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**

To: The Commission

EX PARTE SUBMISSION OF ARRL, THE NATIONAL ASSOCIATION FOR AMATEUR RADIO

ARRL, the national association for Amateur Radio, formally known as the American Radio Relay League, Incorporated (ARRL), by counsel and pursuant to Section 1.1200 of the Commission's Rules (47 C.F.R. § 1200) hereby respectfully submits *ex parte* the following discussion and the attached technical study (***Exhibit A***), with respect to the Commission's reconsideration[1] of the rules governing unlicensed radio frequency (RF) devices to accommodate Broadband over Power Line (BPL) technology. In the interest of the Amateur Radio Service in avoiding harmful interference from BPL systems, and in establishing rules that are appropriate for unlicensed BPL systems and which minimize the interference potential thereof, ARRL states as follows:

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[1] See, the *Request for Further Comment and Further Notice of Proposed Rule Making*, FCC 09-60, 24 FCC Rcd. 9669, 74 Fed. Reg. 42631, released July 17, 2009 (the *Further Notice*).

I. Introduction

1. Since the issuance by the Commission of the *Further Notice* in this proceeding, ARRL has filed comments and reply comments and has made oral and written *ex parte* filings, urging the adoption of Part 15 Rules which reflect both the capabilities and practices of the bulk of the BPL industry, and which are sufficient to protect licensed radio services in the high frequency (HF) and very high frequency (VHF) bands. The Commission's July, 2009 *Further Notice*, beginning at paragraph 25, attempts to justify the Commission's 2004 decision[2] to adopt, and its 2006 decision[3] to affirm, the use of a 40 dB/decade distance extrapolation factor for determining the decay of BPL radiated emissions with distance from the power line. This was one of the specific items to be addressed on remand pursuant to the remand order of the United States Court of Appeals for the District of Columbia Circuit.[4] At Paragraph 2 of the *Further Notice*, the Commission stated:

> In response to [the United States Court of Appeals'] remand of a portion of the BPL measurement procedure, we are also providing an explanation of our reasons for selecting 40 dB per decade as the extrapolation factor for frequencies below 30 MHz. We further explain why we believe the studies and technical proposal submitted earlier by the ARRL do not provide convincing information that we should use an extrapolation factor that is different from that which we adopted. We also note the existence of more recent studies that verify the correctness of our determination, although we do not rely on those studies as *post facto* rationale or justification for our decision.

[2] See, the *Report and Order*, FCC 04-245 ("*Access BPL Order*"), *Amendment of Part 15 Regarding New Requirements and Measurement Guidelines for Access Broadband of Power Line Systems*, 19 FCC Rcd. 21,265 (October 28, 2004).

[3] See, the *Memorandum Opinion and Order*, FCC 06-113, 21 FCC Rcd. 9308, released August 7, 2006 ("*Reconsideration Order*")

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

The *Further Notice*, with respect to the Commission's attempted justification of the 40 dB/decade distance extrapolation factor, references the National Telecommunications and Information Administration's (NTIA) 2007 study entitled *Potential Interference From Broadband Over Power Line (BPL) Systems to Federal Government Radiocommunications at 1.7 – 80 MHz, Phase 2 Study, Volume I,* NTIA Report 08-450, October 2007 ("*NTIA Phase 2 Study"*). At paragraph 26 of the *Further Notice,* the Commission stated:

> Although we do not rely on NTIA's more recent Phase 2 simulation results to justify our earlier decision, we note here that those results indicate that the attenuation at individual locations can be expected to vary around the standard (sic) 40 dB value with frequency, configurations of line arrangements on poles, and other site-specific characteristics. We are therefore aware that measurements of the emissions from BPL systems at different distances will vary, but cluster around the 40 dB per decade factor. As the NTIA simulation results show, this variation is to be expected when measuring emissions below 30 MHz from points near the ground at distances close to a source of emissions.

2. The document attached hereto as ***Exhibit A*** is an analysis of the NTIA Phase 2 Study. ***Exhibit A*** was prepared by ARRL Laboratory Manager and expert on BPL, Mr. Ed Hare. Mr. Hare's Exhibit analyzes and explains the deficiencies and errors in the methodology used for the models and in the assumptions that underlie the conclusions in the NTIA Phase 2 Study, which vitiate any findings with respect to the validity of the 40 dB/decade of distance extrapolation factor for BPL measurements.

3. ARRL has previously, both prior and subsequent to the Court of Appeals' remand of this proceeding to the Commission, submitted extensive and definitive studies and analyses[5] clearly establishing that the correct extrapolation factor is close to 20

[5] See, e.g. Hare, Ed, *Modeling as an Alternative to Measurements in Determining the Extrapolation of Measurements Below 30 MHz,* Exhibit C to ARRL's Comments in this proceeding filed September 23, 2009; Hare, Ed, *Industry Standards Addressing Distance Extrapolation,* Exhibit D to ARRL's Comments

dB/decade in the region beyond wavelength/2Pi of distance from radiating BPL systems. The Commission had in its possession in 2004 and in 2006 at the times that it adopted and affirmed the 40 dB/decade standard, firm evidence that 40 dB/decade is not the correct extrapolation factor.[6] It is not, however, necessary to restate that material already in the record in this proceeding at this late date. Nor is it necessary to reargue that the correct extrapolation factor is 20 dB/decade of distance beyond wavelength/2Pi. Rather, since the Commission's *Further Notice* appears to rely heavily on the NTIA Phase 2 Study,[7] the methodological flaws in that Study and their effect on the conclusions drawn by NTIA bear review.

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in this proceeding filed September 23, 2009; and Hare, Ed, *Rationale for the Abandonment of the Use of a Single 40 dB/decade Extrapolation Factor for Radiated Emissions Measurements Made Below 30 MHz,* Exhibit A to ARRL's written *ex parte* submission in this proceeding filed January 11, 2010.

