# 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

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[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.

* * * * *

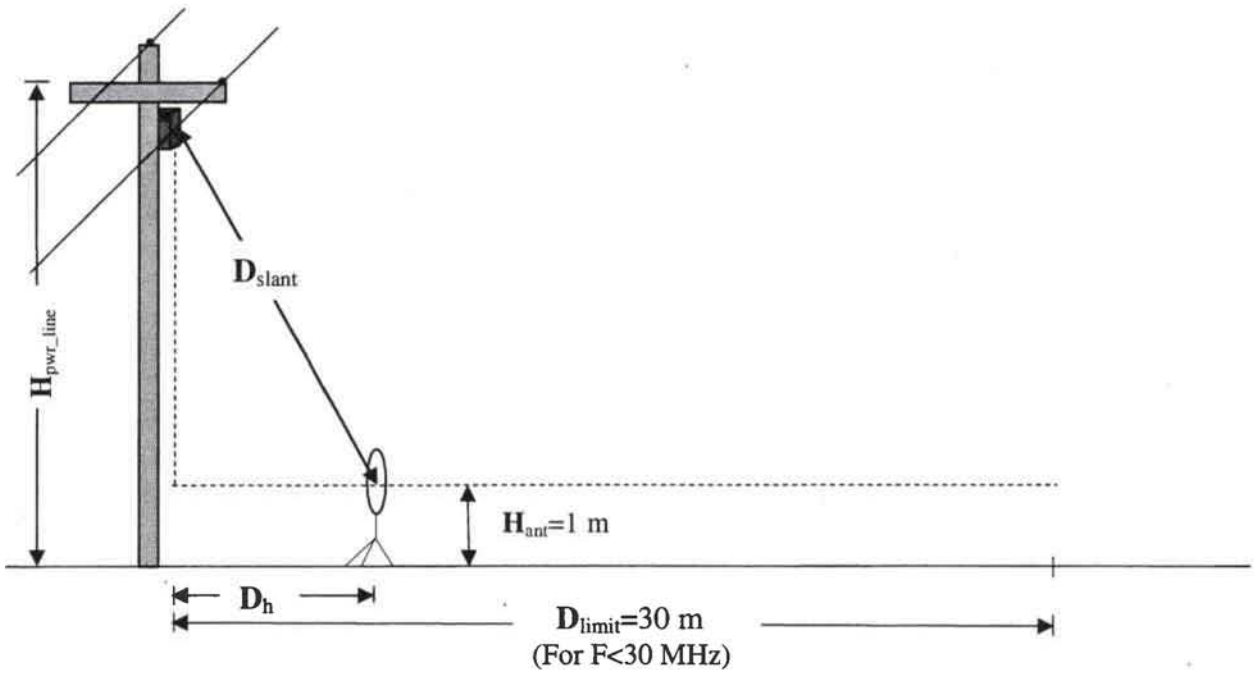
(hh) Slant-Range Distance. Diagonal distance measured from the center of the measurement antenna to the nearest point of the overhead power line carrying the Access BPL signal being measured. This distance is equal to the hypotenuse of the right triangle as calculated in the formula below. The slant-range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

$$d_{slant} = \sqrt{(h_{pwr_line} - h_{ant})^2 + (d_h)^2}$$

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.

