission's Enforcement Bureau to various parties, including Chris Imlay, General Counsel of ARRL.

[142] For example, ARRL reports that BPL manufacturers have [voluntarily] implemented notching of the amateur bands in all of the installed systems. It further indicates that ARRL technical staff has evaluated five different installations using second-generation BPL equipment with 35-dB notch depth applied to the amateur bands and found this to be a successful model to prevent interference problems. ARRL comments at 10, footnote 9. We view these efforts by the BPL industry as an important demonstration of their willingness and commitment to cooperate in avoiding interference to the amateur service under the flexible rules adopted in the *BPL Order*.

[143] CURRENT comments at 2-3.

[144] *See Re: Interference Complaint: IBEC Access Broadband Over Power Line Systems* from ARRL to Kathryn Berthot, Chief, FCC Spectrum Enforcement Division, and Julius Knapp, Chief, FCC Office of Engineering and Technology (filed Dec 29, 2010). The BPL system database (http://www.bpldatabase.org/), which is operated jointly by the United Power Line Council and the Utilities Telecom Council pursuant to the requirement in Section 15.615(a) of the rules (47 C.F.R. § 15.615(a) shows that BPL systems are currently operating in more than 125 zip codes across the United States.

BPL systems to protect licensed services.

B. Measurement Distance Extrapolation Issues

1. The Extrapolation Factor

58. *Overview*. In the *BPL Order*, the Commission set forth guidelines for measurement of the emissions from Access BPL systems.[145] These guidelines, *inter alia*, specify that emissions from Access BPL devices operating below 30 MHz are to be measured for compliance with the radiated emissions limits in Section 15.209 of the rules.[146] Those limits are based on measurements made at 30-meters horizontal (lateral) distance from the device under test.[147] However, for practical reasons associated with measurement in the field, the Access BPL measurement guidelines recommend that measurements should normally be performed at a horizontal separation distance of 10 meters from the overhead power line, and they also indicate that measurements can be performed at 3 meters if necessary because of ambient emissions, safety or practical considerations.[148] The field strength of radiated emissions does, however, decrease with increasing distance from the emitter due to propagation loss. Because of this attenuation with distance, the field strength of emissions from a device measured at the 3-meter or 10-meter distances specified in the guidelines will generally be higher than those measured at the 30-meter distance on which the emission standard is based. In order to apply the emissions standard consistently, the measurement results must be adjusted to account for distance attenuation when measurements are made at a distance other than 30 meters.

59. The Commission specified distance extrapolation factors to convert the BPL emissions measurements for frequencies below and above 30 MHz to appropriate values for tests made at the 3-meter and 10-meter distances recommended in the BPL measurement guidelines. For BPL operations on frequencies below 30 MHz, the frequency range at issue here, some commenters in the initial phase of this proceeding, including ARRL, recommended the use of an extrapolation factor of 20 dB/decade, while others recommended an extrapolation factor of 40 dB/decade.[149] The Commission concluded in the *BPL Order* that "[g]iven the lack of conclusive experimental data pending large scale Access BPL deployments," it would "continue the use of the existing Part 15 distance extrapolation factors" specified in the rules, *i.e*., 40 dB/decade for frequencies below 30 MHz and 20 dB/decade for frequencies at or above 30 MHz, but with the distance measured as the slant-range distance from the overhead power line to the center of the measurement antenna rather than horizontal (lateral) distance from the nearest point of the overhead power line carrying the BPL signals to the center of the measurement antenna, as illustrated in Figure 1 of Appendix C, *infra*. This is the horizontal (lateral) distance between the center of the measurement antenna and the vertical projection of the overhead power line carrying the BPL signals down to the height of the measurement antenna when measurements are taken at a point that is perpendicular to the power lines.[150] It further stated that "if new information became available that alternative emission

[145] *See Guidelines* in Appendix C of the *BPL Order,* at 21339-21343.

[146] *See* 47 C.F.R. § 15.611 and 47 C.F.R. § 15.209.

[147] *See* 47 C.F.R. § 15.31(f).

[148] The common concurrence of power lines and roadways means that the specified distance to conduct measurements will often occur in those roadways on obviously unsafe places, or inside privately-owned properties.

[149] *BPL Order* at 21310.

[150] *Id.* The slant-range distance is the diagonal distance from the center of the measurement loop antenna, which is to be at 1 meter above ground level, to the overhead power line to which the BPL device is coupled, typically several meters above ground. The slant-range method reflects the actual measurement distance from the measurement antenna to the BPL-carrying power line whereas the horizontal distance method used with other Part 15 devices in (continued….)

limit/distance standards or extrapolation factors would be more appropriate," it would revisit this issue at another time.[151]

60. ARRL filed a petition for reconsideration of the Commission's decision in the *BPL Order* to use 40 dB/decade as the extrapolation factor for frequencies below 30 MHz.[152] In support of its argument that an extrapolation factor of 20 dB/decade should be used, ARRL also submitted, through *ex parte* comments, reports on three studies conducted by the United Kingdom's Office of Communications (OFCOM) and a standard by the Special International Committee on Radio Interference (CISPR) regarding emission measurements for BPL systems and a proposal for a sliding scale extrapolation factor based on a 1996 CISPR standard.[153] The first OFCOM study, "*OFCOM, Ascom PLT Measurements in Winchester (May 11, 2005)*" (Winchester Study) reported measurements of an underground *Access BPL trial sy*stem in Winchester, United Kingdom.[154] In that study, OFCOM concluded that the electromagnetic field attenuates at a rate between *20 dB and* 25 dB/de*cad*e at this BPL installation. The second OFCOM study, "*OFCOM, DS2 PLT Measurements in Crieff (May 11, 2005)*" (Crieff DS2 Study) reported measurements of an Access BPL trial system in Crieff, United Kingdom. That study concentrated only on the benefits of programmable notches in the equipment and did not provide any data on distance extrapolation.[155] The third OFCOM study, "OFCOM*, Amperion PLT Measurements in Crieff (May 11, 2005)*" (Crieff Amperion Study) reported measurements of an overhead, pole-mounted Access BPL trial system, also in Crieff, United Kingdom.[156] In the Crieff Amperion Study, OFCOM concluded that the emitted field attenuates at a rate of 28 dB/decade.

61. Subsequent to the filing of the report on the Crieff Amperion Study into the record of

(Continued from previous page)
this case is less than the actual distance to the emitter. *See* illustration of slant-range distance in Appendix C, *infra.* For example, if the measurement antenna is located 10 meters horizontal distance from the nearest point directly under the overhead power line carrying the BPL signal, at a height of 1 meter, and the power line is 11 meters above the ground, the slant range distance from the antenna to the power line is 14.14 meters. As such, because the slant range distance is longer than the horizontal distance to the nearest point directly under the overhead power line carrying the BPL signal (in this example, approximately 140% of the horizontal distance), the permissible emission levels at the measurement distance are reduced when this method is used. Therefore, even though we apply the general emission limits in Part 15 to Access BPL devices, these devices are not allowed to emit as much as other Part 15 devices that must be measured *in situ* and that radiate primarily from a height much greater than 1 meter, due to the application of slant-range distance to calculate the extrapolated emission level. This is another example of the more conservative regulation placed on Access BPL devices as part of the BPL framework the Commission adopted in 2004.

[151] *BPL Order* at 21310.

[152] *See* ARRL Petition for Reconsideration (filed Feb. 7, 2005 in ET Docket 04-37); *see also*, ARRL Petition for Issuance of Further Notice of Proposed Rule Making and for Amendments of Regulations (filed Oct. 18, 2005) in ET Docket No. 04-37.

[153] *See* ARRL *ex parte* Citation of Additional Authority comments (ARRL *ex parte comments*), filed July 8, 2005 in ET Docket 04-37, at http://fjallfoss.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6518006426.

[154] *OFCOM, Ascom PLT Measurements in* Winchester (May 11, 2005) at http://fjallfoss.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6518006428. Note that the FCC recommends making measurements no closer than 10 meters from the power line for safety reasons.

[155] *OFCOM, DS2 PLT Measurements in Crieff* (May 11, 2005) at http://fjallfoss.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6518006429.

[156] *OFCOM, Amperion PLT Measurements in Crieff* (May 11, 2005) at http://fjallfoss.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6518006427.

this proceeding, Amperion submitted comments stating that this report "reflects information that is inappropriate for the public domain, especially the way it is inaccurately represented."[157] Amperion argued that there are "discrepancies in the report," which it attributes to "[OFCOM's] unfamiliarity with the equipment and the hurried nature in which the testing was conducted." These discrepancies include that 1) OFCOM operated the BPL equipment at its maximum power levels, which was above the much lower level used for normal operations, without explaining that in the report, and 2) the system was not configured to comply with the Commission's limits.[158]

62. ARRL's proposal for a sliding scale extrapolation factor referenced a 1996 CISPR Standard.[159] That standard, which was published in 1996 well before Access BPL was developed, evaluates radio noise generated by high-voltage converter power stations and similar high-voltage installations and discusses methods on how to reduce radio noise from inherent power line components, such as mercury arc and thyristor valves. ARRL pointed to a graph in the standard which shows calculated values of the field strength attenuation of emissions from a vertical electrical dipole antenna as a function of the distance on a horizontal plane for different frequencies.[160] Based on this graph, ARRL proposed a formula which effectively constitutes a sliding-scale calculation for an extrapolation factor that varies with frequencies.[161]

63. On reconsideration, the Commission found the OFCOM studies and the CISPR standard unpersuasive in that there was no "new" or convincing information not already known, and affirmed its decision to use the existing Part 15 distance extrapolation factor of 40 dB/decade attenuation rate in the measurements of BPL emissions on frequencies below 30 MHz.[162]

64. In *ARRL v. FCC, supra*, the court found that the Commission did not offer a reasoned explanation for its dismissal of empirical data that was submitted *ex parte* by ARRL, *i.e*., the three OFCOM studies and additional ARRL analysis intended to suggest that an extrapolation factor of 20 dB/decade may be more appropriate for Access BPL.[163] The court ordered the Commission either to "provide a reasoned justification for retaining an extrapolation factor of 40 dB/decade for Access BPL systems sufficient to indicate that it has grappled with the 2005 studies, or adopt another factor and provide a reasoned explanation for it."[164]

65. The Commission acted to respond to the court's directive in the *RFC/FNPRM*. Therein,

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[157] *See* Amperion comments (filed May 20, 2005 in ET Docket 04-37) at http://fccweb01w/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6517611850, at 2-3.

[158] We note that operating the BPL equipment at maximum or typical power levels does not affect the determination of the attenuation characteristics of the signal.

[159] *Radio Interference Characteristics of Overhead Power Lines and High-Voltage Equipment – Part 2: Methods of Measurement and Procedure for Determining Limits,* CISPR 18-2, Amendment 2, (1996), (*CISPR 18-2*) at http://fjallfoss.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6518006430.

[160] ARRL *ex parte* comments at 6. *See also, CISPR 18-2* at 20.

[161] The formula ARRL recommended to the Commission to calculate extrapolation is as follows: Distance at 30 meters = distance at slant range – 20 log (30/slant range) – 20 log (15/frequency in Megahertz). ARRL *ex parte* comments at 6.

[162] *See BPL Reconsideration Order* at 9318.

[163] *ARRL v. FCC* at 241.

[164] *Id.,* at 242. The court did not separately address ARRL's contention that the Commission failed to consider a sliding scale extrapolation factor, assuming that it was properly before the Commission on reconsideration. *Id.*

it provided a more detailed explanation of its reasons for selecting 40 dB/decade as the extrapolation factor for frequencies below 30 MHz and in particular why it does not believe that the studies and technical proposal submitted earlier by ARRL provide convincing information that it should use an extrapolation factor that is different from (and, specifically, less than) 40 dB/decade as required in the second element of the court's directive in *ARRL v. FCC*.[165] In summary of that explanation, the Commission stated that:

> 1) There were no significant studies that examined the very large number of measurements that would be needed to address the different site characteristics that affect the attenuation of emissions below 30 MHz;
> 2) The studies submitted by ARRL in its 2005 *ex parte* provided only anecdotal information on two different types of installations (overhead and underground) from two single sites and also had certain methodological shortcomings; and
> 3) With respect to its proposal for a sliding scale extrapolation factor, ARRL did not provide an explanation as to how its formula was derived or how to use it to determine the extrapolation factor, nor did it provide a rationale for selecting such a formula or information as to the relationship between the performance of emissions from BPL technology and the specifications for reduction of power line noise adopted in the standard.

66. In the *RFC/FNPRM*, the Commission also observed that since its adoption of the *BPL Reconsideration Order*, reports had become available on two new technical studies addressing attenuation of BPL emissions with distance, one by NTIA in October 2007 that described a second phase of its simulation study on the potential for interference from Access BPL systems (*NTIA Phase 2 Study*) and the other by the Federal Republic of Brazil (*Brazil Study*) in June 2008 that presented the results of a measurement study of BPL emissions.[166] In addition, it noted that the IEEE working group on power line communications technology electromagnetic compatibility was working on a standard for EMC testing and measurements methodology for BPL equipment and installations (IEEE P1775/D2) that included a provision for determining extrapolation (distance correction) factors on a site-by-site basis using *in situ* measurements as part of its work on that standard.[167]

67. In view of these new studies and consistent with its stated intention in the *BPL Order* to revisit the extrapolation factor if new information became available and the opportunity provided by the Court's remand of the extrapolation factor, the Commission decided to conduct further

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[165] *See RFC/FNPRM* at 9679-9680. The Commission's explanation of its consideration of the OFCOM reports in the *RFC/FNPRM* responded to the court's directive that the Commission explain that it had "grappled with the empirical data" in those reports. That explanation describes the rationale underlying its succinct conclusion in the *Reconsideration Order* that those reports provided no new information that would provide a convincing argument for modifying the extrapolation factor. *BPL Reconsideration Order* at 9317-18. In paragraphs 71-91 below, we revisit our decision on the extrapolation factor. We maintain our finding that 40dB/decade is the appropriate value for this distance adjustment and provide additional analysis and rationale for our decision and address the arguments of the amateurs for selection of a more conservative value.

[166] *See RFC/FNPRM* at 9680-9681; *see also Potential Interference From Broadband Over Power Line (BPL) Systems to Federal Government Radiocommunications at 1.7 – 80 MHz, Phase 2 Study*, *Volume I*, National Telecommunications and Information Administration (NTIA) Report 08-450, October 2007 ("*NTIA Phase 2 Study"*), at http://www.ntia.doc.gov/osmhome/reports/2007/bpl2007.html; and Federal Republic of Brazil, *Radio Interference Tests from Broadband Power Line Communication Systems*, ITU Radio Communication Group WP-1A, Document 1A-32-E, June 9, 2008 ("*Brazil Study"*) at http://fjallfoss.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6520190420. Both of these studies have been added to the record of this proceeding.

[167] IEEE 1775-2010 was published on Jan 7, 2011. *See* para. 11 and footnote 40, *supra.*

rulemaking to review its decision on the extrapolation factor.[168] It requested that interested parties submit additional comment and information on the BPL extrapolation factor and specifically asked that such comment and information address 1) the three studies and proposal for a sliding scale extrapolation factor submitted previously by ARRL as part of its *ex* parte filing of July 8, 2005 in this proceeding, 2) the *NTIA Phase 2* and *Brazil* studies with respect to their findings on the extrapolation factor for BPL systems, and (3) the existing slant-range method as it pertains to the effective field attenuation rate in a horizontal distance context. The Commission further requested submission of any other new empirical studies or information that may provide information regarding the BPL distance attenuation extrapolation factor. The Commission stated that its goal in this review is to provide BPL measurement procedures that will adequately ensure compliance with the Section 15.209 emissions standard for emissions at or below 30 MHz without placing unfair or undue compliance burdens on equipment manufacturers and users. In conducting this review, the Commission indicated that initially it continued to believe the existing 40 dB/decade extrapolation factor, in conjunction with the slant-range distance method, was reasonable and appropriate for adjusting measurements of BPL emissions on frequencies below 30 MHz.

68. As discussed above, the Commission also recognized that there is considerable variability around the 40 dB/decade value at different sites. The result of this variability is that the actual attenuation at some sites could be less than 40 dB/decade and using the current extrapolation factor at such sites could produce an adjusted measurement that would be less than the level that would be measured at the standard 30-meter measurement distance specified in Section 15.209. The Commission therefore requested comment on whether it would be desirable to modify the value of the BPL extrapolation factor to be 30 dB/decade or some other value.[169] It observed that extrapolated emission levels based on a 30 dB/decade extrapolation factor when applied to slant distance would be comparable to the extrapolated emission levels based on a 20 dB/decade extrapolation factor applied to horizontal (lateral) distance.[170] Recognizing that reliance on a 30 dB/decade extrapolation factor could increase the compliance burden for BPL equipment and systems that are tested at locations where the attenuation rate is in fact in the range of 40 dB/decade or greater, the Commission clarified that in all cases, measurements of Access BPL equipment and systems will be allowed to be made at the 30-meters distance specified in Section 15.209 and that where possible, the Commission's staff will make measurements at this distance when testing for compliance.[171]

69. In its comments, ARRL argues that the Commission's "attempt in the Further Notice to justify the 40 dB/decade extrapolation factor adopted in the Access *BPL Order* and affirmed in the [*BPL*] *Reconsideration Order* is insufficient."[172] It contends that the explanation provided in the *RFC/FNPRM* relies on calculations premised on flawed scientific methodology and disregards empirical measurements. Representatives of the Access BPL industry support maintaining the 40 dB/decade standard. In this regard, Ambient states that the continued use of the 40 dB/decade distance provides the most accurate extrapolation value, within a round-off resolution of 5 dB/decade,

[168] *RFC/FNPRM* at 9680-9681.