[6] The Commission had, among other things, the September, 2004 Briarcliff Manor report prepared by its own Laboratory staff, which concluded that the Commission should, if it intended to permit BPL on overhead MV power lines, adopt a height correction factor (accounting for the use of misleading slant range measurements) and a *"20 log R extrapolation factor*." Thus, the FCC Laboratory recommended that the Commission *use a 20 dB per decade extrapolation factor for signal decay with distance from the power line.* According to the FCC Laboratory, such "reduces interference [from BPL] to fixed stations." There is no reference to this FCC Laboratory recommendation anywhere in the *Further Notice*, or heretofore by the Commission whatsoever. Instead, the Commission attempted in the *Further Notice* to justify its decision for retaining the 40 dB/decade factor by citing studies that were *not in existence* at the time of the 2006 Order on Reconsideration.

[7] The Further Notice, at paragraph 34, stated in part that :

> The recently released study from the Federal Republic of Brazil reports results that show attenuation of emissions from BPL that is greater than the 40 dB per decade extrapolation factor, which indicates variation on the other side of the results found in the OFCOM studies. Here again, the amount of data collected is relatively small.[7] We believe that the information in the NTIA Phase 2 and Brazil studies, when viewed in light of the NTIA's Technical Appendix and the OFCOM studies taken together not only provide validation for our previous conclusions selecting 40 dB per decade as the extrapolation factor, recognizing that there will be variation around that value at individual locations, but also inform our further consideration of this matter.

The Brazil study referred to is: 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*). This study's flaws were well-documented by Hare, Ed, *Inadequacies in the Reporting of Test Results from the BPL System Measurements Made in Brazil*, filed in the record in this proceeding as Exhibit B to ARRL's September, 2009 Comments filed in response to the *Further Notice*.

II. Discrepancies and Errors in the NTIA Phase 2 Study

4. There are deficiencies in the antenna models of power lines used in the NTIA Phase 2 Study, in that they do not match the actual deployed BPL facilities. For example, the wires used in the models are of finite length, and the models have no loads to limit reflections that occur from the ends in the model. There are such loads in actual BPL deployments. The models also do not include loads representing transformers. BPL signals in deployed facilities couple through transformers to secondary 240-volt conductors, distribution line branches or other discontinuities. Many of the NTIA models do not include vertical ground wires which are present in essentially all transformers in deployed systems. Finally, the number of segments of the conductors in the NTIA models did not meet NEC guidelines on all frequencies tested. In the attached ***Exhibit A***, Mr. Hare has adjusted the number of segments in the models in order to meet the NEC guidelines for all frequencies tested.

5. Among the errors in the modeling, NTIA's models predicted electrical field strength, not magnetic field strength. The latter is measured by the use of a loop antenna, as required by the BPL test procedure called for by the Commission and the C63.4 measurement standard. NTIA also misapplied a provision in CISPR 22 dealing with limits and methods of measurement. In addition to this fundamental error, NTIA *discarded data from results* in order to demonstrate compliance in reliance on CISPR 22:2003, Section 7.1.2. That CISPR provision does not allow the discarding of data. The testing is intended to find the peak emissions occurring at any frequency and any geographic point around the equipment being tested. Discarding data points in this context is contrary to this objective. Nor did NTIA attempt to relate the fields calculated

along the ground to radiated emissions at upward angles that are greater than at ground level.

6. NTIA's assumptions were selective, intended to permit findings that supported the Commission's BPL rules adopted in 2004. This made their modeling results inherently subjective. For example, the use of some models which did not include ground wires or loads to simulate the presence of transformers, etc. resulted in findings of emissions that did not reveal the variability in geometry and distance from the line which are present in actual BPL deployments. As another example, NTIA's methodology reasonably ascertains maximum emission levels at 10 meters from overhead lines, but it does not correlate those maximum levels with the actual maximum level of emissions at 30 meters, because it discards the upper 20 percent of such measurements. It is an error to compare maximum levels at one distance with levels that represent the lower 80 percent of the calculated values at another distance.

7. ***Exhibit A*** hereto bases its calculations on actual equipment tests. Since the goal of the modeling conducted by NTIA is to determine actual interference potential, this method is a more accurate indicator of that potential. This involves multiple measurements along the power line at various frequencies. Using a correct methodology and stripping off the incorrect assumptions made by NTIA in its Phase 2 study, it is concluded that the Commission's current rules for test methodology of BPL systems are flawed and inadequate to allow a determination that a BPL system will operate within the limits when deployed.

8. Ultimately, it is determined that there is not, and there cannot be a "site-specific" value of extrapolation. There is a wide variability in the way that fields decay

with distance in any RF environment with large emitters. Even along a single axis on a single frequency, choosing different points will lead to radically different extrapolation values which are therefore unusable. Even changes in frequency of only 100 kilohertz can make a large difference. It is quite clear, however that close-in to the model, field strength actually often *increases* with distance, so close-in point measurements are not useful for a measurement of extrapolation (or measurement of the device under test for compliance with the limits). At any horizontal distance closer to the line than 10 meters, the variation in results is too great to permit measurement of either field strength or extrapolation. Finally, measurement at horizontal distances from the line do not accurately reflect the field strengths at distances from the line measured at heights greater than horizontal to the power line.

III. Conclusions

9. The NTIA Phase 2 Study concludes that the 40 dB/decade of distance extrapolation factor is adequate. This finding is, however, based on a series of methodological errors, and subjective and/or inaccurate assumptions. The Commission's *post hoc* reliance on this NTIA Phase 2 Study in order to justify the Commission's previous adoption of a 40 dB/decade extrapolation factor for BPL *in situ* test measurements is misplaced. It leads to erroneous conclusions and to the vastly overpowered BPL facilities which have been noted time after time in actual measurements of deployments. ARRL continues to urge that the BPL rules be modified by a combination of (1) a correct extrapolation factor based on 20 dB/decade in the region beyond wavelength/2pi from radiating BPL systems; and (2) a mandated, full-time notch depth of 35 dB within all HF Amateur Radio allocations.

Therefore, for all of the above reasons, ARRL, the national association for Amateur Radio, respectfully again requests that the Commission, without further delay, amend the rules governing Access Broadband over Power Line systems in accordance with the foregoing.