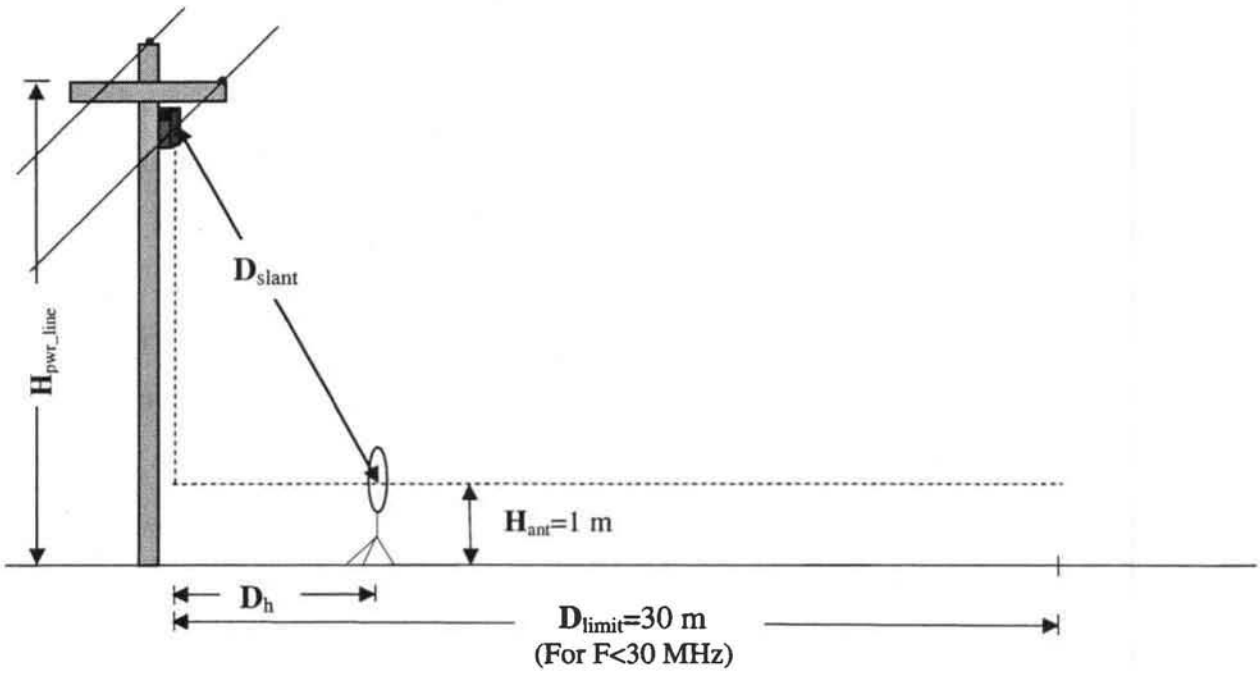
## 5. Responsibility of BPL operator

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:

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

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

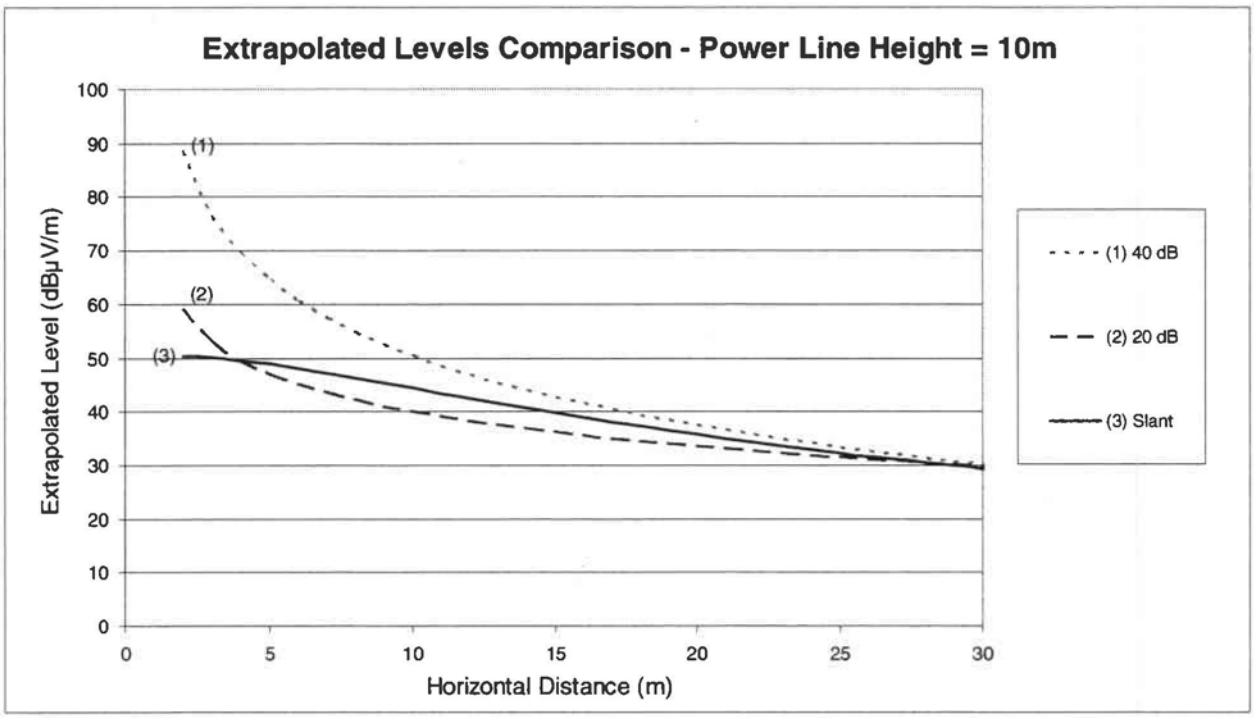
Typical medium-voltage power line heights in the United States are 10-12 meters. Figures 1-3 below illustrate a comparison between the extrapolated emission levels with respect to horizontal (lateral) distance when using extrapolation factors of 40 dB (trace 1), 20 dB (trace 2) and when using the Commission's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