[169] *Id*. at 9679, 9682-9683.

[170] This is true for measurement distances greater than 12 meters laterally from the pole. At measurement distances less than 12 meters, the extrapolated emission levels based on the proposed 30 dB factor applied to slant distance are much more stringent than extrapolated levels based on a 20 dB factor applied to horizontal distance. *See* Figure 3 in Appendix D of the *RFC/FNPRM* at 9693.

[171] *See RFC/FNPRM* at 9682-9683.

[172] ARRL comments at 17-18. Individual amateur radio operators submitting comments indicate that they support ARRL's position on these matters.

for compliance measurements in typical overhead BPL geometries.[173] Arkados Group, Inc. (Arkados), the HomePlug Powerline Alliance (HomePlug) and Intellon Corporation (Intellon) argue that prompt case-by-case resolution of any actual interference complaints is the preferable solution to the issues underlying ARRL's objections, rather than adopting an "overly exclusive" new rule that could stunt the growth of new innovative technologies that hold great promise for broadband and smart grid applications.[174] IBEC submits that it has not experienced any issues with licensed services that could not be addressed within the framework of the existing BPL rules.[175]

70. ARRL and several representatives of the Access BPL industry oppose our proposal to modify the extrapolation factor to be 30 dB/decade, albeit it for differing reasons.[176] While ARRL contends that a 30 dB/decade factor would be too lenient, Arkados and HomePlug contend that making the regulatory environment even more restrictive without strong justification would have severe implications for the government's initiative to provide cleaner and greener energy.[177] SPiDCOM Technologies, S.A. (SPiDCOM) submits that a reduced extrapolation factor would directly reduce the performance of all BPL devices such that it would be difficult if not impossible to provide a marketable product for Access BPL, SmartGrid BPL and In-home BPL markets.[178] No new empirical studies of the attenuation rate of emissions from power lines on frequencies below 30 MHz were submitted into the record of this proceeding.[179]

71. *Discussion*. After consideration of the most recent information and comments on this matter and further deliberation on all of the studies and information in the record, as described above, we are retaining the 40 dB/decade extrapolation factor for frequencies below 30 MHz. As discussed further below, there are several reasons that lead us to this conclusion. Initially, we observe that the 40 dB/decade extrapolation for frequencies below 30 MHz has served successfully in our program to control emissions from radio frequency devices for many years. We also observe that, while ARRL contends that 20 dB is the only scientifically correct and valid value for an extrapolation factor, the studies and information before us show considerable differences in extrapolation factors under various powerline system configurations and usage conditions. We conclude that there is no single "correct" value for an extrapolation for RF emissions from power lines, and instead find that the compelling and reasonable

[173] Ambient reply comments at 1. Ambient also submits 416 pages of simulation data showing that the extrapolation factor varies from 34 to 47 dB/decade for frequencies from 5 to 30 MHz. *Id.* at 4.

[174] Arkados reply comments at 2, HomePlug reply comments at 2; Intellon reply comments at 2.

[175] IBEC comments at 2.

[176] SPiDCOM comments at 2, UPLC comments at 6.

[177] Arkados comments at 2, HomePlug comments at 3.

[178] SPidCOM comments at 2.

[179] On Jan 11, 2010, ARRL submitted in *ex parte* a draft field test report by the Communications Research Centre, Canada that describes measurements of radiated emissions from In-House BPL devices: *Measurements of EM Radiation from In-House Power Line Telecommunications (PLT) Devices Operating in a Residential Environment,* Communications Research Centre, Canada, Field Test Report, Draft 2.3, March 24, 2009. The draft indicates that this report was conducted to determine the extent of potential interference of these devices to broadcast services operating in residential environments. The report noted that the study found an average of 18.2 dB/decade attenuation rate from the side of the house to locations outside the house for the In-House BPL devices tested. However, the report does not present a theoretical discussion or other analysis of the physical properties of the electrical wiring and its layout in the homes tested that would be expected to produce this result. Inasmuch as this draft report describes measurements of emissions from In-house BPL systems, it is not relevant to the discussion of Access BPL systems due to the physical differences in the operating configurations of the two types of systems.

solution is to use the existing Part 15 extrapolation factor that both has a scientific basis and has stood the test of time for a wide variety of devices and systems. We also note that, as discussed below, using the slant range method in performing measurements has the effect of reducing the extrapolation factor to approximately 20 dB. We consider too, that the extrapolation factor used with BPL measurements is only one element in a comprehensive set of rules that are designed and intended to minimize the risk of harmful interference from BPL operations and to put in place appropriate measures to eliminate such interference if it should occur. In that context, the rules require that harmful interference be corrected under any circumstances. Measurements for examination of compliance are important, to be sure, but interference must be corrected even if measurements indicate that the BPL operations at the site are compliant. While ARRL asserts that an extrapolation factor that is too lax will lead to widespread instances of harmful interference that should be corrected *ex ante* as opposed to *ex post*, we have seen little evidence of harmful interference being caused under the rules as adopted with a 40-dB extrapolation factor.

72. In addition, we note that there is no support from any of the commenting parties that modifying the extrapolation factor to 30 dB/decade in order to take a more conservative approach that would compensate for the variability in the attenuation rate would provide a more appropriate extrapolation factor. We therefore are not adopting that change. To provide clarity for those conducting measurements for compliance of Access BPL equipment and systems with the Section 15.209 emissions standards, we are specifying the extrapolated values of compliant emissions levels at 3-meter and 10-meter horizontal (lateral) distance from the nearest point of the overhead power line carrying the BPL signals for typical heights of medium voltage power lines in the BPL measurement guidelines.[180] We are also adopting our proposal for a new method for determination of site specific extrapolation factors in measurements of emissions from BPL systems.

73. Looking more closely at this issue, we find that ARRL has not provided convincing information that the value of the measurement distance extrapolation factor for Access BPL should be reduced from 40 dB/decade to 20 dB/decade or some other number close to that value. While ARRL offers detailed and lengthy submissions of information on propagation of RF energy below 30 MHz and critiques of the studies, analyses and information provided by others, including this Commission, that information does not provide any new insights on radio propagation that would alter our decision. Moreover, its arguments for a 40 dB/decade standard do not account for two key factors that affect the significant attenuation of RF energy in this region of the spectrum: factors in the emissions process (such as ground effects and the presence of multiple power lines and their position on the pole) and the significant variability in attenuation rate across different installation sites.[181]

74. With regard to the OFCOM studies, ARRL maintains that if a single extrapolation number is to be specified in the Commission's rules, the OFCOM Winchester Study establishes that extrapolation should be 20 dB/decade in the spectrum region from 10 to 30 meters. However, ARRL concedes that at lower frequencies, the extrapolation factor could be specified at a higher level, if the Commission wishes to use a frequency/distance based formula.[182] CURRENT argues on the other hand that "Figure 19 of the OFCOM Winchester report shows that over the frequencies of 1.5 to 9 MHz, the extrapolation is consistently greater than 30 dB/decade" and "the data at 3 and 10 meters show an extrapolation rate closer to 35-40 dB/decade." CURRENT also contends that "[a]ll of these data are suspect [because] the

[180] The revised measurement guidelines are set forth in Appendix D below.

[181] The ARRL's presentation of its modeling of a 1000-meter line emitter does show results for emissions at 1 meter height, and those results show that losses from the ground do increase the decay rate, *see* ARRL comments, Appendix C at 15.

[182] ARRL reply comments at 19.

researchers conducting the study used a BPL-equipped substation adjacent to an open tract, and took their measurements in the open space; [further], a close look at the published map shows a low-voltage line running exactly parallel to the measurement path; that line appears to be carrying BPL signals and could well have contaminated the measurements of emissions from the power line that was the subject of the test."[183] It further submits that none of the studies that ostensibly bear on the extrapolation question, *i.e.,* OFCOM Winchester, OFCOM Crieff, *Brazil Study*, *NTIA Phase 2 Study*, and CISPR 18 unambiguously point to a specific value that the Commission could adopt. As we discussed in the *RFC/FNPRM*, the OFCOM Winchester study at best provides only anecdotal information that, not withstanding its methodological shortcomings, is not sufficient to describe the very large number of measurements that would be needed to address the general case in which different site characteristics significantly affect the attenuation of emissions below 30 MHz.

75. ARRL next argues that during the period in which the Commission adopted and affirmed the 40 dB/decade standard, the Commission had evidence that 40 dB/decade is not the correct extrapolation factor. In this regard, ARRL points to slide #19 of the Briarcliff Manor presentation which "recommended" that the Commission should, if it intended to permit BPL on overhead MV power lines, adopt a height correction factor and a "20 log R extrapolation factor."[184] It contends that there is no reference to this "FCC-Laboratory" recommendation" anywhere in the *RFC/FNPRM*, or heretofore by the Commission whatsoever. ARRL also asserts that "instead, the Commission attempts in the *RFC/FNPRM* to justify its decision for retaining the 40 dB/decade factor by citing studies that were not even in existence at the time of the *BPL Reconsideration Order*."[185] We find these arguments to be unpersuasive. First, it is important to recognize that there is no "FCC-laboratory recommendation" as characterized by ARRL. The Commission is under no obligation to discuss in a rulemaking proceeding every staff observation or opinion provided during the course of internal deliberations. We observe that the 20 dB/decade extrapolation factor was part of one of three options presented on slide #19. The presentation offered no specific analysis or measurement data supporting this extrapolation factor. Rather, as specified on the slide, the authors offered it as a way to postpone and/or reduce the interference potential of BPL systems. Additionally, as noted by Arkados and HomePlug, none of the five FCC staff presentations actually examined the path loss extrapolation factor, but rather, they examined other technical issues such as the effect of the distance down the power line, differences in radiated field strength due to the detector that was employed, effect of measurement receiver antenna height, audible interference and antenna polarization.[186] We therefore did not, (and still do not) consider that the information on which the provided option on slide #19 was based to be sufficient or compelling such that it should override or supersede other information that we also considered in the extrapolation factor decision. As UTC

[183] CURRENT comments at 6. Because OFCOM made its measurements for the purpose of showing the distance attenuation of BPL signals of the particular BPL signal source under test away from the power line carrying that BPL emitter, if there are other power lines also carrying BPL signals nearby, the test data may not be valid as the measurements may have been made at a point closer to, or overlapping with, another BPL signal source.

[184] *See* Briarcliff Manor presentation at slide #19.

[185] ARRL comments at 48.

[186] Arkados comments at 4; HomePlug comments at 4. Arkados, HomePlug and Intellon report that a recent study by the Communications Research Center, Canada, found that the path loss coefficient to be 36 dB per decade at 37.8 MHz, with a shadowing standard deviation of 3.39 dB. Arkados comments at 8; HomePlug comments at 8; Intellon comments at 7. The study they reference is: Jeffrey A. Pugh , Robert J. C. Bultitude and Philip J. Vigeron, *Path Loss Measurements With Low Antennas For Segmented Wideband Communications at VHF*, October 23-25, 2006, Communications Research Center, Ottawa, available at http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=4086379. Inasmuch as this study measures propagation at 37.8 MHz, which is above the MF and HF bands, it findings are not relevant to our decision on an extrapolation factor for frequencies below 30 MHz.

observes, the staff presentations merely included a 20 dB/decade extrapolation factor as one option among many for regulating BPL operations in the HF bands; the presentations did not find that a 20-dB extrapolation factor represented the actual rate of decay, nor did they contain any underlying information or analysis that would support such a finding.[187] Further, with respect to ARRL's assertions regarding our use of new studies in the *RFC/FNPRM* as *ex post facto* evidence, it apparently overlooks our quite specific statement therein[188] that our decision to adopt the 40 dB/decade standard was based on information available at the time of the decision, not newly available information.[189]

76. With regard to the new studies identified in the *RFC/FNPRM*, ARRL contends that the major flaw in the *NTIA Phase 2 Study* is that the modeling used does not fully account for the way that field strength decays at angles other than 90 degrees. ARRL further argues that with respect to height, the report errs in its attempted justification of the 5 dB height correction above 30 MHz but not below, and it justifies 40 dB/decade by disregarding 20 percent of the data points.[190] On the other hand, CURRENT quotes the *NTIA Phase 2 Study* as stating: "[a]t or above 10 MHz, the simulation results show good agreement between the rate that field strength decays and the [40 dB/decade] distance extrapolation rate in the Part 15 rules."[191] HomePlug also agrees that the *NTIA Phase 2 Study* clearly demonstrates that the 40 dB/decade extrapolation factor is the correct value at or above 10 MHz, and much closer below 10 MHz than figures used in the studies submitted by ARRL.[192] We observe that NTIA's modeling in its *Phase 2 Study* indicates that the field along a complex power line model is highly varied, with areas of greater and lesser field strength produced by cancellation and reinforcement effects.[193] However, there are some regularities, including field strength maxima at multiples of wavelengths along the power line, which is the reason why we adopted the requirement for measurements at multiple points along the power lines in our BPL measurement guidelines. In addition, as discussed above, ARRL's own modeling shows that the magnetic field (measured below 30 MHz) does not vary greatly with height.[194] Further, we agree with NTIA's position that "the 80th percentile values eliminate the localized peaks that are unlikely to be encountered by a radio receiver randomly located in close proximity to an Access BPL power line."[195] Thus, we find that the *NTIA Phase 2 Study* is not flawed as argued by ARRL.

77. ARRL next contends that the *Brazil Study* is deficient in that it does not identify the test equipment used, the model number of the BPL equipment, the location of the testing, and how the BPL signal was coupled to the power line, making it difficult to evaluate the accuracy of the report.[196]

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[187] UPLC reply comments at 4.

[188] The Commission specifically stated in the *RFC/FNPRM* that it did not rely on NTIA's more recent Phase 2 simulation results to justify its earlier decision. *RFC/FNPRM* at 9678.

[189] While our decisions in the *BPL Order* and *BPL Reconsideration Order* were not based on the *NTIA Phase 2 Study* and the *Brazil Study*, as affirmed in the *RFC/FNPRM*, when we reviewed the issue anew therein, it was entirely appropriate to consider the information from these two studies in explaining our tentative conclusion in reviewing this matter that the 40 dB/decade standard should be retained.

[190] ARRL reply comments at 19-20.

[191] CURRENT comments at 6.

[192] HomePlug comments at 7.

[193] *See* Figure 4-2 in *NTIA Phase 2 Study*, at section 4.2.2.

[194] *See* para. 36 and footnote 83, *supra*.

[195] *See NTIA Phase 2 Study* at Section 2.3.2.

[196] Exhibit B to ARRL comments at 2.

CURRENT states that despite its weaknesses, including unstated set-up conditions (*e.g.* cable height) and too few data points, the *Brazil Study* shows attenuation over distance in excess of 40 dB/decade, and that to the extent of its reliability, it supports the Commission's decision. IBEC agrees with ARRL that these results and the network configurations in this study do not resemble those used in North America and considers them of limited application.[197] We recognize these concerns regarding the *Brazil Study*. In addition, like the OFCOM studies before it, the *Brazil Study* would, in the best of circumstances, provide only anecdotal information on the attenuation rate of BPL emissions as it only conducted measurements at a single location, rather than the very large number of sites that would be needed to develop a generalized description of that parameter. As we stated in the *RFC/FNPRM*, these studies do, however, provide an indication that BPL emissions tend to attenuate at rates that vary substantially across different sites, and that those rates can be much higher than the 20 dB/decade suggested by ARRL. In fact, the *Brazil Study*, while not individually probative, provides support for a much higher extrapolation factor than the similarly insubstantial OFCOM studies provided by ARRL.

78. ARRL states that it also provided a number of modeled studies showing that 40 dB/decade is not the correct factor to apply below 30 MHz.[198] It submits that these studies also showed that at angles upward from radiating power lines, field strength did increase with height and that the correlation between measurements made at 1 meter in height, 10 meters horizontally from an overhead power line, and the field strength at 30-meters distance, at upward angles where amateur HF antennas are most likely to be located, was very close to 20 dB/decade.[199] We agree with ARRL that emissions radiating upwards from overhead power lines are likely to attenuate at lower rates than emissions radiating horizontally and lower to the ground. In cases where an amateur antenna is located on a tower above the height of the power lines, as is typical of fixed amateur stations, we would expect that the level of any emissions received by that antenna might typically be higher than emissions received by a similar antenna located below the height of the power lines, all other things the same, because the path to the tower-mounted antenna will be less affected by the ground. However, our Access BPL rules provide for protection of such antennas by the absolute application of the prohibition against causing harmful interference in Section 15.5 of the rules.[200] Also we would generally expect that if a BPL installer sees a tower-mounted antenna, the installer would take steps to avoid interference to it before the system commences operation. In any case, for safety reasons, our rules provide for measurement of Access BPL systems from locations relatively close to the ground, where attenuation rates are likely to be higher, rather than at heights similar to power lines.[201]

79. ARRL argues a number of technical points to support using the free-space (or near free-space) 20 dB/decade attenuation rate associated with line sources. It provides a technical description that in the radiating "near-field" region of a large emitter (at distances beyond $\lambda/2\pi$, where λ is the

[197] ARRL comments at 48, IBEC comments at 2.