Respectfully submitted,

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Exhibit A

Analysis of the National Telecommunications and Information Administration Report: Potential Interference from Broadband over Power Line (BPL) Systems to Federal Government Radiocommunications Systems at 1.7 - 80 MHz -- Phase 2 Study

June, 2011

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NTIA Antenna Models

In its Phase 2 report on BPL, the National Telecommunications and Information Administration (NTIA) created several antenna models of power lines, using different configurations. However, there are a number of deficiencies in the models created that do not match real-world BPL systems as deployed and tested for FCC certification. These differences potentially explain some of the differences between NTIA findings and the way that extrapolation is handled in the large number of industry standards referenced in the ARRL exhibit filed in this proceeding, "Rationale for the Abandonment of the Use of a Single 40 dB/decade Extrapolation Factor for Radiated Emissions Measurements Made Below 30 MHz."

These discrepancies include the following:

- The wires in the models are, by necessity, of finite length -- typically about 300 meters in length. Although this does in part simulate the way power lines radiate, especially for emissions near the source, many of the models include no loads to limit the reflections that occur from the ends in the model, but do not occur in real world installations.
- Many of the models do not include loads to represent transformers, coupling through the transformers to secondary 240-volt conductors, distribution-line branches or other discontinuities which are present in actual installations.
- Many of the models do not include vertical ground wires that are present at virtually every transformer and at other places in the system.
- Although it is possible that NTIA adjusted the number of segments for the conductors as it ran the models on different frequencies, the number of segments as seen in the models that NTIA published as part of the Phase 2 report did not meet the NEC guidelines on all frequencies tested. The results presented in this exhibit were obtained by an adjustment in the number of segments in the models to satisfy the NEC guidelines for all frequencies tested.

Errors in NTIA Methodology

NTIA also made several errors in the methodology used for the modeling. These include the following:

- The models predict electric field strength, not the magnetic field strength that is measured by the use of a loop antenna as required by the FCC's BPL test procedure and the C63.4 measurement standard.
- NTIA misapplied a provision in CISPR 22 which indicates that it is probable that if a device or system is tested to be in compliance with the standard, this will apply to 80% of the mass-produced units of that model[1]. This observation in

[1] *See e.g.*, Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement, CISPR 22:2003, ("CISPR 22"), Section 7.1.2 "The significance of the limits for equipment

CISPR 22 was never intended to allow testing or analysis of test methods which discard data from the results in order to demonstrate compliance. Testing is intended to find the maximum emissions occurring at any frequency and at any geographical point around the equipment being tested.

- NTIA did not try to relate the fields calculated along the ground to emissions at upward angles that are greater than at ground level. See Table 1 in the ARRL exhibit filed in the record in this proceeding by ARRL and entitled "Analysis of Distance Extrapolation of Field Strength Calculated from the Antenna Models Provided to the FCC In the BPL Notice of Rulemaking Comments and Reply Comments". This paper describes the modeled relationship between measurements made at 1 meter height and the extrapolation to 30 meters at ground level and at upward angles, representing the typical location of nearby HF receive antennas.

Selective Assumptions and Modeling Conditions

NTIA, for its Phase 2 Study, used modeling with assumptions that allowed it to make findings of fact that support the FCC's current BPL rules completely. Other conditions for the modeling could have been specified which would have allowed different findings and supported other desired outcomes just as easily. This can result in irreconcilable results and subjective support for the assumptions made about the correct models and conditions to use in order to determine how fields should be measured and extrapolated with distance.

To minimize this subjectivity, a common set of assumptions must be utilized. The end result of the BPL rules is to allow the certification and compliance testing of BPL systems. For this reason, there is no better assumption to use than to rely on the conditions used in the certification of actual systems, as documented in the test reports provided by BPL manufacturers to the FCC. ARRL has selected the certification testing of IBEC as representative of how certification testing is currently being done. In this exhibit, ARRL uses the distances along the line based on the FCC's BPL rules and the mid-point frequency of the emissions found in the IBEC testing.

Models without Ground Wires and Loads

A number of the models used by NTIA in its analysis did not include ground wires, or loads to simulate the presence of transformers and other losses. This resulted in emissions seen in the model which did not exhibit the same variability with geometry and distance found in actual BPL systems tested by FCC, ARRL and others.

Figure 1 below shows the emissions measured by the FCC of the BPL system formerly operated by the Ambient Corporation in Briarcliff Manor, NY. This shows the measured magnetic field along the line, at a height of approximately 1 meter, approximately 10 meters from the source. These data show a broad, slight peak near the source and emissions that decrease slowly with

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shall be that, on a statistical basis, at least 80% of the mass-produced equipment complies with the limits with at least 80% confidence."

distance along the line beyond that peak. This is typical of what has been observed and measured by ARRL staff at a number of BPL installations.

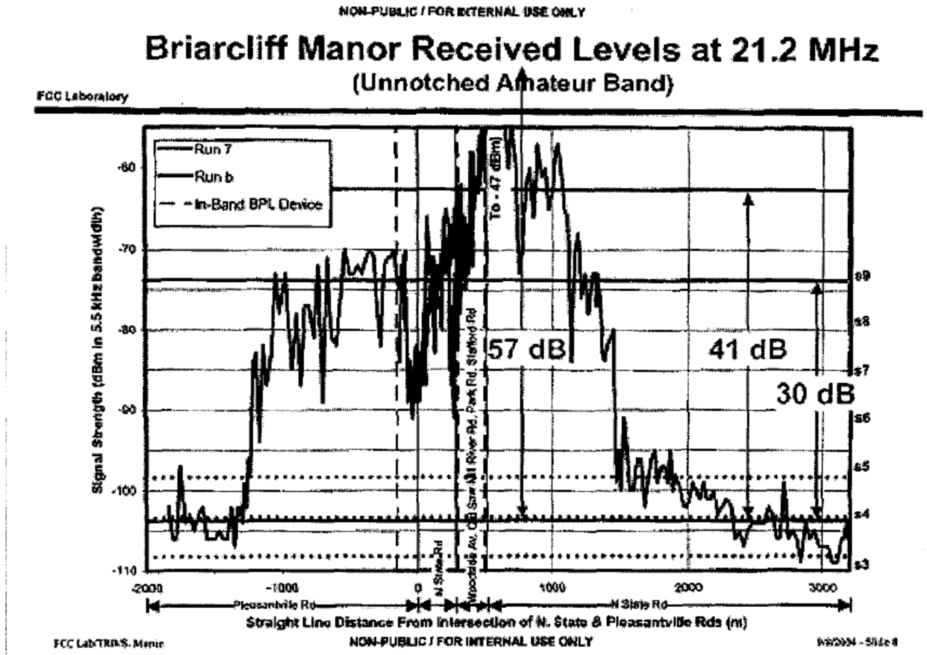

Figure 1 - This graph shows a measurement of the level of BPL radiated emissions from a power line carrying BPL on a frequency of 21.2 MHz. These measurements were made by FCC staff in 2004 of the BPL system formerly operated in Briarcliff Manor, NY.