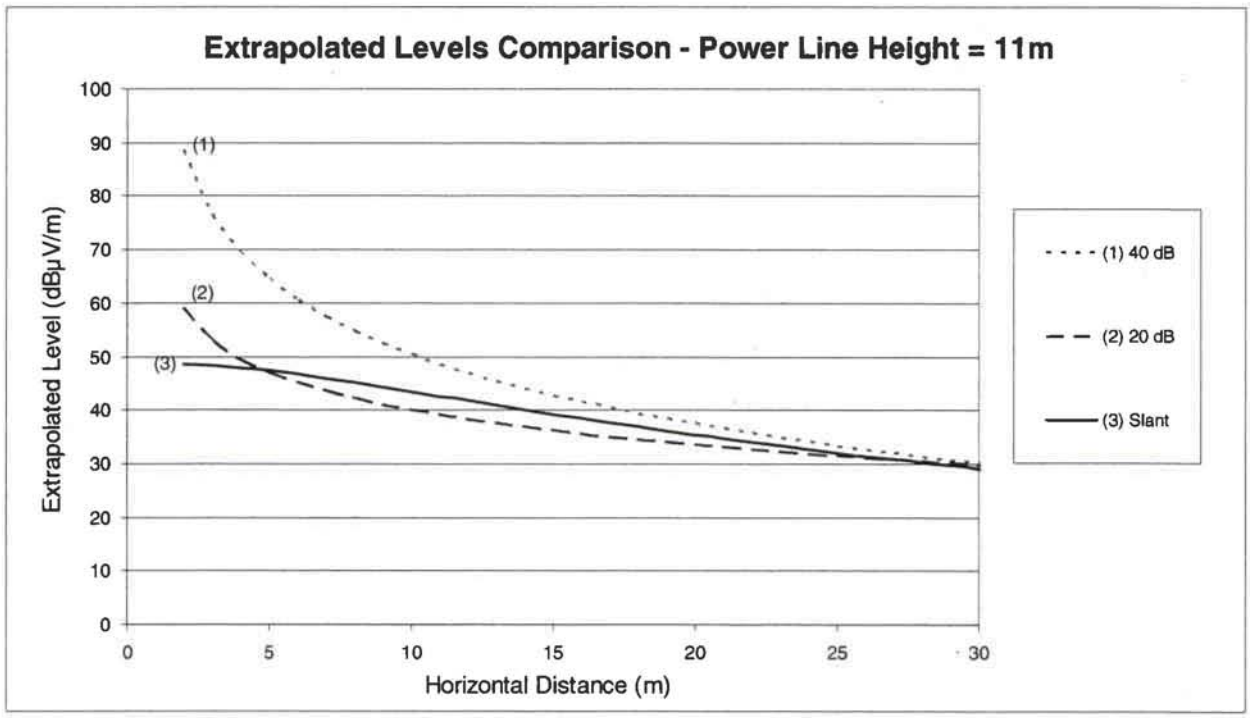

As illustrated in Figure 1 for power line heights of 10 meters, the Commission's slant-range method using a 40 dB/decade extrapolation factor applied to slant-range distance provides an extrapolated emission level graph that reveals the following.