[198] ARRL comments at 49. ARRL does not specifically identify these studies.

[199] ARRL comments at 52-54. ARRL also points out that few if any HF antennas are located at the 1 meter height at which test may be made under the Access BPL measurement guidelines. We further note that while fixed amateur HF antennas are indeed typically mounted higher than 1 meter, most mobile HF antennas are likely to be mounted on vehicles at heights of approximately 1-2 meters.

[200] 47 C.F.R. § 15.5.

[201] ARRL itself recognizes the wisdom of making measurements close to the ground and generally supports the Commission's measurement guidelines, including measuring with a loop antenna at frequencies below 30 MHz, as it states in its May 2004 comment in this proceeding "ARRL understands and accepts the safety reasons that it is not practical to make measurements *in-situ* at heights typical of power lines." *See* ARRL comments May 2004, Exhibit D at 27, http://webapp01.fcc.gov/ecfs2/document/view?id=6516182983.

wavelength of the emission)[202], 1) the field strength does not decay uniformly with distance; 2) the field strength does not have a 377-ohm E (electric) to H (magnetic) field relationship; 3) the fields are not planar but rather follow a cylindrical Bessel function; 4) emissions along the emitter develop standing waves in which the magnitude of the fields varies up and down with distance; and 5) the average of varying fields follows a 1/R or 20 dB/decade attenuation rate with distance.[203] ARRL also notes that there are two types of near-field, reactive and radiating, and that in the reactive near-field region often assumed to be bounded by a distance of $\lambda/2\pi$ from the radiator, the fields do decay more rapidly than in the far field.[204] Again, we agree with ARRL on all of these technical points of well-documented RF propagation theory. While we did not explain our earlier decisions on Access BPL at the level of detail that involved mentioning these factors (and do not believe that it is routinely necessary to explain propagation considerations which are a matter of accepted electromagnetic physics theory), we did consider them in our decision. In fact, they were an intrinsic element of our deliberations. As a result**,** we included provisions in the Access BPL measurement guidelines for testing along the power lines at specified intervals where emissions would be expected to be highest.[205] We also considered that ground absorption and other environmental effects present near the surface that limit RF propagation typically result in attenuation of emissions in the MF and HF bands at rates much higher than the 20 dB/decade free space model, especially at the 1 meter height specified in the Access BPL measurement guidelines.

80. ARRL contends it is illogical to conclude that, if a 20 dB/decade extrapolation is appropriate at 30.001 MHz, the extrapolation somehow suddenly jumps to 40 dB/decade at 29.999 MHz. It submits that the sliding scale formula it had suggested in its petition for reconsideration took into account the fact that some increase in the extrapolation factor was indeed seen in its analyses at 3.5 MHz, so some adjustment for a 20 dB/decade factor versus frequency decreases to 3 MHz is appropriate. ARRL argues that while 40 dB/decade may be appropriate in the reactive near field (within a distance of $\lambda/2\pi$), the arbitrary specification of 40 dB/decade from 3 to 30 MHz is not supported by electromagnetic physics theory or any accurate engineering in the proceeding to date. While ARRL is correct with regard to the physics of this issue, as CURRENT observes, "regulation is often a matter of drawing bright lines through gray lines."[206] The Commission commonly uses "bright line" standards in its rules to provide clarity, simplicity, predictability and ease of applicability.[207] The "bright line" difference in the extrapolation factors for under and over 30 MHz is intended to provide clear guidance in a region of the spectrum where there is considerable variability in the predictability of results. We continue to believe that the current "fixed line" or "bright-line" approach for the different extrapolation factors above and below 30 MHz is appropriate for practical and administrative purposes.[208]

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[202] The wavelength λ of an electromagnetic waveform is given by $\lambda = V/F$, where V is the speed of light and F is the frequency of the waveform. As an example, the wavelength of a 10 MHz signal is about: $3\times10^8 / 10\times10^6 = 30$ meters.

[203] ARRL comments at 49-50 and Exhibit C to ARRL comments.

[204] *Id.*, at 56.

[205] *See BPL Order*, Appendix C (Measurement Guidelines) at 21340.

[206] CURRENT Technologies comments at 11-12.

[207] *See* for example, 47 C.F.R. §§ 15.107 (a), 15.207 (a), or 15.250 (d). In each of these sections, a different limit applies to each band of frequencies, despite their adjacency.

[208] Courts have found that, in complex areas of regulation, an administrative agency often "must create bright lines to separate prohibited and permissible activity. We defer to this line-drawing provided the interpretation is both reasonable and consonant with Congress' intent." *Beazer East, Inc. v. United States Environmental Protection Agency, Region III*, 963 F.2d 603, 610 (3rd Cir., 1992).

81. ARRL next observes that the NTIA 2004 comments the Commission relied on in part in some decisions made in the *BPL Order* provided "significant analyses that showed that if a large number of BPL emitters are deployed, they will raise the worldwide levels of man-made noise."[209] It submits that these analyses all presumed that the field strength of a BPL system is 29.54 dBμV/m at 30-meters distance and that the angles that will be propagated from overhead BPL lines are all upward from the [power] line, not downward toward the ground. It contends that for the *NTIA Phase 1* modeling of sky wave propagation to have had any merit at all, the test methods used must have determined accurately the point of maximum emissions above the power lines and they did not. ARRL submits that its analysis of the NTIA model showed that if a 40 dB/decade extrapolation is used, the test will not accurately reflect the actual maximum emissions from these systems, *i.e.*, the emissions above the power lines will attenuate at 20 dB/decade. ARRL is incorrect in its speculative statement that the NTIA model used the 29.54 dBμV/m at 30-meters distance value in accounting for upward propagation when it estimated the impact of BPL emissions on the levels of background man-made noise. While NTIA did not measure emissions above the power lines, we would not expect its staff to undertake such a hazardous task. Moreover, measurements above the power lines are not necessary to the estimation method NTIA used. The NTIA model does appropriately account for higher levels of radiation above the power line in the far-field gain pattern input calculated from the VOAAREA power line modeling used in the *Phase 1 Study*.[210] Conversely, ARRL does not provide any information to support its assertion that the model used by NTIA does not properly estimate the attenuation rate of emissions that might contribute to sky wave propagation. It merely asserts that "ARRL's analysis of the NTIA model showed that if a 40 dB/decade extrapolation is used, the test will not accurately reflect the actual maximum emissions from these systems."[211]

82. We also observe that in its *Phase 2 Study*, the NTIA estimates that under conditions of low solar activity that produce the lowest aggregate BPL signal via ionospheric propagation relative to the local noise floor at any geographic point, approximately 916,000 overhead BPL devices alone could be deployed before realizing a 1-dB increase in the noise floor.[212] NTIA also found that under high solar activity, more than 1.35 million overhead BPL devices would be required to raise the noise floor by 1 dB.[213] However, most Access BPL installations have a combination of overhead and underground devices, making the number of BPL devices that can be deployed before a 1-dB increase in the noise floor occurs much higher than the numbers listed above, depending on the particular combination of overhead and underground BPL devices.[214] Further, if BPL exclusive overhead installations reach such numbers, the Commission could consider whether a change in its rules to account for a change in the noise floor is appropriate at that time.

83. ARRL's arguments regarding propagation and the extrapolation factor also address the behavior of RF fields. It again points to provisions in the rules specifying that at frequencies above 30 MHz, 20 dB/decade is used at the measurement extrapolation factor while at frequencies below 30

[209] ARRL comments at 52.

[210] VOAAREA is one of the software tools in the NTIA/ITS Voice of America Coverage Analysis Program (VOACAP) HF Propagation Prediction software suite. The same tool was used in all of the NTIA modeling reports (*NTIA Phase 1 Study*, *NTIA Technical Appendix* and *NTIA Phase 2 Study*). We would, in fact, expect the attenuation rate to be much less than 40 dB/decade in skyward directions.

[211] ARRL comments at 52.

[212] *See NTIA Phase 2 Study* at Section 5.4.1, Figure 5-4.

[213] *Id.*, at Figure 5-3.

[214] *Id.*

MHz 40 dB/decade is used and presumes this difference is because above 30 MHz, measurements are made in the far field, while below 30 MHz, measurements are made in the near field.[215] ARRL submits that the way that fields vary in the reactive and radiating near field regions differ. It asserts that in the reactive near field region, bounded by a distance of $\lambda/2\pi$, field strength decays at a 40 dB/decade rate and in the radiating near field region beyond that boundary, fields generally develop a standing-wave pattern that diminishes with distance, but one that, on the whole, varies at a 20 dB/decade rate. It argues that the inadequacy of the present BPL rules is due to the fact that the rules assume that all areas below 30 MHz are in the "near field" region without differentiating between reactive and radiating near field phenomena. It submits that a 40 dB/decade extrapolation factor beyond the reactive near field region is flawed and at distances of 10 meters or more from the radiating source, all points are outside the reactive near field boundary for all frequencies above 4.78 MHz.[216]

84. In its reply comments, CURRENT argues that ARRL rests much of its argument regarding the reactive and radiating near field propagation characteristics on a logical error.[217] It observes that ARRL supposes two contradictory propositions to be simultaneously true that: 1) Access BPL systems comprise large radiating systems and 2) the far field region begins very close to the antenna. It submits that correcting this error yields a much larger extrapolation factor than ARRL acknowledges. In this regard, CURRENT states that if the first point is true, that is, if BPL-equipped power lines function as large, distributed antennas, then the near field extends well beyond 30 meters from the line.[218] It submits that in that case, all extrapolation takes place in the near field and the attenuation with distance is much steeper in the near field than beyond it, so that regardless of what happens farther out, 40 dB/decade is a conservative estimate in the near field. CURRENT notes that on the other hand, if ARRL's second proposition is true, that is, if the far field begins very close to the antenna, it follows that the antenna must be functioning similarly to a point source, in which case the extrapolation factor is close to 40 dB/decade.

85. The arguments of ARRL and CURRENT concerning the technical validity of using 40 dB/decade as the extrapolation factor for measuring emissions on frequencies below 30 MHz demonstrate the complexity involved in describing and estimating field strengths in the near-field regions of emissions. ARRL is generally correct in its technical presentation of the theory of such fields, *i.e.*, that emissions decay in the reactive near field at a rate of 40 dB/decade within a distance of $\lambda/2\pi$ from the source and then in the radiating near field out to $2D^2/\lambda$ at a rate of 20 dB/decade. The very long lengths of typical power line segments therefore would not be expected to affect the decay rate of field strengths relative to reactive near field phenomena and therefore at distances greater than 10 meters all frequencies above 4.78 MHz will generally be outside the reactive near field boundary. However, ARRL's description of the behavior of fields also shows that while the attenuation rate in the radiating near field is

[215] ARRL comments at 56-58.

[216] ARRL notes that for large line radiators, the calculation of the reactive near field distance is more complex, but states that it can be approximated by assumption of a line source radiator. ARRL submits that for these radiators, within the region of $\lambda/2\pi$, the fields do not decay at 40 dB/decade as they do for physically small radiators, but generally decay up close at approximately 20 dB/decade. It states that beyond the reactive near-field region, the calculated field strength shows a standing wave, but the peaks of that standing wave, or the average of the fields of the standing wave, decay at a 20 dB/decade rate. ARRL comments at 57.

[217] CURRENT reply comments at 10-11.

[218] CURRENT observes that the generally accepted boundary beyond which points are not considered as being in the radiating near field is $2D^2/\lambda$, where λ is the wavelength of the emission and D is the largest physical dimension of the radiating element, CURRENT reply comments, Appendix A at i. In the case of a BPL system, $2D^2/\lambda$ will typically be much farther than the 30 meter reference distance for the BPL emission limit specified in Section 15.209 of the rules (this measure does not properly describe the near field boundary in the case of emitters as long as power lines, *see* for example, ARRL reply comments, Appendix A at 7-8.)

generally on the order of 20 dB/decade (in the free-space or near free-space case), there are standing wave patterns and other phenomena that make predictions unreliable. In addition, when measuring relatively close to the ground (at the 1-meter height specified for measurements at frequencies below 30 MHz), the proximity to and variation of ground features and other conditions cause great variability in signal levels.[219] ARRL recognizes these ground effects, but argues that licensed services should not be protected only at ground level and that to do this the extrapolation factor should take into account the normally encountered antenna height of the victim receiver. Given that BPL measurements will be made close to the ground for the safety and practical reasons indicated above and the propagation characteristics that are likely to be present in ground environments, we therefore continue to believe that there is justification for presuming that the expected attenuation rate of measured emissions at frequencies below 30 MHz is greater than 20 dB/decade. We also agree with ARRL that licensed services should be protected in all cases and in this regard, the regime of rules we have established for Access BPL systems, as discussed above, provides that protection.

86. To further support its argument for an extrapolation factor of 20 dB/decade, ARRL submits a paper analyzing the industry standards for radiated emissions below 30 MHz.[220] It states that there are very few such standards because regulations for most unlicensed devices control conducted emissions below 30 MHz and radiated emissions above 30 MHz. It argues that all of these standards stipulate that electric fields or magnetic fields be extrapolated at 20 dB/decade, except in the reactive near-field region, nominally considered to be bounded by a distance of $\lambda/2\pi$ from the radiating source.[221] On the other hand, HomePlug observes that these standards basically confirm that there are multiple views of what the extrapolation factor should be, and that it is generally greater than 20 dB/decade in the near field, and often 40 dB/decade or more on the lower end of the frequency range. HomePlug asserts that in fact, the various documents mentioned by ARRL demonstrate that there are different standards with multiple extrapolation factors -- a fact that HomePlug asserts support the current rule.[222] IBEC states that use of the slant-range approach in determining extrapolated values of the emission standard is a fair compromise that contemplates the geometry of measuring emissions from power lines in close proximity to the lines.[223]

87. We observe that none of the standards mentioned by ARRL apply to Access BPL equipment and the specific environments in which these devices operate, as discussed above.[224] In particular, even

[219] ARRL comments at 57.

[220] ARRL comments at 58 and Exhibit D to ARRL comments.

[221] ARRL lists the following standards: 1) ANSI C63.12:1999 American National Standard Recommended Practice for Electromagnetic Compatibility Limits; 2) Telcordia GR-1989 Electromagnetic Compatibility and Electrical Safety - Generic Criteria for Network Telecommunications Equipment; 3) CISPR 18-2 1986 Radio interference characteristics of overhead power lines and high-voltage equipment -- Part 2: Methods of measurement and procedure for determining limits; 4) CISPR 11 Industrial, scientific and medical equipment -- Radio-frequency disturbance characteristics -- Limits and methods of measurement; and 5) 47 C.F.R Part 18 Industrial, Scientific and Medical Equipment (ISM).

[222] HomePlug reply comments at 5. For example, although CISPR 11 uses a 20 dB/decade extrapolation factor, CISPR 18-2 suggests an extrapolation factor of 33 dB/decade for frequencies below 30 MHz.

[223] IBEC comments at 5. It also believes that distances measured to determine the slant range should be to the closest radiating wire on the power pole. The amended rules provide for determination of the slant range distance from the power line carrying the BPL signals.

[224] For example, CISPR 11 and FCC Part 18 are only applicable to ISM equipment. Telcordia GR 1089 is only applicable to telecommunications systems. ANSI C63.12 is not a standard but merely a recommended practice. CISPR 18 only evaluates radio noise generated by high-voltage converter power stations and discusses methods on (continued….)

though ARRL insists that the CISPR 18 standard does apply to BPL as it would apply to any source of RF noise,[225] we note that CISPR has been working on the subject of an emission standard for BPL as far back as 2000 under CISPR Subcommittee G. The work to develop a standard specific to BPL has continued in CISPR Subcommittee I, however, this work has been recently reset to its preliminary stage due to the complex issues surrounding RF emissions at frequencies below 30 MHz, with signal attenuation being highly variable depending on the localized environment, as we discussed above.[226] Moreover, we find that the record in this proceeding has established a substantial body of information that supports the use of 40 dB/decade in conjunction with slant-range distance to adjust the emissions level for test results obtained in accordance with the measurement standards we have adopted for Access BPL.