Figure 2 below shows the calculated emissions from two representative power-line models from the NTIA Phase 2 Study. This variability is typical of the wide range of results seen when using the NTIA models:

File	Description
Tri26.nec	Two-wire model, center-fed, no grounds or transformers, 0.6 meter spacing
Tri210.nec	Two-wire model, center-fed, no grounds or transformers, 1.0 meter spacing

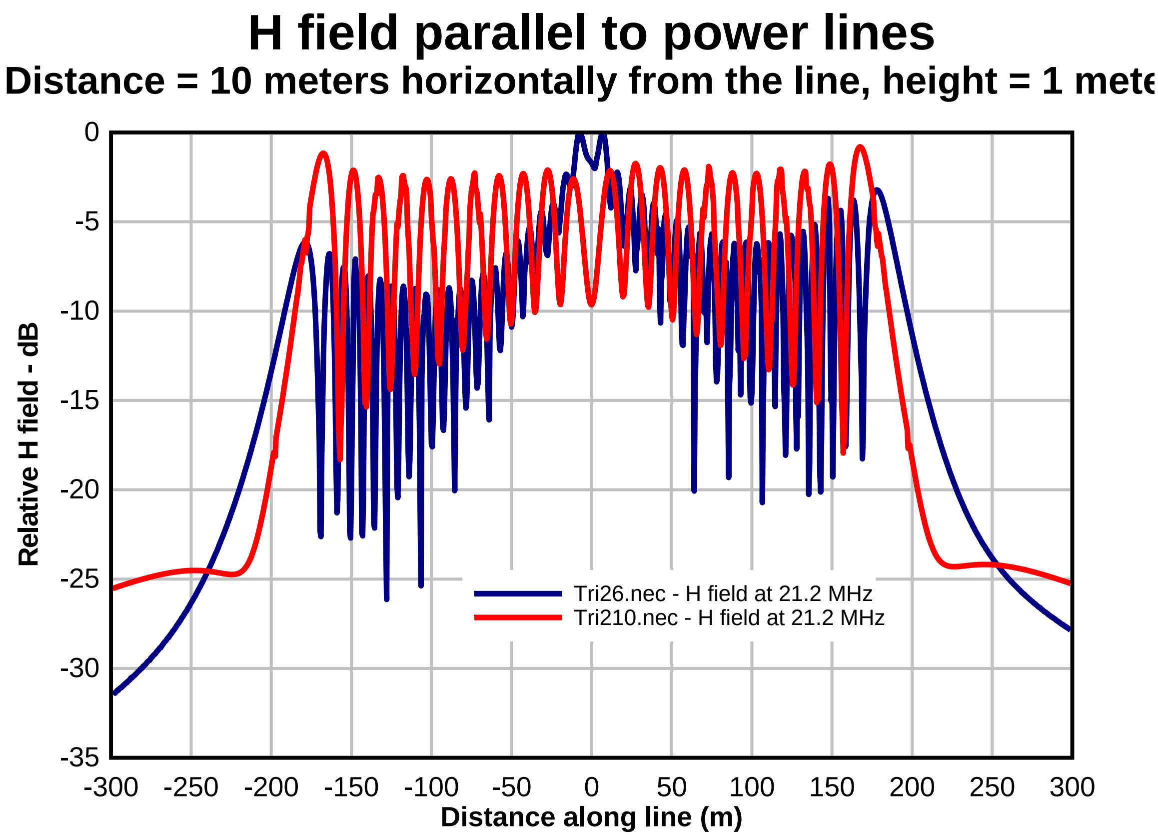

Figure 2 -- This shows how widely the modeled results vary, even on a single frequency. When compared to the "real" model as measured by FCC, it is clear that at least in some cases, the models yield results that do not resemble real-world BPL systems. Similar deviations from the expected results are seen in most of the NTIA models.

80% Versus Maximum Emissions - Flawed Test Methodology

The NTIA methodology does in many cases do a reasonable job of finding the maximum level of emissions at a distance of 10 meters from overhead lines. (This is presuming that *all* of the points along the line are actually measured – something not at all evident from recent certification test-result reports filed by manufacturers with the FCC.) The NTIA Study, however, does not compare that finding with the maximum level of emission at a distance of 30 meters. Instead, it compares the maximum found with the lower 80% of the measured or calculated points at a slant-range distance of 30 meters, discarding the actual maximum level at 30 meters when it discards the upper 20%. This is a *flawed methodology*. It is neither appropriate nor accurate to compare maximum levels with the levels that represent 80% of the calculated values, especially under circumstances under which near and far levels exhibit a standing wave with distance from the radiator. It is no more appropriate to do this than it would be to measure harmonics from a radio transmitter for certification testing, then discard the worst-case 20% of the data, claiming that on 80% of the frequencies measured, the device complies with the limits.

The wide variation in the models and the flawed methodology do not represent a consistent or accurate means of evaluating field strength near power lines. FCC rules for other devices would never allow certification on a basis that discarded the top 20% of the measurements. To the contrary, FCC rules and all industry test practices require that the *top* 6 measurements be reported. It would be unacceptable to report the lower 80% of measurements.

It is equally unacceptable to use anything except the actual maximum levels found in measurements or models that will be used to set the parameters on which certification of all future devices will be based.