- 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

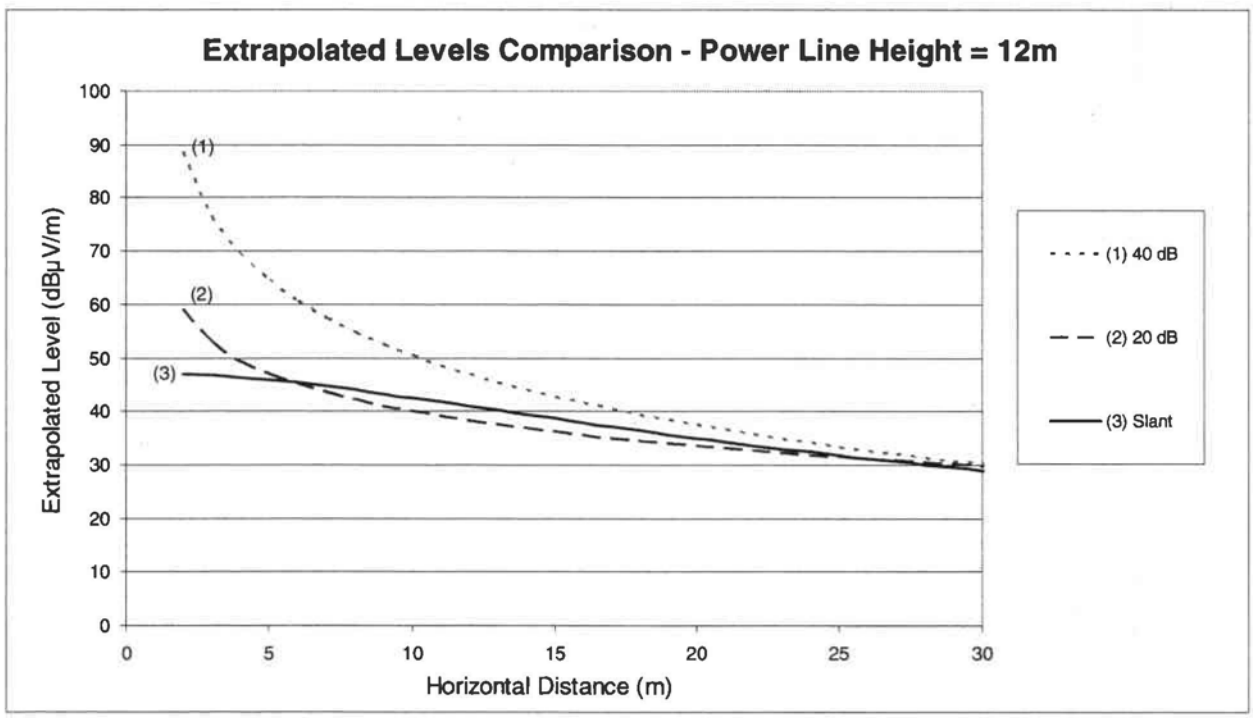
dB/decade extrapolation factor for horizontal (lateral) distance (trace 1), by as much as 14 dB.

- 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]

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

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*<br>*BPL Test in Raleigh_V-SSB-S1.mp4*<br>*BPL Test in Raleigh_V-AM-S2.mp4*<br>*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*<br>*BriarcliffVid2_320x240x15-300kbps-32kbps.mp4*<br>*BriarcliffVid3_320x240x15-300kbps-32kbps.mp4*<br>*BriarcliffVid4_320x240x15-300kbps-32kbps.mp4*<br>*BriarcliffVid5_320x240x15-300kbps-32kbps.mp4*<br>*BriarcliffVid6_320x240x15-300kbps-32kbps.mp,*<br>*BriarcliffVid5_640x480x30-3800kbps-32kbps.mp4*<br>*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.<br><br>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 |