88. In addition, as we discussed in the *RFC/FNPRM*, the slant-range distance method in the Access BPL measurement guidelines works with the 40 dB/decade factor to yield extrapolated emissions level values that have the effect of imposing a more conservative emissions standard than would be derived using the horizontal (lateral) distance from the nearest point of the overhead power line carrying the BPL signals.[227] In this regard, at the relatively short distances at which Access BPL emissions are to be measured, *i.e.*, distances 30 meters or less, applying the slant-range measurement method in the extrapolation of the measurements effectively reduces the compliant emission levels for BPL systems with respect to the horizontal distance from the power line. This reduction results because at any given horizontal distance from the power line, the slant-range distance is longer than the horizontal distance. The relationship is one of basic plane geometry that occurs due to the height of the power line on which the BPL signal injector is installed.[228] When extrapolated values at 40 dB per decade of slant-range distance are plotted against the horizontal distance, the effective extrapolated emission level curve more closely follows the emission level curve based on a 20 dB per decade extrapolation factor at horizontal

(Continued from previous page)

how to reduce radio noise from inherent power line components, such as mercury arc and thyristor valves. Although CISPR 18-2 discusses the attenuation of noise sources with distance from the power lines, we note that this standard states (and ARRL points out) that "an attenuation factor of 33 dB/decade is somewhat valid for frequencies between 1.7 MHz and 30 MHz." *See* CISPR 18-2, Section 2.3.5.1; *see also* Exhibit D to ARRL comments at 5.

[225] *See* ARRL *ex parte* comments filed January 11, 2010 at 3.

[226] *See* the work of CISPR Subcommittee I at http://www.iec.ch/cgi-bin/procgi.pl/www/iecwww.p?wwwlang=E&wwwprog=sea1112.p&committee=CIS%2FI&class=&refno=&type=&date.

[227] The rules for testing Part 15 devices specify that "[t]o the extent practicable, the device under test shall be measured at the distance specified in the appropriate rule section. The distance specified corresponds to the *horizontal* [emphasis added] distance between the measurement antenna and the closest point of the equipment under test, support equipment or interconnecting cables as determined by the boundary defined by an imaginary straight line periphery describing a simple geometric configuration enclosing the system containing the equipment under test." 47 C.F.R. § 15.31(f). However, for Access BPL devices operating on overhead power lines, the Commission adopted the slant range method due to the location of the BPL device on a power pole that is typically several meters above ground and above the measurement antenna. *See Guidelines* in Appendix C of *BPL Order* at 21339-21343 and Figure 1 in Appendix D, *infra*.

[228] The geometric relationship between horizontal and slant distances is that of a right triangle in which the hypotenuse is equal to the square root of the sum of the squared lengths of the other two sides, *i.e.,* $h = \sqrt{(x^2 + y^2)}$. For example, using a 40 dB per decade distance extrapolation factor, the maximum permitted emission level at a horizontal distance of 10 meters from the power line is 48.6 dBµV/m. However, for that same horizontal distance of 10 meters, the slant distance is 14.9 meters (assuming the power line is 12 meters in height, thus the measurement height with the antenna at 1 meter from the ground would be 11 meters) making the maximum permitted emission level to be only 41.7 dBµV/m, a level that is 7 dB more stringent. This means that instead of being able to emit up to 48.6 dBµV/m, an Access BPL device could only emit 41.7 dBµV/m, a level 7 dB less than if horizontal distance as specified for other Part 15 devices was used in the calculation of extrapolated levels. *See* illustrations and formulae in Appendix E, *infra*.

distances than the emission level curve based on a 40 dB per decade extrapolation factor at horizontal distances.[229] NTIA's modeling results in its *Phase 2 Study* effectively reflect this observation.[230] Also, given that the Access BPL measurement guidelines require compliance measurements to be taken at 30 meters or less, the effect of the slant-range distance provision is significant at all distances where the extrapolation factor can be used.[231] As shown in Appendix E, *infra*, the extrapolated Access BPL emissions level based on the existing 40 dB/decade factor and the slant-range measurement approach is very close (within a 5 dB range for typical medium-voltage power line heights) to the level that would result from use of the 20 dB/decade extrapolation factor with the traditional horizontal measurement distance.[232]

89. ARRL and several of the commenting parties address our request for comment on whether it would be desirable to modify the extrapolation factor to be 30 dB/decade or some other value to account for the considerable variability around the 40 dB/decade expected attenuation value at different sites. Our intent was that this lower value would apply a more conservative approach that would compensate for those cases where the actual attenuation is less than 40 dB. In opposing this plan, ARRL asserts that the Commission is not apparently convinced by its own *ex post* argument justifying use of 40 dB/decade, as it immediately thereafter abandoned that argument and proposed instead to adopt an equally unjustified 30 dB/decade extrapolation factor in what appears to be the "King Solomon" approach rather than a real scientific analysis. ARRL rejects the approach underlying the 30 dB/decade proposal and argues that the Commission is obligated to adopt a scientifically valid extrapolation standard, which it contends is 20 dB/decade.[233] The UTC and CURRENT also oppose such a change, stating that the Commission was correct to select 40 dB/decade as the distance extrapolation and that we should maintain that value. UPLC argues that a 30 dB/decade value would be inappropriate and that a reduced value would impose a significant compliance burden on Access BPL systems.[234] CURRENT argues that the Commission's original selection of 40 dB/decade is well supported by the record and that the mere possibility of other supportable conclusions, especially if based on other studies, does not warrant a change.[235] CURRENT and the UTC further submit that the now-demonstrable lack of interference reports from CURRENT's

[229] *See* illustration in Figures 1-3 in Appendix E, *infra*.

[230] *See NTIA Phase 2 Study*, at Section 2.5. NTIA found that "the Commission's modification to the rules for distance extrapolation [by using slant distance instead of horizontal distance for Access BPL devices] resulted in good agreement between the extrapolated field strength level and the rate in which field strength decays from the overhead MV power line."

[231] *RFC/FNPRM* at 21280. Because the slant range distance is dependent on the height of the power line on which the Access BPL equipment is installed, the extrapolated emission levels vary the most when the horizontal distance between the center of the measurement antenna and the nearest point directly under the overhead power line carrying the BPL signal is between 5 meters and 20 meters, with the maximum difference between the slant range and horizontal approaches at around 10 meters. *See* illustrations in Exhibit E, *infra.*

[232] Appendix E, *infra*, shows that for power line heights of 10 meters, the extrapolated emission level using 40 dB/decade in conjunction with slant distance is 4.4 dB less stringent than the use of 20 dB/decade with horizontal (lateral) distance, when the measurement antenna is placed at a horizontal distance of 10 meters from the nearest point directly under the overhead power line carrying the BPL signal. For power line heights of 12 meters, the extrapolated emission level using 40 dB/decade in conjunction with slant distance is 2.7 dB less stringent than the use of 20 dB/decade with horizontal distance, when the measurement antenna is placed at a horizontal distance of 10 meters from the nearest point directly under the overhead power line carrying the BPL signal.

[233] ARRL comments at 59.

[234] UPLC comments at 5-6.

[235] CURRENT comments at 8.

extensive operations supports not changing the extrapolation standard.[236]

90. It is plain from the record that reducing the extrapolation factor to the more conservative 30 dB/decade level to compensate for those situations in which the actual attenuation is less than 40 dB/decade would not satisfy the concerns of any of the parties to this matter or otherwise provide any benefits that would improve our Access BPL measurement guidelines. Contrary to ARRL's misapprehension, our consideration of a reduction in the extrapolation factor was not intended as a "compromise" approach in consideration of the wide variations in the studies and data before us. Rather, it was a recognition of the uncertainty or inexactness inherent in the information available and the amount of analysis undertaken at the time, and a signal of our openness in reconsidering the issue in that light.

91. Taking into consideration the above evaluations and all of the additional information before us now, we believe that the most compelling path points to retaining the 40 dB extrapolation factor. In this regard, we first observe that we have used this extrapolation value successfully with measurements at frequencies below 30 MHz in our program to control emissions from radio frequency devices for many years. This includes not only consumer products, but also industrial, scientific and medical equipment that may use thousands of watts of power and couple radio noise onto power lines that can radiate for significant distances. In addition, while ARRL asserts that there is only one scientifically correct and valid answer of an extrapolation factor of 20 dB, the studies and information before us show considerable differences in extrapolation factors under various system configurations and usage condition. We therefore conclude that there is no single "right" value for the extrapolation factor that accurately reflects environmental conditions in all cases, and instead find that the most appropriate decision is to use the existing value in the rules that both has a scientific basis and has stood the test of time for a wide variety of devices and systems. We also consider that, as observed in the discussion above, using the slant range to perform measurements has the effect of reducing the extrapolation factor to approximately 20 dB. In addition, the attenuation factors that are typically present when making measurements close to the ground, as specified in the BPL rules, tend to increase the signal loss above that which occurs from the spreading of energy in free space propagation. Finally, while one can debate the propriety and scientific validity of any particular extrapolation factor, we must consider that the extrapolation factor is but one element in the context of an overall set of rules that are designed to minimize the risk of harmful interference and to put in place appropriate measures to eliminate such interference if it should occur. Whether the extrapolation factor is 20 dB or 40 dB or somewhere in between is far less important than the fact that harmful interference must be corrected under any circumstances. While ARRL asserts that an extrapolation factor that is too lax will lead to widespread instances of harmful interference that should be corrected *ex ante* as opposed to *ex post*, we have seen little evidence of harmful interference being caused.[237] Accordingly, we are not modifying the extrapolation factor for the emissions standard for frequencies below 30 MHz to compensate for the variability in the field strength attenuation rate at different locations.

92. We also are reiterating here the clarification we issued in the *RFC*/*FNPRM* that measurements of BPL equipment and systems should be made at the 30-meters distance specified in Section 15.209 unless circumstances such as high ambient noise levels or geographic limitations are present, in which case, a 3-meter or 10-meter horizontal distances indicated in the BPL measurement guidelines may be used.[238] We are further clarifying that measurements made at the 30-meter distance

[236] CURRENT comments at 8; UPLC comments at 5. We note that CURRENT's operations are mainly above 30 MHz on overhead MV lines.

[237] As noted above, the BPL system database shows that BPL systems are currently operating in 125 zip codes across the United States.

[238] No extrapolation of the emissions level is needed for measurements made at the 30-meter distance specified in the standard.

specified in the Section 15.209 emissions standard will prevail over measurements made at shorter distances and that where possible and practical, the Commission's staff will make measurements at this distance when testing for compliance.[239] As indicated above, to provide additional clarity in our compliance requirements, we are also amending the BPL measurement guidelines to specify the extrapolated values of the emissions level for compliance at 3-meter and 10-meter horizontal distances from the nearest point of the overhead power line carrying the BPL signals for typical heights of medium voltage power lines. These clarifications of the existing rules as well as the adoption of the definition for slant-range distance would assist the industry in ensuring compliance of BPL systems without imposing additional regulatory costs.

2. Site-Specific Extrapolation Factors

93. In the *RFC/FNPRM*, the Commission proposed to allow parties testing BPL systems for compliance with the radiated emissions limits to determine distance correction factors on a site-by-site basis using a new *in situ* measurement procedure designed specifically for Access BPL.[240] This plan, which was based on a concept under consideration in the IEEE Working Group P1775/D2 effort at that time and which has been finalized since,[241] would allow entities conducting measurements of Access BPL systems and equipment to determine an extrapolation factor specific to a site by fitting a straight line to measurements of field strength in dBμV/m vs. logarithmic distance in meters from the nearest conductor carrying BPL emissions, where the extrapolation factor would be taken as the slope of that line.[242] The Commission indicated that the site-specific extrapolation factor would be an alternative to the extrapolation factor specified in the BPL measurement guidelines and would be replacing the existing method using only two data points for determining site-specific extrapolation factors currently in the rules.[243] The proposed alternative method would only be applicable to Access BPL devices operating on frequencies below 30 MHz.

94. Under the proposal in the *RFC/FNPRM*, entities conducting measurements would determine an extrapolation factor specific to the site by fitting a straight line to measurements of field strength in dBμV/m vs. logarithmic distance in meters from the nearest conductor carrying BPL emissions, where the extrapolation factor would be taken as ten times the slope, *n*, of that line. The slope *n* any point on the straight line in μV/m would be:

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[239] CURRENT states that while it has no objection in principle to measurement of BPL emissions at 30 meters, it does foresee possible problems in practice. In this regard, CURRENT submits that a suitable test site would have to be removed from power lines (apart from the one under test) by a distance of several times 30 meters. Such a location will be difficult to find in a built-up environment, so studies may have to take place in rural areas. CURRENT comments at 11. We agree with this observation and caution parties taking measurements at 30 meters (and also at closer distances) to take into account the presence of other nearby power lines which may also be carrying BPL signals or be a source of ambient noise.

[240] Section 15.31(f)(2) of the rules currently allows the results of measurements performed at frequencies below 30 MHz to be extrapolated on a site-specific basis, specifying that test results are to be extrapolated to the standard distance by making measurements at a minimum of two distances on at least one radial to determine the proper extrapolation factor, *see* 47 C.F.R. § 15.31(f)(2).

[241] *See* IEEE 1775-2010 at Annex A, p. 41-43.

[242] *See RFC/FNPRM* at 9682-9684.

[243] Currently, for frequencies below 30 MHz, the rules stipulate that "[w]hen performing measurements at a closer distance than specified, the results shall be extrapolated to the specified distance by either making measurements at a minimum of two distances on at least one radial to determine the proper extrapolation factor or by using the square of an inverse linear distance extrapolation factor (40 dB/decade)." 47 C.F.R. § 15.31(f)(2).

$(20\log E_r - 20\log E_2)/(10\log D_2 - 10\log D_r)$

where E_r is the measured field strength at distance D_r

The field strength in dBμV/m at any distance D along the best straight line fit is estimated from the value of *n* as:

$$20\log E_r = 20\log E_2 + n(10\log D_2 - 10\log D_r)$$

The extrapolation factor would be derived from a best straight line fit determined by a linear least squares regression calculation from measurements made at four or more lateral distances from the overhead line, starting at no less than 6 meters from the lateral plane and spaced from each other by at least 3 meters. If these measurements allow a straight line with a negative slope to be calculated or drawn with reasonable fit (the minimum regression coefficient of multiple correlation would be 0.9), the best straight line fit would be used to calculate field strength at the 30-meters standard measurement distance in the rules according to the equation above. If the four measurements do not fall near any straight line or negative slope, measurements at a new distance would be added until a reasonable fit to a straight line is indicated. In addition, measurements that obviously show a "null" or other "outlier" value would be ignored.[244] Parties employing site-specific extrapolation values would be required to provide a record of the measurements under the above procedure and to submit those measurements and their derivation of the *in situ* values with any measurements with compliance submissions to the Commission.

95. Several commenting parties representing the Access BPL industry support our proposal to establish a special procedure for determining site-specific extrapolation factors for use in measuring emissions from BPL systems and equipment. In particular, CURRENT, HomePlug, IBEC, Intellon Corporation (Intellon) and UTC support allowing BPL systems operators to develop their own *in situ* BPL extrapolation factors on a voluntary basis as a means to provide them with flexibility in demonstrating compliance with the rules.[245] IBEC states that in certain cases it may be advantageous to create special procedures to address unique site-related issues. It submits that these special procedures should be implemented at the option of the equipment manufacturer, who should also bear the responsibility for justifying the procedures and ensuring that they meet the requirements and intent of the rules.

96. ARRL opposes the establishment of a procedure for determining site-specific extrapolation factors for Access BPL measurements, arguing that our proposal "is flawed and unacceptable, based on an incomplete IEEE standard which is still under development, and not yet published."[246] It further observes that the IEEE draft standard has been the subject of a number of negative comments in the ballot process, which must yet be addressed by the IEEE's working group.[247] With regard to methodology, ARRL argues that measurement at only four points (as proposed in the IEEE draft standard) cannot

[244] "Outliers" are high and low values that fall well out of the range of typical values.

[245] CURRENT comments at 8, HomePlug comments at 4-5, IBEC comments at 3, Intellon reply comments at 5 and UPLC comments at 7. CURRENT indicates that it supports this proposal so long as the manufacturer also retains the option of applying the fixed extrapolation factor in the rules.

[246] ARRL comments at 18.

[247] We note that the IEEE did adopt a standard for determining site-specific extrapolation factors in measuring emissions from BPL systems (IEEE 1775-2010 Standard, published on Jan 7, 2011) that includes the methodology proposed in the draft standard. However, we also note that the IEEE EMC Society did not support that standard, citing deficiencies on procedural and substantive grounds; nonetheless, IEEE 1775-2010 remains a published and valid standard, sponsored and supported by the Power System Communications Committee of the IEEE Power & Energy Society and the Standards Committee of the IEEE Communications Society.

determine the actual extrapolation value, because any attempt to apply any measurement of extrapolation to the power lines' complex environment is a recipe for inaccuracy and would encourage "cherry picking" the results. It contends that this would allow those doing the measurements to provide any value of extrapolation that they want in either direction.[248]

97. In their reply comments, HomePlug and Intellon submit that contrary to ARRL's position, the IEEE draft standard on Access BPL site-specific extrapolation values currently is under review by a large and competent body of experts who have studied and validated the *in-situ* measurement procedures.[249] They state that even as a draft, this standard represents the most recent collaborative work to accurately measure radiation specifically from power lines carrying BPL signals.