Distances Along the Line

With all of the possible configurations of modeling and assumptions, each of which could yield different outcomes, a baseline needs to be established that can ensure consistent results. The purpose of the NTIA analysis is to determine whether the existing FCC rules are adequate to permit measurements that are made to reasonably correspond to actual emissions from BPL systems. Although ARRL has noted that having to make multiple measurements along an overhead power line is unnecessarily cumbersome, it is the basis on which measurements are made to certificate access BPL devices. The most useful analysis of the NTIA modeling and results would be to compare its findings with the methodology used to test real world systems.

The FCC-described test methodology for BPL requires that measurements be made at a distance of 10 meters horizontally from overhead lines, at a height of 1 meter, at distances of 0.25, 0.5, 0.75 and 1 wavelength along the line, at the mid-point frequency of the emission. Additional measurement points are required, at increments of 0.5 wavelengths, if the mid-point frequency exceeds the minimum frequency by a factor of two or more.

The most recent FCC certification testing was done by IBEC. This testing is ideal to use for analysis that determines if there are deficiencies in the test methodology prescribed by the FCC rules because recent ARRL (and other) measurements in IBEC access-BPL systems in Virginia and Pennsylvania showed that the systems were operating at levels significantly above the emissions limits, indicating that there are serious discrepancies in the test methodology that results in "legal" systems operating significantly above the rules when deployed[2].

The rules require that testing be done at the maximum-possible operating level, the test reports did not indicate that attenuation was applied and the certification test data showed that all measurements made showed compliance with the emissions limits. Yet these systems, when deployed, had emissions as high as 40 dB or more above the FCC limits. (A BPL device that is operating at 40 dB above the limits is making as much noise as 10,000 legal devices!)

One can reasonably conclude that the disparity between the IBEC certification data and the operating levels of their deployed systems demonstrate that the test methodology as presently defined is technically incorrect and inadequate to determine that BPL will operate within the limits when deployed.

In its certification test results, IBEC reports that its systems operate using frequencies from 2 to 34 MHz. The mid-point frequency is therefore 18 MHz. IBEC made a mid-point calculation assuming a 3 MHz lowest frequency, using distances along the line based on a mid-point

[2] Recent BPL-system testing done by ARRL in central Virginia and Pennsylvania, (the results of which were reported to the Commission's Enforcement Bureau and filed in the ET Docket 04-37 Docket proceeding) showed more than just a few spot locations with emissions (and other) violations. Across major parts of the systems tested, it was obvious that the certification testing done on these devices is completely inadequate to ensure compliant installed systems.

frequency of 18.5 MHz, although for its tests of Mode 7, it used a mid-point frequency of 18 MHz. These were based on the actual frequencies of operation below 30 MHz. The majority of the testing was done using an 18.5 MHz mid-point frequency, so this analysis will investigate distances along the line based on a mid-point frequency of 18.5 MHz. This corresponds to distances along the line of 0, 4.1, 8.1, 12.2, 16.2, 24.3, 31.3, 40.5, 48.6, 56.8, 64.9 and 72.9 meters. Of note, IBEC did not report any of the measurements made at distances greater than 16.7 meters along the line. It is possible that none of these distant points contained any of the 6 highest levels required for reporting.

Frequencies

The way that the models and real-world systems behave is very much dependent on frequency. It is not practical to model every 1 MHz step from 3 to 30 MHz, with all of the combinations of models, frequencies and distances that could be analyzed from the NTIA data. For this reason, ARRL has selected three frequencies in the Amateur bands, not harmonically related, to show a reasonable representation of what to expect from models and real-world deployments. The Frequencies chosen are 3.9 MHz, 10.1 MHz and 24.9 MHz.

Modeling of the NTIA models shows that a small change in frequency can make a major difference in the way that field strength decays with distance from the line. One might expect that a change of a mere 100 kHz would make little difference to the behavior of the large models used by NTIA, but as seen in Figure 3 below, the change of a mere 100 kHz in frequency can change the extrapolation and decay rate significantly, especially at close-in distances that it is common for manufacturers to use for certification testing.

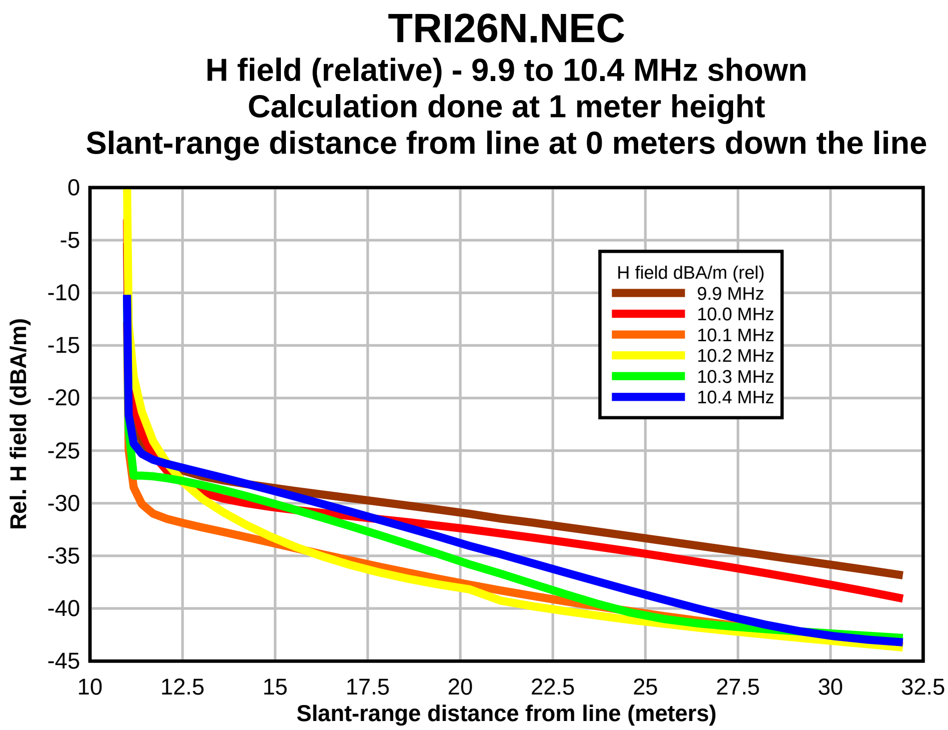

Figure 3 – These data are the NEC-4 calculated H field strengths at a height of 1 meter, at the feed-point source (0 meters) of one of the NTIA models. As can be seen, a change of a mere 100 kHz in frequency can change the extrapolation value significantly.

Number of Models and Frequencies

NTIA provided a total of 14 models, representing a wide range of configurations. Some of these are not typically seen in real-world installations. To simplify the analysis of these models, ARRL selected the following models as representative of the range of possible configurations and modeled results. The data from these models shows sufficient range of variability that the points about this variability are adequately made. The models selected are:

- Tri26 - Two-wire line, horizontal configuration, 0.6 meters separation, no loads or grounds
- Tri310n – Three wire line, horizontal configuration, 1.0 meters separation, with loads to represent transformers and ground wires
- Ver36n - Three wire line, vertical configuration, 0.6 meters separation, with loads to represent transformers and ground wires

ARRL selected the following frequencies for its analysis. These were chosen to be non-harmonically related frequencies across most of the 2-30 MHz range.

- 3.9 MHz
- 10.1 MHz
- 24.9 MHz

Maximum levels at 10 meters distance

Table 1 below shows the maximum levels found at 10 meters horizontal distance and 27.9 meters horizontal distance (30 meters slant range) at a height of 1 meter. These data are shown for various distances along the overhead power line that would be required to be measured, based in the mid-point frequency of the model. These levels are being compared to the actual modeled maximum at 10 meters horizontal separation, as determined by modeling all points along the line at 0.1 meter increments.

The red entries represent the “worst case” that is the desired maximum intended to be found during certification testing. Note that if that maximum point is not found, significant under-estimation of field strength will occur. It is also noted that the magnetic field strength as measured along the ground is a significant underestimate of the field strength at similar distances upward from the power lines (but not over them). Most HF receive antennas will be located at heights above that of the power line.

Table entries in **bold red** indicate the point of maximum emission found at the measurement points along the line.

Model	Frequency	Distance along the line at 10 meters horizontal separation and 1 meter height	Error relative to maximum at 10 meters horizontal separation and 1 meter height
tri26	3.9 MHz	0m	-1.0 dB
		4.1m	-1.5 dB
		8.1m	-3.2 dB
		12.2m	-10.4 dB
		16.2m	-6.3 dB
		40.5m	**-0.3 dB**
	10.1 MHz	0m	-14.2 dB
		4.1m	-12.4 dB
		8.1m	-4.1 dB
		12.2m	**-0.5 dB**
		16.2m	-1.6 dB
	24.9 MHz	0m	-2.8 dB
		4.1m	**-1.0 dB**
		8.1m	-1.3 dB
		12.2m	-3.1 dB
		16.2m	-4.6 dB
Tri310n	3.9 MHz	**0m**	**-2.2 dB**
		4.1m	-3.6 dB
		8.1m	-6.0 dB
		12.2m	-10.2 dB
		16.2m	-15.9 dB
	10.1 MHz	0m	-5.3 dB
		4.1m	-8.6 dB
		8.1m	-14.2 dB
		12.2m	-5.8 dB
		16.2m	-6.1 dB
		31.3m	**-4.5 dB**
		56.8m	**-4.5 dB**
	24.9 MHz	0m	-2.3 dB
		4.1m	-2.0 dB
		8.1m	**-0.6 dB**
		12.2m	-2.5 dB
		16.2m	-3.5 dB

Ver36n	3.9 MHz	0m	-2.1 dB
		4.1m	-4.4 dB
		8.1m	-6.9 dB
		12.2m	-11.4 dB
		16.2m	-15.1 dB
		31.3m	**-2.0 dB**
	10.1 MHz	0m	-5.5 dB
		4.1m	-8.4 dB
		8.1m	-12.6 dB
		12.2m	-7.1 dB
		16.2m	-7.0 dB
		73.9m	**-4.8 dB**
	24.9 MHz	0m	-3.4 dB
		4.1m	-2.0 dB
		8.1m	**-1.6 dB**
		12.2m	-3.1 dB
		16.2m	-5.4 dB

Table1 – This shows the deviation from the maximum field strength seen along the line at a distance of 10 meters horizontally when only the points along the line at distances related to the mid-point frequency are considered. The chart shows the relative levels at 0.0, 0.25, 0.5, 0.75 and 1 wavelength along the line and, if the peak was at a greater distance along the line than one wavelength, it shows the value at that peak.

The data in Table 1 do show that, for the most part, if all of the points along the line are measured for all frequencies and the maximum peak is found along the line (a big if, looking closely at the FCC certification test reports on file), the distances along the line specified by the FCC are reasonably sufficient to find the maximum peak. The emissions from BPL systems are broadband and if one frequency range is underestimated, it is highly probable that measurements on other frequencies will pick up the maximum emission. However, as the following data and discussion demonstrates, this is not sufficient to allow an accurate measurement of extrapolation by measuring only four points along a single axis perpendicular from an overhead power line.

Extrapolation – Pick and Choose

ARRL used the NTIA models and measured the values of magnetic field strength laterally away from the selected overhead power-line models. For each point, ARRL then determined the slant-range distance to the overhead lines and, using the methodology incompletely described in the *Further Notice of Proposed Rulemaking*, it determined the calculated extrapolation from 4 points selected along that axis. ARRL used this method to determine the value of calculated extrapolation for 3.9 MHz, 10.1 MHz and 24.9 MHz, perpendicular away from the line.

The points analyzed are the following horizontal distances perpendicular from the overhead line:

- 2, 4, 6 and 8 meters
- 6, 8, 10 and 12 meters
- 10, 12, 14 and 16 meters

The results of those calculations of extrapolation are shown in Table 2 below. The values shown in bold red represent extrapolation determined from the points along the overhead line that were the maximum levels at a horizontal distance of 10 meters. Values for other distances along the line are also shown to demonstrate the much wider range that will occur if an attempt is made to determine the "real" extrapolation at other points along the overhead line.