98. We continue to believe the availability of a site-specific approach for determining values for extrapolation of measurements of Access BPL emissions on frequencies below 30 MHz is a desirable and useful alternative to the fixed extrapolation factor. The option to use site-specific values can substantially alleviate the measurement concerns associated with the standard extrapolation factor and the variability in attenuation rates that may be observed in the field, and particularly where measurements at a site may plainly not appear to conform to the 40 dB/decade standard.[250] We also recognize ARRL's concerns that a site-specific option could be abused by careful selection of measurement points. However, we find that our proposed approach that requires four measurements spaced at least 3 meters apart with provisions for additional measurements where a straight line with a negative slope is not approximated by the four initial measurements, is sufficient to develop a reliable indication of the attenuation rate at a site. In particular, we believe the requirement in this new procedure that the measurements used to develop the extrapolation value approximate a straight line with a negative slope as determined through the linear least squares regression method (with a minimum regression coefficient of multiple correlation of 0.9) will adequately guard against the "cherry picking" concern mentioned by ARRL. Where such a line cannot be approximated, we will also require that measurements be made at a different perpendicular position along the power line very nearby or at the same perpendicular position but on the opposite side of the line from the first set of measurements.

99. This new site-specific procedure will replace the existing Section 15.31(f)(2) alternative for Access BPL that only requires two measurements. This plan conforms substantially to the IEEE P1775-2010 standard which has been developed, as HomePlug and Intellon point out, by a body of experts. We observe that a straight line best fit of multiple data points using the least squares regression technique is not a new idea developed by the IEEE standard, it is a well-established and commonly used statistical method. We note that in the *RFC/FNPRM,* we proposed to derive the extrapolation factor from a best straight line fit determined by a linear least squares regression calculation from measurements made at four or more lateral distances from the overhead line, starting at no less than 6 meters from the lateral plane and spaced from each other by at least 3 meters; at that time, the IEEE standard was in a state

[248] ARRL comments at 54. ARRL also submits a paper in Exhibit C of its comments describing that near-field measurements contain a high degree of variability and that a few meters along the line will make a significant difference in the rate at which the signal strength decays perpendicular to the line, making any measurement unreliable for determining an extrapolation value, even at ground level. ARRL argues that, based on the conclusions of its Exhibit C, it is not possible to measure actual signal levels in the complex *in-situ* environment surrounding the power lines, unless a very large number of measurements can be made; thus, 4 measurement points as proposed by IEEE will not yield an accurate, reliable or predictable extrapolation number, ARRL comments at 55 and Exhibit C.

[249] HomePlug reply comments at 4-5, Intellon reply comments at 5.

[250] For example, development of a site-specific extrapolation value might be needed if the equipment that has been tested and found to comply with the emissions limit at other sites is found to be out of compliance as installed at the site under test.

of transition and we were merely proposing a measurement concept. We now observe the IEEE P1775-2010 has finalized its standard to specify that measurements be made at four or more lateral distances from the overhead line, starting at no less than 3 meters from the lateral plane and spaced from each other by at least 3 meters. We are adopting the distances as specified in the IEEE published standard for the new site-specific measurement procedure. This procedure is an improvement over the current procedure for determining site-specific extrapolation factors in Section 15.31(f)(2) of the rules, which requires only two measurement points without any specific separation distance, as stated above. We caution parties responsible for certification measurements to bear in mind that the objective of the site-specific procedure is to plot enough data points to draw a valid extrapolation curve; accordingly, in some situations the number of measurement points may need to exceed the recommended minimum for the resulting extrapolation to be valid.[251] Further, as we stated in the *BPL Order* and the *BPL Reconsideration Order*, operators of Access BPL systems are responsible for eliminating any harmful interference that may occur or must cease operation upon notification by a Commission representative that the device is causing harmful interference.[252] Accordingly, we are amending our rules as set forth in Appendix C to establish a new method for determining site-specific extrapolation values for Access BPL measurements as described herein. Because this is an alternative method intended to facilitate compliance measurements which may be used at the BPL operator's discretion, the requirement provides benefits without imposing additional regulatory costs. The benefits of having this additional method would enable BPL operators to better adjust the operating parameters of BPL devices according to specific installation sites that might not conform to the standard extrapolation value, which could lead to cost savings and reduced interference potential. Additional provisions of this procedure are set forth in the revised Access BPL measurement guidelines in Appendix D.

100. We will not allow the site-specific procedure to be used at locations within 30 meters of a power pole with a ground conductor where the Access BPL signals devices are carried on a neutral/grounded line of the power system. In this regard, we are concerned that emissions from a grounding conductor mounted on the side of a power line pole could combine with the emissions from the overhead neutral power line to produce false indications of the attenuation rate that would distort the slope of the extrapolation curve. Accordingly, we are amending our rules as set forth in Appendix C to establish a new method for determining site-specific extrapolation values for Access BPL measurements as described herein. Additional provisions of this procedure are set forth in the revised Access BPL measurement guidelines in Appendix D.

C. The Access BPL Database

101. ARRL contends that the BPL database is virtually useless due to errors, omissions and listings of systems that are not operating any longer and systems that have never been placed in operation. It cites as an example an incident in which it sent an e-mail message to the person listed in the database for the Manassas, VA, BPL system, it found the e-mail contact was invalid and follow-up e-mail messages to the City of Manassas went unanswered.[253] In its reply comments, the City of Manassas submits that when the system operator, Comtek, transferred operation of the system to the city, the contact was not updated immediately but the error was corrected promptly in April 2009 when the city was notified by ARRL that the listing was incorrect.[254] We agree with ARRL that the database should be

[251] A valid extrapolation curve would have a minimum regression coefficient of multiple correlation of 0.9.

[252] *BPL Order* at 21276; *BPL Reconsideration Order* at 9327.

[253] ARRL comments at 59-60.

[254] City of Manassas, VA comments at 1-2. The City of Manassas also states that amateurs in Northern VA knew who to contact regarding its BPL system.

maintained with accurate, up-to-date information. Our staff contacted the database manager, UTC, about ARRL's concerns and in its reply comments, UTC affirms that the database has been and is being reviewed periodically to ensure that the information is currently accurate.[255] We do note that while it is important that the database be up-to-date in all respects, it is most important that operating and soon-to-be operating systems not be omitted and we do not have information that such systems were not or are not listed. We therefore encourage UTC to continue to be diligent in its management of the database and other interested parties to work with UTC in providing information to ensure that the records in the database are accurate and up-to-date.

IV. PROCEDURAL MATTERS

102. *Final Regulatory Flexibility Analysis.* As required by the Regulatory Flexibility Act, 5 U.S.C. § 603, the Commission has prepared a Final Regulatory Flexibility Analysis (FRFA) of the possible significant economic impact on small entities of the proposals suggested in this document. The FRFA is set forth in Appendix B.

103. *Paperwork Reduction Act.* This document contains no new or modified information collection requirements subject to the Paperwork Reduction Act of 1995 (PRA), Public Law 104-13. In addition, therefore, it does not contain any new or modified "information collection burden for small business concerns with fewer than 25 employees," pursuant to the Small Business Paperwork Relief Act of 2002, Public Law 107-198, *see* 44 U.S.C. 3506(c)(4*)*.

104. *Congressional Review Act.* The Commission will send a copy of this Second Report and Order in a report to be sent to Congress and the Government Accountability Office pursuant to the Congressional Review Act, *see* 5 U.S.C. 801(a)(1)(A).

V. ORDERING CLAUSES

105. Accordingly, IT IS ORDERED that pursuant to pursuant to the authority contained in Sections 4(i), 301, 302, 303(e), 303(f) and 303(r) of the Communications Act of 1934, as amended, 47 USC Sections 154(i), 301, 302, 303(e), 303(f) and 303(r), this Second Report and Order is hereby ADOPTED and Part 15 of the Commission's Rules ARE AMENDED as set forth in Appendix C, effective 30 days after publication in the Federal Register.

[255] UPLC reply comments at 8.

106. IT IS FURTHER ORDERED that the Commission's Consumer and Governmental Affairs Bureau, Reference Information Center, SHALL SEND a copy of this Second Report and Order, including the Final Regulatory Flexibility Analysis, to the Chief Counsel for Advocacy of the Small Business Administration.

FEDERAL COMMUNICATIONS COMMISSION

Marlene H. Dortch
Secretary

APPENDIX A

Parties Submitting Comments

Comments

1. The Arkados Group, Inc. (Arkados)
2. The National Association for Amateur Radio (ARRL)
3. Neville Bedford
4. Jeff Beiermann
5. Michael J. Brenza
6. Don Bullard
7. CURRENT Technologies, LLC (CURRENT)
8. James R. Devillier
9. Malachi Doane
10. Michael Elcsisin
11. Roy Gilbert
12. Kurt Harnish
13. The HomePlug Powerline Alliance (HomePlug)
14. The Intellon Corporation (Intellon)
15. The International Broadband Electric Communications, Inc. (IBEC)
16. Morris Jones
17. Neil Klagge
18. Erik Laymon
19. Wayne Longman
20. Gregory r. Marino
21. John Mattesini
22. Timothy J. Newton
23. SPiDCOM Technologies, S.A.
24. Andrew Stenberg
25. Jack L. Sykes
26. David Tessitore
27. The Utilities Telecom Council (UTC)
28. Thomas M. Walsh
29. James Edwin Whedbee, M.Ed. (James Whedbee)
30. Keith Whitaker
31. Larry Yonge

Reply Comments

1. Ambient Corporation (Ambient)
2. The Arkados Group, Inc.
3. The National Association for Amateur Radio
4. The City of Manassas, VA (City of Manassas)
5. CURRENT Technologies, LLC
6. The HomePlug Powerline Alliance
7. The Intellon Corporation
8. The United Power Line Council
9. James Edwin Whedbee, M.Ed.

APPENDIX B

Final Regulatory Flexibility Analysis

As required by the Regulatory Flexibility Act (RFA),[1] an Initial Regulatory Flexibility Analysis (IRFA) was incorporated in the *Request for Comment and Further Notice of Proposed Rulemaking (RFC/FNPRM)* in ET Docket Nos. 04-37 and 03-104.[2] The Commission sought written public comment on the proposals in the *RFC/FNPRM,* including comment on the IRFA. This present Final Regulatory Flexibility Analysis (FRFA) conforms to the RFA.

A. Need for, and Objectives of, the Second Report and Order.

The Second Report and Order maintains the existing Access BPL emissions standards and other technical operation rules, as well as the existing extrapolation 40 dB/decade factor prescribed in the rules for use in measurement of emissions from Access BPL systems. In addition, the Second Report and Order modifies the rules to 1) require a deeper notch filter depth when a notch filter is used to avoid interference to a specific frequency band; 2) adopt a definition for the slant-range distance used in the BPL measurement guidelines to further clarify its application; and 3) establish a new procedure for determining site-specific extrapolation factors.

The decisions in the Second Report and Order are consistent with the mandate by the United States Court of Appeals for the District of Columbia in *ARRL v. FCC,* and will provide regulatory certainty for both manufacturers of Access BPL equipment and systems operators so that development of equipment and construction of facilities can proceed unimpeded by any concerns about the status of the regulations with which equipment and systems must comply.[3]

B. Statement of Significant Issues Raised by Public Comments in Response to the IRFA.

There were no public comments filed that specifically addressed the rules and policies proposed in the IRFA.

C. Response to Comments by the Chief Counsel for Advocacy of the Small Business Administration

Pursuant to the Small Business Jobs Act of 2010, the Commission is required to respond to any comments filed by the Chief Counsel for Advocacy of the Small Business Administration, and to provide a detailed statement of any change made to the proposed rules as a result of those comments. The Chief Counsel did not file any comments in response to the proposed rules in this proceeding.

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[1] *See* 5 U.S.C. § 603. The RFA, *see* 5 U.S.C. § 601-612, has been amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA), Public Law No. 104-121, Title II, 110 Stat. 857 (1996), and the Small Business Jobs Act of 2010, Public Law No. 111-240, 124 Stat. 2504 (2010).

[2] *Request for Further Comment and Further Notice of Proposed Rulemaking* in ET Dockets No. 04-37 and 03-104 *(Amendment of Part 15 Regarding New Requirements and Measurement Guidelines for Access Broadband Over Power Line Systems, Carrier Current Systems)*, 24 FCC Rcd 9669 (2009) (*RFC/FNPRM*).

[3] *See American Radio Relay League, Incorporated, v. Federal Communications Commission (ARRL v. FCC)*, 524 F.3d 227 (D.C. Cir. 2008).

D. Description and Estimate of the Number of Small Entities to Which the Rules Will Apply.

The RFA directs agencies to provide a description of, and, where feasible, an estimate of the number of small entities that may be affected by the proposed rules, if adopted.[4] The RFA defines the term "small entity" as having the same meaning as the terms "small business," "small organization," and "small business concern" under Section 3 of the Small Business Act.[5] Under the Small Business Act, a "small business concern" is one that: (1) is independently owned and operated; (2) is not dominant in its field of operations; and (3) meets may additional criteria established by the Small Business Administration (SBA).[6]

Nationwide, there are a total of approximately 27.5 million small businesses, according to the SBA.[7] A "small organization" is generally "any not-for-profit enterprise which is independently owned and operated and is not dominant in its field."[8] Nationwide, as of 2002, there were approximately 1.6 million small organizations.[9] The term "small governmental jurisdiction" is defined generally as "governments of cities, towns, townships, villages, school districts, or special districts, with a population of less than fifty thousand."[10] Census Bureau data for 2002 indicate that there were 87,525 local governmental jurisdictions in the United States.[11] We estimate that, of this total, 84,377 entities were "small governmental jurisdictions."[12] Thus, we estimate that most governmental jurisdictions are small.

The adopted rules pertain to manufacturers of unlicensed communications devices. The appropriate small business size standard is that which the SBA has established for radio and television broadcasting and wireless communications equipment manufacturing. The Census Bureau defines this category as follows: "This industry comprises establishments primarily engaged in manufacturing radio and television broadcast and wireless communications equipment. Examples of products made by these establishments are: transmitting and receiving antennas, cable television equipment, GPS equipment, pagers, cellular phones, mobile communications equipment, and radio and television studio and broadcasting equipment."[13] The SBA has developed a small business size standard for firms in this

[4] *See* 5 U.S.C. § 603(b)(3).

[5] *Id.* § 601(3).

[6] *Id.* § 632.

[7] *See* SBA, Office of Advocacy, "Frequently Asked Questions," http://www.sba.gov/advo/stats/sbfaq.pdf (accessed Dec. 2010).

[8] 5 U.S.C. § 601(4).

[9] Independent Sector, The New Nonprofit Almanac & Desk Reference (2002).

[10] 5 U.S.C. § 601(5).

[11] U.S. Census Bureau, Statistical Abstract of the United States: 2006, Section 8, page 272, Table 415.

[12] We assume that the villages, school districts, and special districts are small, and total 48,558. *See* U.S. Census Bureau, Statistical Abstract of the United States: 2006, section 8, page 273, Table 417. For 2002, Census Bureau data indicate that the total number of county, municipal, and township governments nationwide was 38,967, of which 35,819 were small. *Id.*

[13] U.S. Census Bureau, 2007 NAICS Definitions, "334220 Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing"; http://www.census.gov/naics/2007/def/ND334220.HTM#N334220.

category, which is: all such firms having 750 or fewer employees.[14] According to Census Bureau data for 2007, there were a total of 939 establishments in this category that operated for part or all of the entire year. Of this total, 784 had less than 500 employees and 155 had more than 100 employees.[15] Thus, under this size standard, the majority of firms can be considered small.

E. Description of Projected Reporting, Record keeping and Other Compliance Requirements.

The Second Report and Order does not contain new or modified information collection requirements. The minor modified technical requirements adopted in this Second Report and Order, as discussed below, do not impose significant burden and will not have a significant economic impact on a substantial number of small entities that are, or may be, subject to the requirements of the rules in the item.

F. Steps taken to Minimize Significant Economic Impact on Small Entities and Significant Alternatives Considered.

The RFA requires an agency to describe any significant alternatives that it has considered in reaching its proposed approach, which may include the following four alternatives (among others): (1) the establishment of differing compliance or reporting requirements or timetables that take into account the resources available to small entities; (2) the clarification, consolidation, or simplification of compliance or reporting requirements under the rule for small entities; (3) the use of performance, rather than design, standards; and (4) an exemption from coverage of the rule, or any part thereof, for small entities.[16]

In this Second Report and Order, we modify our rules and measurement procedures for Access BPL devices operating below 30 MHz to 1) require a deeper notch filter depth when a notch filter is used to avoid interference to a specific frequency band; 2) establish a new procedure for determining site-specific extrapolation factors; and 3) adopt a definition for the slant-range distance used in the BPL measurement guidelines to further clarify its application. In reviewing the requirement for a 20-dB notching capability and current developments in BPL equipment, we now find that it would be appropriate to increase the required notching capability of Access BPL systems operating below 30 MHz to 25 dB from the existing requirement of 20 dB, when a notch filter is used to avoid interference to a specific frequency band. This deeper notching capability is technologically available and voluntarily implemented in the field by Access BPL operators to avoid potential interference to amateur radio operators; therefore, the new requirement would not pose a substantial burden on Access BPL manufacturers. To afford manufacturers time to redesign their equipment to comply with the new, more conservative 25-dB notching requirement, we are allowing an 18-month period from the date this action is published in the Federal Register before the requirement becomes effective.