Note: In table below, values in red are the data from the distance along the line that had the greatest emission at 10 meters distance at the indicated test distance along the line. This is the point that would have been reported in the test report used to obtain certification of a BPL device.

Model	**Frequency**	**Distance along line at 1 meter**	**dB/decade 2/4/6/8m**	**dB/decade 6/8/10/12m**	**dB/decade 10/12/14/16m**
tri26	**3.9 MHz**	**0m**	**-34.2 dB / decade**	**-35.6 dB / decade**	**-38.0 dB / decade**
		4.1m	**-34.2 dB / decade**	**-35.5 dB / decade**	**-37.9 dB / decade**
		8.1m	**-34.2 dB / decade**	**-35.1 dB / decade**	**-37.3 dB / decade**
		12.2m	**-33.7 dB / decade**	**-34.2 dB / decade**	**-34.8 dB / decade**
		16.2m	**-27.6 dB / decade**	**-26.72 dB / decade**	**-29.2 dB / decade**
		40.5m	**-31.2 dB / decade**	**-32.5 dB / decade**	**-34.1 dB / decade**
	10.1 MHz	**0m**	**-101.6 dB[3] / decade**	**-139.14 dB / decade**	**-40.7 dB / decade**
		4.1m	**-77.9 dB / decade**	**-55.9 dB / decade**	**-7.64 dB / decade**
		8.1m	**-28.5 dB / decade**	**-32.6 dB / decade**	**-34.6 dB / decade**
		12.2m	**-38.8 dB / decade**	**-42.1 dB / decade**	**-47.1 dB / decade**
		16.2m	**-45.4 dB / decade**	**-46.7 dB / decade**	**-51.34 dB / decade**
	24.9 MHz	**0m**	**-52.5 dB / decade**	**-52.3 dB / decade**	**-27.6 dB / decade**
		4.1m	**-4.7 dB / decade**	**-19.7 dB / decade**	**-33.6 dB / decade**
		8.1m	**-24.3 dB / decade**	**-31.8 dB / decade**	**-36.4 dB / decade**
		12.2m	**-38.8 dB / decade**	**-42.1 dB / decade**	**-47.1 dB / decade**
		16.2m	**-45.44 / decade**	**-46.7 dB / decade**	**-51.3 dB / decade**
Tri310n	**3.9 MHz**	**0m**	**-74.2 dB / decade**	**-37.3 dB / decade**	**-37.6 dB / decade**
		4.1m	**-33.2 dB / decade**	**-25.8 dB / decade**	**-32.4 dB / decade**
		8.1m	**-23.3 dB / decade**	**-24.4 dB / decade**	**-29.0 dB / decade**
		12.2m	**-15.8 dB / decade**	**-18.9 dB / decade**	**-19.8 dB / decade**
		16.2m	**-3.6 dB / decade**	**+15.4 dB[4] / decade**	**+9.9 dB / decade**

[3] This is not a typographical error. The calculation was being made *into* a null. There are numerous additional examples of this in the data in the table.

[4] This is not a typographical error. The calculation was being made *out of* a null. There are numerous additional examples of this in the data in the table.

	10.1 MHz	0m	+10.5 dB / decade	-18.5 dB / decade	-26.3 dB / decade
		4.1m	+19.3 dB / decade	-13.3 dB / decade	-20.8 dB / decade
		8.1m	+2.3 dB / decade	-15.9 dB / decade	-30.0 dB / decade
		12.2m	-1.0 dB / decade	-30.3 dB / decade	-46.5 dB / decade
		16.2m	+1.2 dB / decade	-28.4 dB / decade	-41.1 dB / decade
		31.3m	+1.3 dB / decade	-26.2 dB / decade	-37.8 dB / decade
		56.8m	+2.8 dB / decade	-23.7 dB / decade	-33.7 dB / decade
	24.9 MHz	0m	-59.4 dB / decade	-38.6 dB / decade	-28.5 dB / decade
		4.1m	-47.9 dB / decade	-26.0 dB / decade	-22.0 dB / decade
		8.1m	-12.3 dB / decade	-31.8 dB / decade	-44.7 dB / decade
		12.2m	+14.4 dB / decade	-5.9 dB / decade	-15.8 dB / decade
		16.2m	+13.9 dB / decade	-19.1 dB / decade	-31.7 dB / decade
Ver36n	3.9 MHz	0m	-122.0 dB / decade	-44.2 dB / decade	-36.9 dB / decade
		4.1m	-67.3 dB / decade	-29.0 dB / decade	-28.5 dB / decade
		8.1m	-39.0 dB / decade	-27.0 dB / decade	-23.4 dB / decade
		12.2m	-20.9 dB / decade	-26.2 dB / decade	-10.3 dB / decade
		16.2m	+12.0 dB / decade	+21.7 dB / decade	+10.7 dB / decade
		31.3m	-25.6 dB / decade	-26.0 dB / decade	-25.3 dB / decade
	10.1 MHz	0m	+15.1 dB / decade	+6.7 dB / decade	-8.3 dB / decade
		4.1m	-2.4 dB / decade	+4.2 dB / decade	-4.2 dB / decade
		8.1m	+0.5 dB / decade	-16.7 dB / decade	-30.9 dB / decade
		12.2m	+16.2 dB / decade	-17.2 dB / decade	-37.6 dB / decade
		16.2m	+21.5 dB / decade	-8.9 dB / decade	-26.6 dB / decade
		72.0m	+14.5 dB / decade	-8.5 dB / decade	-23.3 dB / decade
	24.9 MHz	0m	-136.8 dB / decade	-65.3 dB / decade	-30.6 dB / decade
		4.1m	-66.6 dB / decade	-27.7 dB / decade	-20.2 dB / decade
		8.1m	-31.5 dB / decade	-49.0 dB / decade	-57.8 dB / decade
		12.2m	-6.38 dB / decade	-6.8 dB / decade	-13.4 dB / decade
		16.2m	-4.5 dB / decade	-33.4 dB / decade	-48.7 dB / decade

Table 2 – This shows the calculated values of extrapolation for different sets of four points laterally away from overhead power lines. These data are based on the slant-range distances to the power lines.

No Single "Site-Specific" extrapolation

It is clear from looking at the data in Table 2 that there is not, and cannot be, a "site-specific" value of extrapolation. The wide variability in the way that fields decay with distance seen is exactly what is to be expected in a complex EMC environment with very large emitters. Real-world variability is worse than what is shown in these simple models. This variability has been demonstrated in information previously provided by ARRL. It is seen in the FCC certification test-result reports and in testing done by FCC technical staff. It is seen in the measurements made by Current Technologies that were previously provided to the Commission in this proceeding, where any four points along the axis Current reported that it measured yielded a different value of extrapolation.

Even along a single axis on a single frequency, one can obtain wildly differing extrapolation values, just by choosing different points. Clearly, even to the layman, this cannot represent a reasonable way to extrapolate measurements made at one distance on one frequency at one point along a line to even a measurement made at the same frequency along the same axis away from the radiator. When measurements are made on different frequencies, a change of as little as 100 kHz can make a major difference in the extrapolation value obtained.

In some cases, especially at close-in measurements, field strength increased with distance. In another instance, using the tri310n.nec model at 10.1 MHz, there were two points along the line that showed the same field-strength value maximum. Either could legitimately be used as the starting point for an extrapolation measurement, yet the resultant calculation varied across a 40 dB range!

The finding that close-in to the model, field strength actually increases with distance is of extreme significance, especially related to the current certification testing practices. It is clear that these close-in points cannot be used for a measurement of the emissions from the system or for a measurement of extrapolation, as no manufacturer would want to apply an extrapolation that showed that field strength would increase with increasing distances from the source. Yet, again and again in the certification data, manufacturers have found reasons to measure close-in data, and then apply the current 40 dB/decade extrapolation. This could very handily explain why again and again, systems deployed in the field have been seen to operate at tens of dB above the emissions limits for BPL.

The modeled data clearly show that close-in measurements from overhead power lines should not be permitted. At any horizontal distance closer to the line than 10 meters, the variations in results are too great to permit a measurement of either field strength or extrapolation.

Some of the results in Table 2 are the result of the complex environment. It is clear that some of the points measured could not be used for a measurement of extrapolation, but looking at the points along the line where the maxima at 10 meters were seen, the results show that these maxima are just as likely to have anomalous extrapolation as any other. These data drive home an important point -- not only is possible to pick and choose to get a desired result, it is ***necessary*** to pick and choose, to get a result that is at least within the boundaries of credibility.

Comparison of modeled data at 10 meters distance to the modeled data at 30 meters distance

The data show that measurements of overhead power lines should not be made closer than 10 meters to the radiating source. The current FCC guidelines requiring that a measurement point of 10 meters horizontally be used are reasonable, from both a technical and safety perspective.

The following table shows how measurements made at 10 meters distance along an overhead line at the measurement points specified for the mid-point frequency of the emission compare to the actual maxima at 30 meters, at 1 meter height and at a height upward from the line that represents 30-meters slant range, still 10 meters horizontally away from the power lines. This is the general geometrical region where it is likely that HF antennas will be located. This chart is intended to show how poorly the current measurement and extrapolation apply to the actual maxima that are the intended end result of all measurements and regulatory specifications.

Model	Frequency	Distance along line. (This is the point of maximum emissions at 10 meters lateral distance for this model on this frequency.)	10m lateral value compared to maximum 30m SR value at 1m height.	10m lateral value compared to maximum 30m SR value at 23m height.
Tri26	3.9 MHz	40.5m	-10.8 dB (7.2 dB error)	-12.48 dB (2.0 dB error)
	10.1 MHz	12.2m	-9.7 dB (7.8 dB error)	-4.2 dB (26.2 dB error)
	24.9 MHz	4.1m	-10.3 dB (6.2 dB error)	-4.5 dB (25.1 dB error)
Tri310n	3.9 MHz	0m	-7.7 dB (14.8 dB error)	-9.5 dB (8.7 dB error)
	10.1 MHz	31.3m*	-6.6 dB (18.5 dB error)	-2.2 dB (32.7 dB error)
	10.1 MHz	56.8m*	-9.9 dB (7.6 db error)	-7.2 dB (16.2 dB error)
	24.9 MHz	8.1m	-7.1 dB (16.5 dB error)	-5.2 dB (23.0 dB error)
Ver36n	3.9 MHz	31.3m**	-10.1 dB (6.9 dB error)	-10.9 dB (4.3 dB error)
	10.1 MHz	73.9m	-5.7 dB (21.1 dB error)	-3.7 dB (28.0 dB error)
	24.9 MHz	4.1m	-8.3 dB (12.8 dB error)	-1.2 dB (36.1 dB error)

Table 3 – This shows how measurements made at 10 meters horizontal distance (SR=14.9 meters) from the line at a height of 1 meter relate to the field strength at 29.7 meters horizontal distance at a height of 1 meter and at a height of 23 meters (both SR = 30 meters).

Notes for the table:

** The emission levels at these two distances along the line were at the same value (after rounding to 0.1 relative), so either could be used as the basis of an extrapolation measurement.*

***The emissions from this model were significantly different "upstream" and "downstream" from the injection point. The emissions in the opposite direction were larger than the emissions in the direction chosen for this table. The Part 15 rules do not require that measurements be made in both directions from an injection point, so in all cases, the positive direction in the model was chosen. In this case, variability results from a combination of(1) the variation in emissions from one side of the model to the other;(2) the fact of measurement points based on multiples of a quarter wavelength at the mid-point frequency of the emission; (3) the underestimation of emissions if a 40 dB/decade extrapolation is applied; and (4) the variation in emissions with height added to produce a significant error in the correlation of a measurement made at 1 meter height at a distance of 10 meters and the actual points of maximum emissions, at 1 meter height or greater heights laterally away from the line where it is likely that high-frequency (HF) Amateur Radio antennas will be located in close geographic proximity.*