We further establish an alternative method to allow parties testing BPL systems for compliance with the radiated emissions limits to determine distance correction factors on a site-by-site basis using an *in situ* measurement procedure when measurements cannot be made at the reference measurement distance of 30 meters as specified in the rules. Because this is an alternative method intended to facilitate compliance measurements which may be used at the BPL operator's discretion, the requirement provides benefits without imposing additional regulatory costs. The benefits of having this additional method

[14] 13 C.F.R. § 121.201, NAICS code 334220.

[15] http://factfinder.census.gov/servlet/IBQTable?_bm=y&-fds_name=EC0700A1&-geo_id=&-_skip=300&-ds_name=EC0731SG2&-_lang=en.

[16] 5 U.S.C. § 603(c).

would enable BPL operators to better adjust the operating parameters of BPL devices according to specific installation sites that might not conform to the standard extrapolation value, which could lead to cost savings and reduced interference potential.

In addition, we clarify that parties testing BPL equipment and systems for compliance with emissions limits in our rules should measure at the standard reference 30-meter distance whenever possible, and only measure at the shorter distances recommended in the BPL measurement guidelines if safety or ambient conditions require taking measurements at a closer distance such as 10 meters or 3 meters from the overhead line. We also adopt a definition for the slant-range distance used in the BPL measurement guidelines to further clarify its application. We also modify our BPL measurement guidelines to provide clarity for those conducting measurements for compliance of Access BPL equipment and systems with the Section 15.209 emissions standards by specifying the extrapolated values of compliant emissions levels at 3-meter and 10-meter horizontal (lateral) distance from the nearest point of the overhead power line carrying the BPL signals, for typical heights of medium voltage power lines. These clarifications of the existing rules as well as the adoption of the definition for slant-range distance would assist the industry in ensuring compliance of BPL systems, promoting possible cost savings without imposing additional regulatory costs.

Report to Congress: The Commission will send a copy of the Second Report and Order, including this FRFA, in a report to be sent to Congress pursuant to the Congressional Review Act.[17] In addition, the Commission will send a copy of the Second Report and Order, including this FRFA, to the Chief Counsel for Advocacy of the SBA. A copy of the Report and Order and FRFA (or summaries thereof) will also be published in the Federal Register.[18]

[17] *See* 5 U.S.C. § 801(a)(1)(A).

[18] *See* 5 U.S.C. § 604(b).

APPENDIX C

Final Rules

For the reasons discussed in the preamble, the Federal Communications Commission proposes to amend 47 C.F.R. Part 15 to read as follows:

PART 15 – RADIO FREQUENCY DEVICES

1. The authority citation for part 15 continues to read as follows:

AUTHORITY: 47 U.S.C. 154, 302, 303, 304, 307 and 544A.

2. Section 15.3 is amended by adding paragraph (hh) to read as follows:

Section 15.3 Definitions.

* * * * *

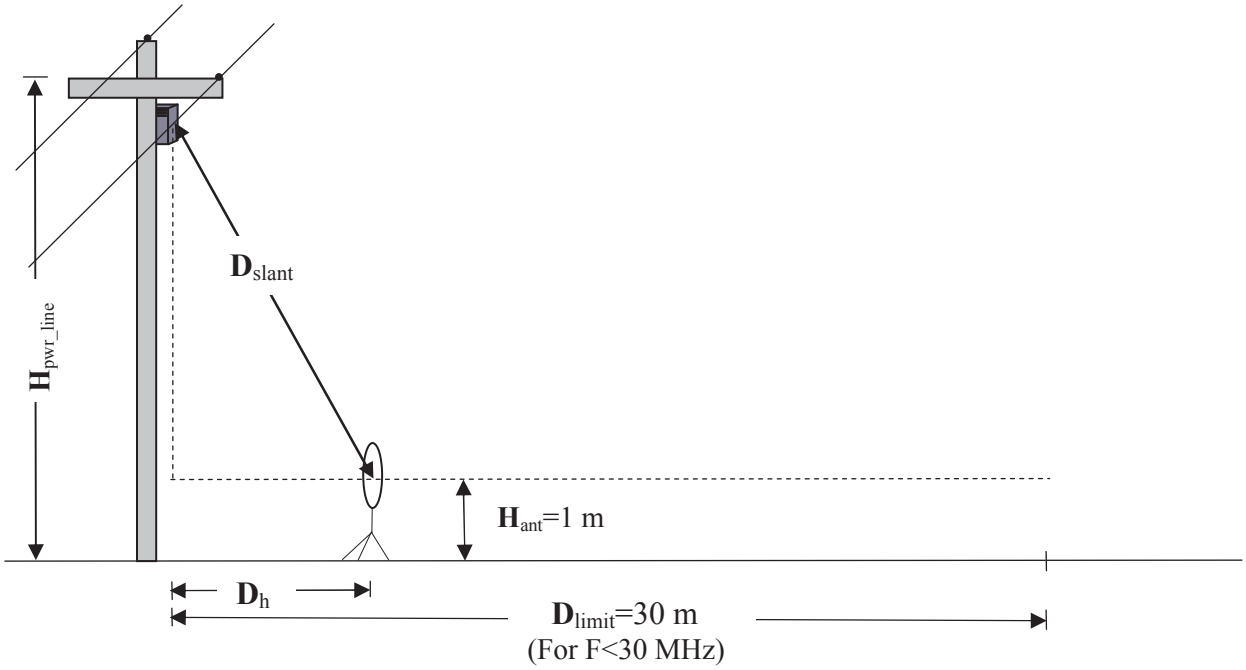
(hh) Slant-Range Distance. Diagonal distance measured from the center of the measurement antenna to the nearest point of the overhead power line carrying the Access BPL signal being measured. This distance is equal to the hypotenuse of the right triangle as calculated in the formula below. The slant-range distance shall be calculated as follows:

$$d_{slant} = \sqrt{\left(h_{pwr\_line} - h_{ant}\right)^2 + \left(d_h\right)^2}$$

Where:

d_{slant} is the slant-range distance, in meters (see Figure 1, below);
d_h is the horizontal (lateral) distance between the center of the measurement antenna and the vertical projection of the overhead power line carrying the BPL signals down to the height of the measurement antenna, in meters;
h_{pwr_line} is the height of the power line, in meters; and
h_{ant} is the measurement antenna height, in meters.

Figure 1 – Illustration of Slant-Range Distance



D_{slant} is the slant-range distance, in meters;
D_h is the horizontal (lateral) distance between the center of the measurement antenna and the vertical projection of the overhead power line carrying the BPL signals down to the height of the measurement antenna, in meters;
D_{limit} is the distance at which the emission limit is specified in Part 15 (*e.g.*, 30 meters for frequencies below 30 MHz);
H_{pwr_line} is the height of the power line, in meters; and
H_{ant} is the measurement antenna height, in meters.

3. Section 15.31 is amended by revising paragraph (f)(2) to add a sentence at the end of this paragraph, by re-designating paragraphs (f)(3) through (f)(5) as (f)(4) through (f)(6), and by adding a new paragraph (f)(3), to read as follows:

Section 15.31 Measurement standards.

* * * * *

(f) * * *

* * * * *

(2) * * * This paragraph shall not apply to Access BPL devices operating below 30 MHz.

(3) For Access BPL devices operating below 30 MHz, measurements shall be performed at the 30-meter reference distance specified in the regulations whenever possible. Measurements may be performed at a distance closer than that specified in the regulations if circumstances such as high ambient noise levels or geographic limitations are present. When performing measurements at a distance which is closer than specified, the field strength results shall be extrapolated to the specified distance by using the square of an inverse linear distance extrapolation factor (*i.e.*, 40 dB/decade) in conjunction with the slant-range distance defined in Section 15.3(hh) of this part. As an alternative, a site-specific extrapolation factor derived from a straight line best fit of measurements of field strength in dBμV/m vs. logarithmic distance in meters for each carrier frequency, as determined by a linear least squares regression calculation from measurements for at least four distances from the power line, may be used. Compliance measurements for Access BPL and the use of site-specific extrapolation factors shall be made in accordance with the Measurement Guidelines for Access BPL systems specified by the Commission. Site-specific determination of the distance extrapolation factor shall not be used at locations where a ground conductor is present within 30 meters if the Access BPL signals are on the neutral/grounded line of a power system.

* * * * *

4. Section 15.37 is amended by adding paragraph (o) to read as follows:

Section 15.37 Transition provisions for compliance with the rules.

* * * * *

(o) All Access BPL devices operating below 30 MHz that are manufactured, imported, marketed or installed on or after **[*insert date 18 months from date of publication in the Federal Register*]** shall comply with the requirements specified in Section 15.611(c)(1)(i) of this part.

5. Section 15.611 is amended by revising paragraph (c)(1) (i) to read as follows:

Section 15.611 General technical requirements.

* * * * *

(c) * * *

(1) * * *

(i) For frequencies below 30 MHz, when a notch filter is used to avoid interference to a specific frequency band, the Access BPL system shall be capable of attenuating emissions within that band to a level at least 25 dB below the applicable Part 15 limits.

* * * * *

APPENDIX D

Measurement Guidelines for Broadband Over Power Line (BPL) Devices Or Carrier Current Systems (CCS) and Certification Requirements For Access BPL Devices

This appendix is intended to provide general guidance for compliance measurements of Broadband over power line (BPL) devices and other carrier current systems (CCS). For BPL systems, the measurement principles are based on the Commission's current understanding of BPL technology. Modifications may be necessary as measurement experience is gained.

1. General Measurement Principles for Access BPL, In-House BPL and CCS

1) Testing shall be performed with the power settings of the Equipment Under Test (EUT) set at the maximum level.

2) Testing shall be performed using the maximum RF injection duty factor (burst rate). Test modes or test software may be used for uplink and downlink transmissions.

3) Measurements should be made at a test site where the ambient signal level is 6 dB below the applicable limit. (See ANSI C63.4-2003, section 5.1.2 for alternatives, if this test condition cannot be achieved.)

4) If the data communications burst rate is at least 20 burst per second, quasi-peak measurements shall be employed, as specified in Section 15.35(a) of the rules. If the data communications burst rate is 20 bursts per second or less, measurements shall be made using a peak detector.

5) For frequencies above 30 MHz, an electric field sensing antenna, such as a biconical antenna is used. The signal shall be maximized for antenna heights from 1 to 4 meters, for both horizontal and vertical polarizations, in accordance to ANSI C63.4-2003 procedures. For Access BPL measurements only, as an alternative to varying antenna height from 1 to 4 meters, these measurements may be made at a height of 1 meter provided that the measured field strength values are increased by a factor of 5 dB to account for height effects.

6) For frequencies below 30 MHz, an active or passive magnetic loop is used. The magnetic loop antenna should be at 1 meter height with its plane oriented vertically and the emission maximized by rotating the antenna 180 degrees about its vertical axis. When using active magnetic loops, care should be taken to prevent ambient signals from overloading the spectrum analyzer or antenna pre-amplifier.

7) The six highest radiated emissions relative to the limit and independent of antenna polarization shall be reported as stated in ANSI C63.4-2003, section 10.1.8.2.

8) All operational modes should be tested including all frequency bands of operation, as required by Section 15.31(i) of the rules.

2. Access BPL Measurement Principles

a. Test Environment

1) The Equipment Under Test (EUT) includes all BPL electronic devices *e.g.,* couplers, injectors, extractors, repeaters, boosters, concentrators, and electric utility overhead or underground medium voltage lines.

2) *In-situ* testing shall be performed on three typical installations for overhead line(s) and three typical installations for underground line(s).

b. Radiated Emissions Measurement Principles for Access BPL on Overhead Line Installations

1) Measurements should normally be performed at the horizontal reference distance as specified in Sections 15.209 and 15.109 of the rules (*i.e.,* 30 meters for frequencies below 30 MHz and 10 meters for frequencies 30-88 MHz.) If necessary, due to ambient emissions, for frequencies below 30 MHz, measurements may be performed at a closer distance such as 10 meters (or 3 meters if necessary for safety or because measurements cannot practically be performed at 30 meters or 10 meters) from the overhead line. Distance corrections are to be made in accordance with paragraph (4), below.

2) Testing shall be performed at distances of 0, ¼, ½, ¾, and 1 wavelength down the line from the BPL injection point on the power line. Wavelength spacing is based on the mid-band frequency used by the EUT. In addition, if the mid-band frequency exceeds the lowest frequency injected onto the power line by more than a factor of two, testing shall be extended in steps of ½ wavelength of the mid-band frequency until the distance equals or exceeds ½ wavelength of the lowest frequency injected. (For example, if the device injects frequencies from 3 to 27 MHz, the wavelength corresponding to the mid-band frequency of 15 MHz is 20 meters, and wavelength corresponding to the lowest injected frequency is 100 meters. Measurements are to be performed at 0, 5, 10, 15, and 20 meters down line—corresponding to zero to one wavelength at the mid-band frequency. Because the mid-band frequency exceeds the minimum frequency by more than a factor of two, additional measurements are required at 10-meter intervals until the distance down-line from the injection point equals or exceeds ½ of 100 meters. Thus, additional measurement points are required at 30, 40, and 50 meters down line from the injection point.)

3) Testing shall be repeated for each Access BPL component (injector, extractor, repeater, booster, concentrator, etc.)

4) The distance correction used to calculate the applicable extrapolated emission levels for the measurements that are closer than the specified reference distance in Section 15.209 of the rules shall be based on the slant-range distance, which is the diagonal distance from the center of the measurement antenna to the nearest point of the overhead power line carrying the BPL signals being measured, as defined in Section 15.3(hh) of the rules. Calculations of the slant-range distance and the applicable extrapolated emission levels are made according to Equations (1) and (2) in Section 6, below.

5) For Access BPL devices operating below 30 MHz, if the site-specific alternative extrapolation method is selected, the extrapolation factor is determined by fitting a straight line to measurements of field strength in dBµV/m vs. logarithmic distance in meters from the nearest conductor carrying BPL emissions. Site-specific determination of the extrapolation factor is not permitted for BPL devices

that inject signals on the neutral/grounded line of a power system if a grounding conductor (typically located at each pole) is located within 30 meters of any of the measurement locations.

a. Measurements shall be made for at least four horizontal distances from the overhead line, at no less than 3 meters from the lateral plane and differing from each other by at least 3 meters. If these measurements allow a straight line with a negative slope to be calculated or drawn with reasonable fit (the minimum regression coefficient of multiple correlation would be 0.9), the best straight line fit would be used to calculate field strength at the 30-meter standard measurement distance in the rules.

b. If the four measurements do not satisfy the regression coefficient requirement specified above, measurements at one or more additional distances shall be added until the regression coefficient is satisfied. If the regression coefficient is not satisfied, a site-specific extrapolation rate may not be used.

Note: In cases where Access BPL devices are coupled to low-voltage power lines (*i.e.*, In-House BPL or modem boosters), apply the overhead-line procedures as stated above along the low-voltage power lines.

c. Radiated Emissions Measurement Principles for Access BPL in Underground Line Installations

1) Underground line installations are those in which the BPL device is mounted in, or attached to a pad-mounted transformer housing or a ground-mounted junction box and couples directly only to underground cables.

2) Measurements should normally be performed at the horizontal reference distance as specified in Section 15.209 of the rules (*i.e.,* 30 meters for frequencies below 30 MHz and 10 meters for frequencies 30-88 MHz.) If necessary, due to ambient emissions, for frequencies below 30 MHz, measurements may be performed at a closer distance such as 3 meters or 10 meters from the in-ground transformer. Distance corrections are to be made in accordance with Section 15.31(f) in the rules.

3) Measurements shall be made at positions around the perimeter of the in-ground power transformer where the maximum emissions occur. ANSI C63.4-2003, section 8.1, specifies a minimum of 16 radial angles surrounding the EUT (in-ground transformer that contains the BPL device(s)). If directional radiation patterns are suspected, additional azimuth angles shall be examined.

d. Conducted Emissions Measurement Principles

Conducted emissions testing is not required for Access BPL.

3. In-House BPL and Carrier Current Systems Measurement Principles

1) In-House BPL devices are typically composite devices consisting of two equipment classes (Carrier current system and personal computer peripheral (Class B)). While carrier current systems require Verification, personal computer peripherals require Declaration of Conformity (DoC) or Certification, as specified in Section 15.101 of the Rules. Appropriate tests to determine compliance with these requirements shall be performed.

2) *In-situ* testing is required for testing of the carrier current system functions of the In-House BPL device.

3) If applicable, the device shall also be tested in a laboratory environment, as a computer peripheral, for both radiated and conducted emissions tests per the measurement procedures in C63.4-2003.

a. Test Environment and Radiated Emissions Measurement Principles for In-House BPL and CCS *In-Situ* Testing

1) The Equipment under Test (EUT) includes In-House BPL modems used to transmit and receive carrier BPL signals on low-voltage lines, associated computer interface devices, building wiring, and overhead or underground lines that connect to the electric utilities.

2) *In-situ* testing shall be performed with the EUT installed in a building on an outside wall on the ground floor or first floor. Testing shall be performed on three typical installations. The three installations shall include a combination of buildings with overhead-line(s) and underground line(s). The buildings shall not have aluminum or other metal siding, or shielded wiring (e.g.: wiring installed through conduit, or BX electric cable).

3) Measurements shall be made at positions around the building perimeter where the maximum emissions occur. ANSI C63.4-2003, section 8.1, specifies a minimum of 16 radial angles surrounding the EUT (building perimeter). If directional radiation patterns are suspected, additional azimuth angles shall be examined.

4) Measurements should normally be performed at the horizontal reference distance as specified in Sections 15.209 and 15.109 of the rules (*i.e.,* 30 meters for frequencies below 30 MHz and 3 meters for frequencies 30-88 MHz.) If necessary, due to ambient emissions, for frequencies below 30 MHz, measurements may be performed at a closer distance such as 3 meters or 10 meters around the building perimeter as outlined in step 3) above. Distance corrections are to be made in accordance with Section 15.31(f) of the Rules.

b. Additional Measurement Principles for In-House BPL and CCS *In-Situ* Testing With Overhead Lines

1) In addition to testing radials around the building, testing shall be performed at three positions along the overhead line connecting to the building (*i.e.* the service wire). It is recommended that these measurements be performed starting at a distance 10 meters down the line from the connection to the building. If this test cannot be performed due to insufficient length of the service wire, a statement explaining the situation and test configuration shall be included in the technical report.

2) Measurements should normally be performed at the horizontal reference distance as specified in Sections 15.209 and 15.109 of the rules (*i.e.,* 30 meters for frequencies below 30 MHz and 10 meters for frequencies 30-88 MHz.) Measurements may then be performed at a closer distance such as 3 meters or 10 meters from the overhead line. Distance corrections are to be made in accordance with paragraph 2.b.4 above.

c. Measurement Principles for Testing In-House BPL and CCS as a Computer Peripheral

1) The data rate shall be set at the maximum rate used by the EUT. Test modes or test software may be used to simulate data traffic.

2) For In-House BPL devices operating as unintentional radiators below 30 MHz, the conducted emissions shall be measured in the 535 – 1705 kHz band as specified in Section 15.107(c). For In-House BPL devices operating as unintentional radiators above 30 MHz, the conducted emissions shall

be measured as specified in Section 15.107(a). Conducted emissions measurements shall be performed in accordance with ANSI C63.4-2003 (Section 7 and Annex E).

3) For In-House BPL devices operating as unintentional radiators either below 30 MHz or above 30 MHz, the radiated emissions limits of Section 15.109(a) apply. The radiated emissions from the computer peripheral shall be measured at an Open Area Test Site (OATS) in accordance with the measurement procedures in C63.4-2003 (Section 8 and Annex D)

4. Certification Technical Report Requirements for Access BPL Devices

1) Certification applications shall be accompanied by a technical report in accordance with Section 2.1033 of the Rules. Each device used in an Access BPL system requires its own Certification.

2) For Access BPL devices, the statement describing how each device operates shall include the following information: modulation type, number of carriers, carrier spacing, channel bandwidth, notch capability/control, power settings/control, and range of signal injection duty factors.

3) For Access BPL devices, the measurement report shall include representative emissions spectrum plot(s) of the reported data.

4) For Access BPL devices operating below 30 MHz, if the site-specific method for determining the extrapolation factor was used, the measurement report shall include detailed information on the calculations and the data points taken.

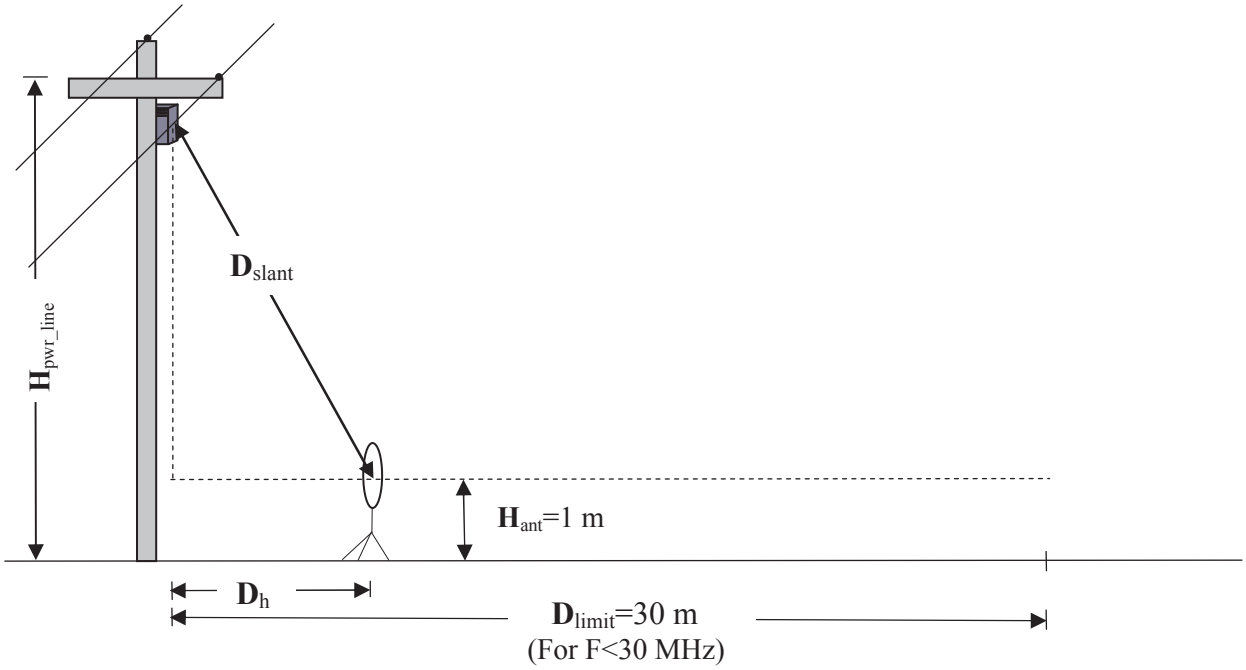
5. Responsibility of BPL operator

It is recommended that a BPL operator perform initial installation and periodic testing of Access BPL systems on his power lines. These tests shall be performed to ensure that the system in conjunction with the installation site complies with the appropriate emission limits using the measurement procedures outlined in Section 3 of this document. The BPL operator should use typical installation sites within his service area as outlined in section 2(a) of this document. Selection of typical sites shall be made according to the characteristics of the installation as a whole. The BPL operator is not required to submit the test results. In the instance that the Access BPL system was tested on the operator's network for certification purposes, the initial installation tests do not need to be repeated. However, periodic testing of installed Access BPL systems is recommended to ensure that the system maintains compliance with Part 15 emission limits.

6. Calculation of Slant-Range Distance and Extrapolated Emission Level for Access BPL operating on overhead power lines

Figure 1 shows an example of the testing configuration of Access BPL devices operating below 30 MHz on overhead power line installations. It is provided to illustrate the calculation of extrapolated emission levels using the slant range method when the device cannot be tested at the required reference distance of 30 meters specified in the rules. As explained below, when making emission measurements at a distance closer than 30 meters, the measured result must be extrapolated to the Part 15 specified measurement distance (*i.e.*, 30 meters) to determine compliance with the Part 15 emission limit, because the radiated emission limit for Access BPL devices operating below 30 MHz is only specified at the reference distance of 30 meters.

Figure 1 – Testing configuration of Access BPL devices operating below 30 MHz



D_{slant} is the slant-range distance, in meters;
D_h is the horizontal (lateral) distance between the center of the measurement antenna and the vertical projection of the overhead power line carrying the BPL signals down to the height of the measurement antenna, in meters;
D_{limit} is the distance at which the emission limit is specified in Part 15 (*e.g.*, 30 meters for frequencies below 30 MHz)
H_{pwr_line} is the height of the power line, in meters; and
H_{ant} is the measurement antenna height, in meters.

a. Slant-Range Distance Formula

The slant-range distance is calculated using the following formula:

$$d_{slant} = \sqrt{\left(h_{pwr\_line} - h_{ant}\right)^2 + \left(d_h\right)^2} \qquad \textbf{(Equation 1)}$$

Where:
d_{slant} is the slant-range distance, in meters;
d_h is the horizontal (lateral) distance between the center of the measurement antenna and the vertical projection of the overhead power line carrying the BPL signals down to the height of the measurement antenna, in meters;
h_{pwr_line} is the height of the power line, in meters; and
h_{ant} is the measurement antenna height, in meters.

b. Extrapolated Emission Level Formula

Because the radiated emission limit for Access BPL devices operating below 30 MHz is specified at the reference distance of 30 meters, when making emission measurements at a distance closer than 30 meters, the measured result must be extrapolated to the specified measurement distance (*i.e.*, 30 meters) to determine compliance with the Part 15 emission limit. The extrapolated emission level (in dBμV/m) is calculated using the following formula:

$$E_{extrap} = E_{meas} - N \cdot Log_{10}\left(\frac{d_{limit}}{d_{slant}}\right) \qquad \textbf{(Equation 2)}$$

Where:
N is the distance extrapolation factor, *e.g.,* 40 for frequencies below 30 MHz;
d_{limit} is the horizontal measurement distance corresponding to the Part 15 emissions limits, *e.g.,* 30 meters for frequencies below 30 MHz;
d_{slant} is the slant-range distance, in meters;
E_{meas} is the measured electric field strength at a horizontal distance, d_h, in dBμV/m; and
E_{extrap} is the electric field strength value after applying the distance extrapolation factor, in dBμV/m

If the extrapolated electric field strength value exceeds the Part 15 emission limit (*i.e.* 29.54 dBμV/m for Access BPL operating below 30 MHz as specified for a horizontal measurement distance of 30 meters), the Access BPL device must lower its emission level to comply with the limit.

c. Extrapolated Emission Levels For Access BPL Devices Installed on Typical Overhead Power Line Heights

The tables below show examples of extrapolated maximum allowable emission levels for Access BPL devices installed on typical overhead power line heights (10-12 meters in the United States). If the power line height involved is different than the illustrated heights below, the slant-range distance and applicable extrapolated emission level must be calculated using Equations 1 and 2, above.

Table 1 - Power Line Height of 10 m

Frequency (MHz)	Horizontal Distance from nearest point of overhead power line carrying the BPL signals (meter)	Power Line Height (meter)	Calculated Slant-Range Distance (meter)	Extrapolated Radiated Emission Maximum Allowable Level (dBμV/m)
1.705-30	3	10	9.49	49.54
1.705-30	10	10	13.45	43.47

Table 2 - Power Line Height of 11 m

Frequency (MHz)	Horizontal Distance from nearest point of overhead power line carrying the BPL signals (meter)	Power Line Height (meter)	Calculated Slant-Range Distance (meter)	Extrapolated Radiated Emission Maximum Allowable Level (dBμV/m)
1.705-30	3	11	10.44	47.88
1.705-30	10	11	14.14	42.60

Table 3 - Power Line Height of 12 m

Frequency (MHz)	Horizontal Distance from nearest point of overhead power line carrying the BPL signals (meter)	Power Line Height (meter)	Calculated Slant-Range Distance (meter)	Extrapolated Radiated Emission Maximum Allowable Level (dBμV/m)
1.705-30	3	12	11.40	46.35
1.705-30	10	12	14.87	41.74

APPENDIX E

Extrapolated Emission Maximum Allowable Levels Using Slant-Range Method With Various Power Line Heights

I. SLANT-RANGE METHOD FOR MEASURING BPL EMISSIONS ON OVERHEAD POWER LINES

The Commission adopted a slant-range method for measuring BPL emissions on overhead power lines in Appendix C of the *BPL Order*. With the slant-range method, the distance correction for the overhead-line measurements of Access BPL emissions is based on the slant-range distance, which is the diagonal distance from the center of the measurement loop antenna to the overhead power line, illustrated in Figure 1 of the amended Measurement Guidelines, *supra*. Slant-range distances are calculated based on the height of the power line and the horizontal (lateral) distance (D_h) between the center of the measurement antenna and the vertical projection of the overhead power line carrying the BPL signals down to the height of the measurement antenna (see Equation 1, below). Slant-range distance corrections are made in accordance with Section 15.31(f)(3) (*e.g.,* using 40 dB/decade extrapolation factor for frequencies below 30 MHz).

II. EXTRAPOLATED LEVELS COMPARISONS WITH TYPICAL POWER LINE HEIGHTS

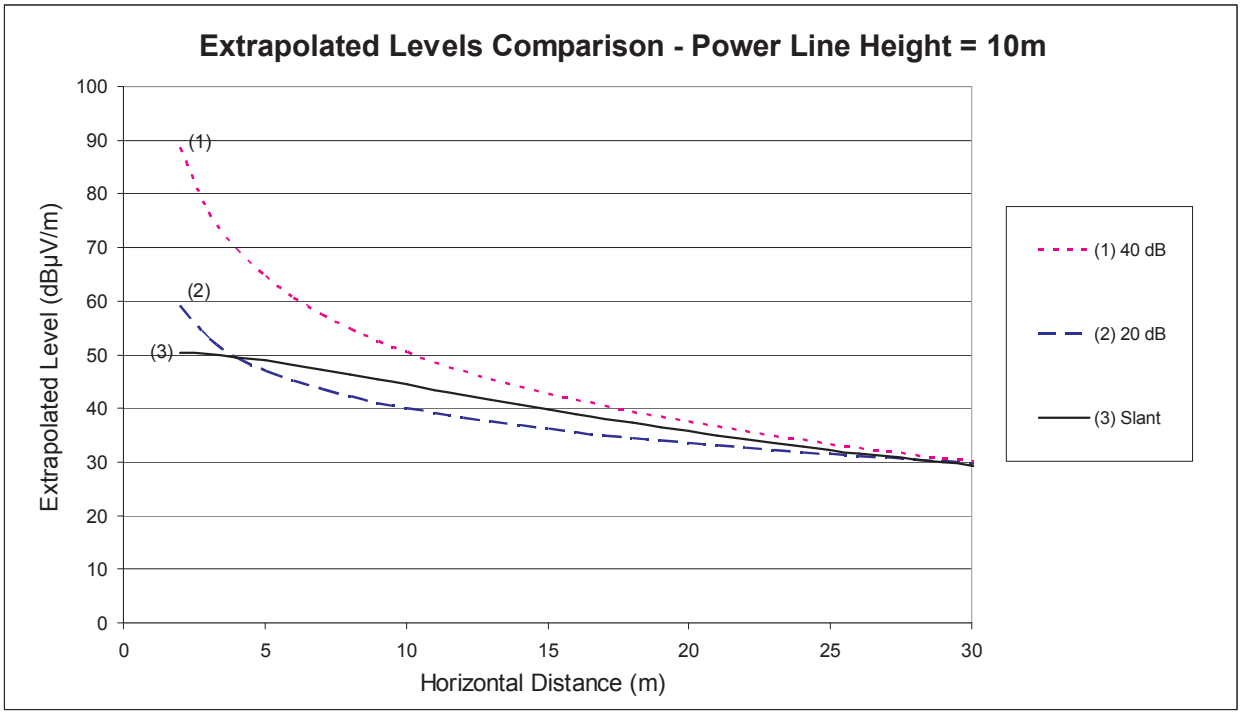
Typical medium-voltage power line heights in the United States are 10-12 meters. Figures 1-3 below illustrate a comparison between the extrapolated emission levels with respect to horizontal (lateral) distance when using extrapolation factors of 40 dB (trace 1), 20 dB (trace 2) and when using the Commission's slant-range method calculated using 40 dB/decade extrapolation factor (trace 3).

As illustrated, the resulting extrapolated maximum allowable emission level applied to Access BPL devices is more stringent than for other Part 15 devices operating below 30 MHz by virtue of using the slant-range distance in the calculation of extrapolated emission levels. This extrapolated maximum allowable level is very close (within a 5 dB range for typical medium-voltage power line heights) to what ARRL is requesting, *i.e.,* using 20 dB/decade extrapolation factor with straight horizontal (lateral) distance.

A. Extrapolated Levels using 40 dB/decade and Slant-range distance From a Power Line Height of 10 meters

Figure 1 illustrates a comparison between the extrapolated maximum allowable emission levels with respect to horizontal (lateral) distance when using extrapolation factors of 40 dB/decade (trace 1), 20 dB/decade (trace 2) and when using the Commission's slant-range distance method calculated with 40 dB/decade extrapolation factor (trace 3). Calculations are made according to Equations 1 and 2 below, using a power line height of 10 meters. This results in a measurement height of 9 meters, because the measurement loop antenna is at 1 meter from the ground.

Figure 1 – Extrapolated Levels Comparison with 40 dB/decade Extrapolation Factor Applied to Slant-Range Distance – Power Line Height at 10 meters



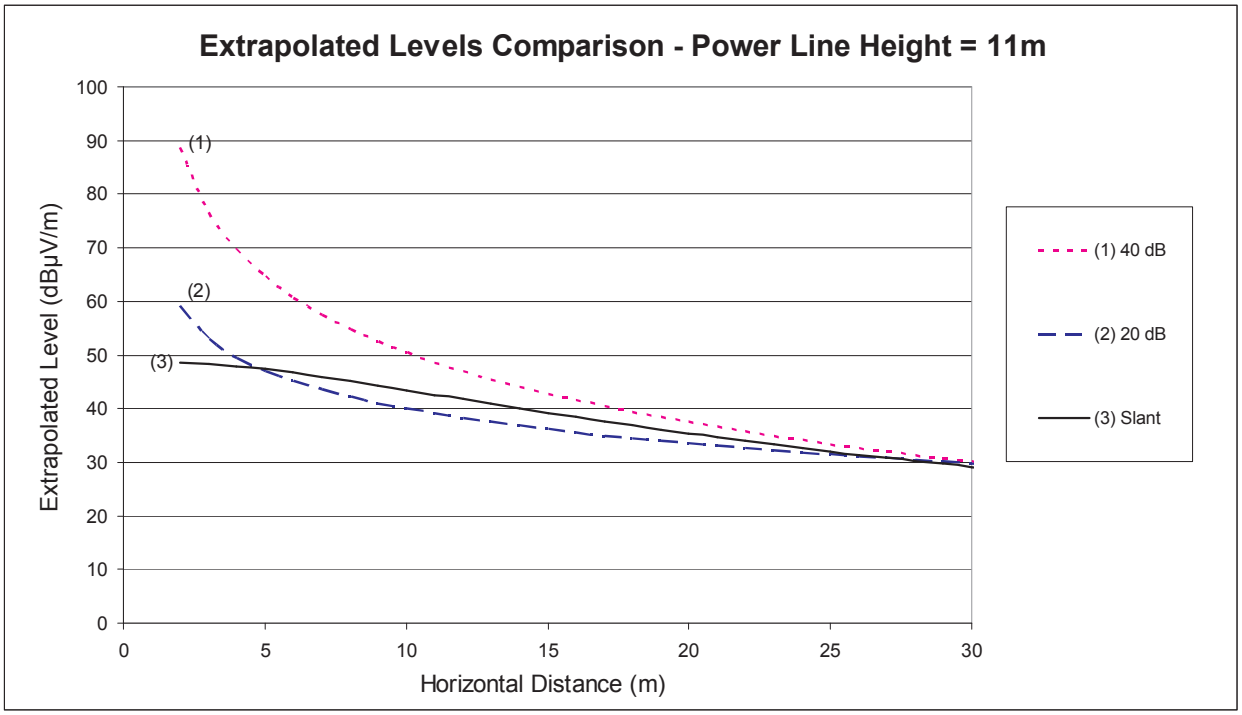
As illustrated in Figure 1 for power line heights of 10 meters, the Commission's slant-range method using a 40 dB/decade extrapolation factor applied to slant-range distance provides an extrapolated emission level graph that reveals the following.

- At measurement distances greater than 5 meters, the extrapolated maximum allowable emission levels for slant-range distance based on the existing 40 dB/decade factor (trace 3) are LESS stringent than extrapolated emission levels based on 20 dB/decade extrapolation factor for horizontal (lateral) distance (trace 2), by a **maximum of 4.4 dB**. This maximum difference between the two traces (trace 2 and trace 3) is found at a horizontal distance of 9 meters from the nearest point of the overhead power pole carrying the BPL signals.
- At these same measurement distances (greater than 5 meters), the extrapolated maximum allowable emission levels for slant-range distance based on the existing 40 dB/decade factor (trace 3) are MORE stringent than extrapolated emission levels based on 40 dB/decade extrapolation factor for horizontal (lateral) distance (trace 1), by as much as 12.6 dB.
- However, at measurement distances less than 5 meters, the extrapolated maximum allowable emission levels for slant-range distance based on the existing 40 dB/decade factor (trace 3) are MORE stringent than extrapolated emission levels for horizontal (lateral) distance based on either 20 dB/decade (trace 2) or 40 dB/decade extrapolation factor (trace 1).

B. Extrapolated Levels using 40 dB/decade and Slant-range distance From a Power Line Height of 11 meters

Figure 2 illustrates a comparison between the extrapolated maximum allowable emission levels with respect to horizontal (lateral) distance when using extrapolation factors of 40 dB/decade (trace 1), 20 dB/decade (trace 2) and when using the Commission's slant-range distance method calculated with 40 dB/decade extrapolation factor (trace 3). Calculations are made according to Equations 1 and 2 below, using a power line height of 11 meters. This results in a measurement height of 10 meters, because the measurement loop antenna is at 1 meter from the ground.

Figure 2 – Extrapolated Levels Comparison with 40 dB/decade Extrapolation Factor Applied to Slant-Range Distance – Power Line Height at 11 meters



As illustrated in Figure 2 for power line heights of 11 meters, the Commission's slant-range method using a 40 dB/decade extrapolation factor applied to slant-range distance provides an extrapolated emission level graph that reveals the following.

- At measurement distances greater than 5 meters, the extrapolated maximum allowable emission levels for slant-range distance based on the existing 40 dB/decade factor (trace 3) are LESS stringent than extrapolated emission levels based on 20 dB/decade extrapolation factor for horizontal (lateral) distance (trace 2), by a **maximum of 3.5 dB**. This maximum difference between the two traces (trace 2 and trace 3) is found at a horizontal distance of 10 meters from the nearest point of the overhead power line carrying the BPL signals.
- At these same measurement distances (greater than 5 meters), the extrapolated maximum allowable emission levels for slant-range distance based on the existing 40 dB/decade factor (trace 3) are MORE stringent than extrapolated emission levels based on 40

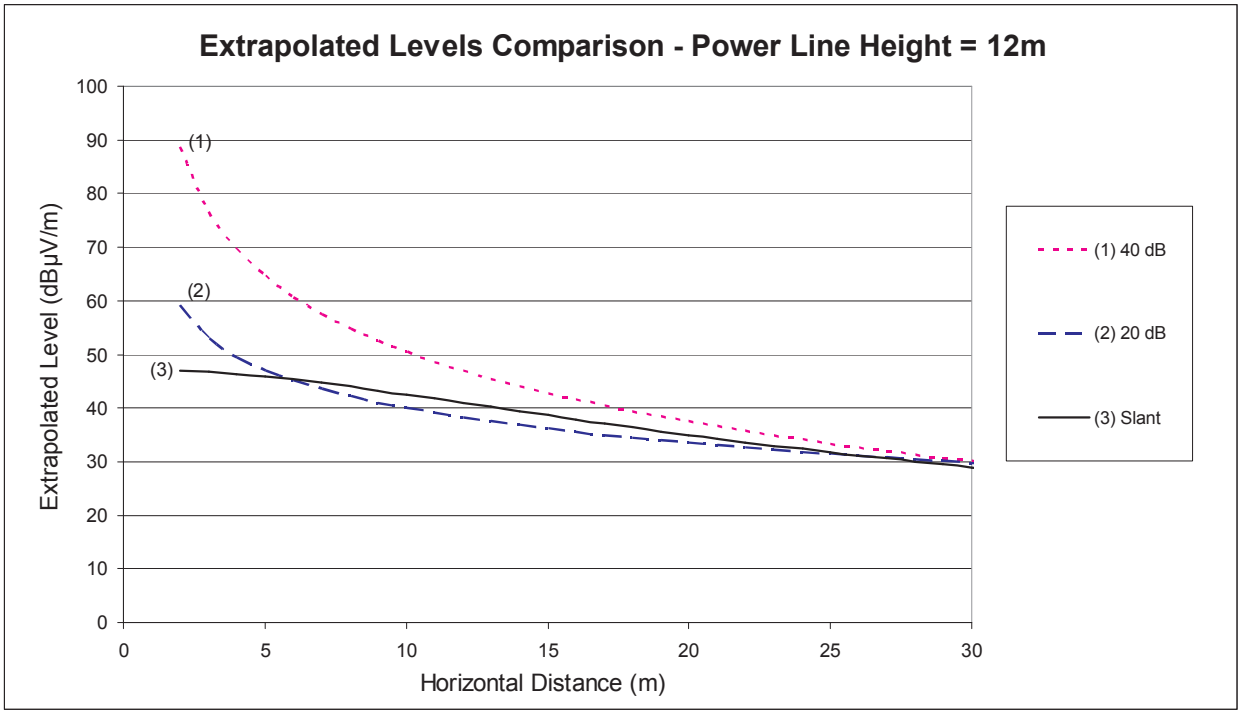
dB/decade extrapolation factor for horizontal (lateral) distance (trace 1), by as much as 14 dB.

- However, at measurement distances less than 5 meters, the extrapolated maximum allowable emission levels for slant-range distance based on the existing 40 dB/decade factor (trace 3) are MORE stringent than extrapolated emission levels for horizontal (lateral) distance based on either 20 dB/decade (trace 2) or 40 dB/decade extrapolation factor (trace 1).

C. Extrapolated levels using 40 dB/decade in conjunction with slant-range distance from a power line height of 12 meters

Figure 3 illustrates a comparison between the extrapolated maximum allowable emission levels with respect to horizontal (lateral) distance when using extrapolation factors of 40 dB (trace 1), 20 dB (trace 2) and when using the Commission's slant-range distance method calculated with 40 dB per decade extrapolation factor (trace 3). Calculations are made according to Equations 1 and 2 below, using a power line height of 12 meters. This results in a measurement height of 11 meters, because the measurement loop antenna is at 1 meter from the ground.

Figure 3 – Extrapolated Levels Comparison with 40 dB/decade Extrapolation Factor Applied to Slant-Range Distance – Power Line Height at 12 meters



As illustrated in Figure 3 for power line heights of 12 meters, the Commission's measurement method using a 40 dB/decade extrapolation factor applied to slant-range distance provides an extrapolated emission level graph that reveals the following.

- At measurement distances greater than 5 meters, the extrapolated maximum allowable emission levels for slant-range distance based on the existing 40 dB/decade factor (trace 3) are LESS stringent than extrapolated emission levels based on 20 dB/decade extrapolation factor for horizontal (lateral) distance (trace 2), by a **maximum of 2.7 dB**. This maximum difference between the two traces (trace 2 and trace 3) is found at a horizontal distance of 10 meters from the nearest point of the overhead power line carrying the BPL signals.
- At these same measurement distances (greater than 5 meters), the extrapolated maximum allowable emission levels for slant-range distance based on the existing 40 dB/decade factor (trace 3) are MORE stringent than extrapolated emission levels based on 40 dB/decade extrapolation factor for horizontal (lateral) distance (trace 1), by as much as 15.3 dB.
- However, at measurement distances less than 5 meters, the extrapolated maximum allowable emission levels for slant-range distance based on the existing 40 dB/decade factor (trace 3) are MORE stringent than extrapolated emission levels for horizontal (lateral) distance based on either 20 dB/decade (trace 2) or 40 dB/decade extrapolation factor (trace 1).

III. SLANT-RANGE DISTANCE CALCULATION FORMULA

The slant-range distance is calculated using the following formula:[1]

$$d_{slant} = \sqrt{\left(h_{pwr\_line} - h_{ant}\right)^2 + \left(d_h\right)^2} \qquad \textbf{(Equation 1)}$$

Where:
d_{slant} is the slant-range distance, in meters;
d_h is the horizontal (lateral) distance between the center of the measurement antenna and the vertical projection of the overhead power line carrying the BPL signals down to the height of the measurement antenna, in meters;
h_{pwr_line} is the height of the power line, in meters; and
h_{ant} is the measurement antenna height, in meters.

IV. EXTRAPOLATED EMISSION LEVEL CALCULATION FORMULA

The extrapolated emission level (in dBμV/m) is calculated using the following formula:[2]

[1] *See NTIA Phase 2 Study*, *supra* at Section 2.5.1.

[2] *Id.*

$$E_{extrap} = E_{meas} - N \cdot Log_{10}\left(\frac{d_{limit}}{d_{slant}}\right)$$ **(Equation 2)**

Where:
N is the distance extrapolation factor, *e.g.,* 40 for frequencies below 30 MHz;
d_{limit} is the horizontal measurement distance corresponding to the Part 15 emissions limits, *e.g,.* 30 meters for frequencies below 30 MHz;
d_{slant} is the slant–range distance, in meters;
E_{meas} is the measured electric field strength at a horizontal distance, d_h, in dBµV/m; and
E_{extrap} is the electric field strength value after applying the distance extrapolation factor, in dBµV/m

If the extrapolated electric field strength value exceeds the Part 15 emission limit (*i.e.* 29.54 dBµV/m for Access BPL operating below 30 MHz as specified for a horizontal measurement distance of 30 meters), the Access BPL device must lower its emission level to comply with the limit.

APPENDIX F

List of Additional Materials Included in the Record

Index of BPL Files

Summary of Presentations Including HomePlug Emissions and Noise Near Power Lines

File Name	Title and Date	Description
Index of BPL Files.doc	"Index of BPL Files", 4/16/2009	Index of BPL files
Field Strength Measurements Relative to ARRL Concerns Regarding BPL-wEmbeddedDate.ppt	"Field Strength Measurements Relative to ARRL Concerns Regarding BPL", 10/16/2003	Presentation including measurements of ambient spectrum levels near residential power lines and of access BPL emissions
BPL--FccLab to OET 12-03-2003a-wEmbeddedDate.ppt	"Broadband Over Power Line (BPL) Test Results and Considerations", 12/3/2003	Presentation including measurements of ambient spectrum levels near power lines, measurements of access BPL emissions, and tests of in-house BPL interference to reception on portable shortwave radio and on fixed amateur HF antenna (spectrum levels and embedded audio)**
BPL & Ambient Noise7.xls	*Spreadsheet*	Supporting Data: Raw data and plots of ambient noise measurements near power lines and of access BPL emissions—used in "Field Strength Measurements Relative to ARRL Concerns Regarding BPL" and "Broadband Over Power Line (BPL) Test Results and Considerations"
HomePlug Test In Gary Hendrickson neighborhood.xls	*Spreadsheet*	Supporting Data: Raw data and plots of ambient and HomePlug-generated spectrum levels measured on an HF amateur antenna—used in "Broadband Over Power Line (BPL) Test Results and Considerations"

** Should be played in Power Point slide show mode due to embedded audio. See file at http://www.fcc.gov/oet/info/bpl/.

Raleigh Test Results (Amperion)

File Name	Title and Date	Description
BPL Test in Raleigh_V-AM-S1.mp4 *BPL Test in Raleigh_V-SSB-S1.mp4* *BPL Test in Raleigh_V-AM-S2.mp4* *BPL Test in Raleigh_V-SSB-S2.mp4*	"BPL Interference Test Near Raleigh, NC—July 1, 2004"	MPEG4 video files documenting BPL sounds observed at two fixed sites (S1 and S2) as a radio receiver operating in either AM or SSB mode was tuned across spectrum used by BPL system
BPL Test in Raleigh_V-AM-D2.mp4	No title	MPEG4 video file documenting reception of a shortwave radio broadcast while driving toward overhead power lines carrying BPL signals

Briarcliff Manor Test Results (Ambient)

File Name	Title and Date	Description
Briarcliff Test Report-2004final-wEmbeddedDate.ppt	"BPL Emission Tests In Briarcliff Manor, NY, August 17 - 19, 2004"	Presentation documenting Briarcliff Manor tests of an access BPL system
Briarcliff Manor BPL Video Files-L01a.doc	"Briarcliff Manor BPL Video Files"	Description of video files of driving tests from Briarcliff Manor
BriarcliffVid1_320x240x15-300kbps-32kbps.mp4 *BriarcliffVid2_320x240x15-300kbps-32kbps.mp4* *BriarcliffVid3_320x240x15-300kbps-32kbps.mp4* *BriarcliffVid4_320x240x15-300kbps-32kbps.mp4* *BriarcliffVid5_320x240x15-300kbps-32kbps.mp4* *BriarcliffVid6_320x240x15-300kbps-32kbps.mp,* *BriarcliffVid5_640x480x30-3800kbps-32kbps.mp4* *BriarcliffVid6_640x480x30-3800kbps-32kbps.mp4*	"BPL Interference Test—Briarcliff Manor, NY—August 17-19, 2004"	MPEG4 video files documenting interference to reception of simulated radio transmissions during driving tests. Files with names containing "_320x240x15-300kbps-32kbps" are medium-resolution videos. Files with names containing "_640x480x30-3800kbps-32kbps" are high-resolution files (videos 5 and 6 only)
BriarcliffLevelVsGPSCoord16.xls	*Spreadsheet*	Supporting data: GPS coordinates and received levels during driving tests in Briarcliff Manor