

# EXHIBIT E

## ARRL PETITION FOR RECONSIDERATION

### **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**

#### **1. Background**

- 1.1 ARRL submitted a number of papers and studies to the FCC during the course of the BPL Notice of Inquiry (ET 03-104) and Notice of Proposed Rulemaking (ET 04-37). These submissions demonstrated to the Commission that the 40-dB/distance decade extrapolation permitted by §15.31(f)(2) is inappropriate for a large distributed emitter such as the medium-voltage wiring used by BPL.
- 1.2 In the BPL Report and Order, the FCC announced that it was choosing not to make any changes to the extrapolation permitted by §15.31(f)(2):
- 1.3 The R&O indicated that the FCC had relied heavily on the NTIA's antenna modeling to reach its decisions:

*107. Decision. We find the extensive measurement and modeling efforts presented in the NTIA Phase I Study and the Technical Appendix to NTIA's comments to be highly useful in our efforts to develop appropriate measurement procedures for Access BPL. The scientific engineering in those submissions clarifies the interference potential of Access BPL on radio reception and the recommended techniques for measurement of Access BPL emissions provide us with a well thought-out plan on which to base our decisions on measurement issues. Our decision, discussed below, takes into account NTIA's research and adopts a modified version of its recommendations.*

- 1.4 The R&O also indicated that the record supports the FCC's decision to continue to use a 40 dB/distance decade extrapolation:

*109. Measurement Distance. Despite the stated aversion of NTIA and ARRL to distance extrapolation, we recognize that at many in situ test locations, it may not be possible or practicable to measure at the proposed fixed distances of 10 and 3 meters. If a 10-meter distance places the measurement antenna on a roadway, safety may dictate increasing the distance to, e.g., 14 meters in order to position the testers out of harm's way. Hence, we expect that distance extrapolation will be necessary for in situ testing. We note that NTIA's latest computer modeling results show that the variation of field strength with distance is consistent with the existing Part 15 distance extrapolation when used with the slant range distance to the power line as was proposed in Appendix C of the Notice. We also note that although the ARRL and ARINC recommend the use of a 20 dB per decade extrapolation factor rather than the existing 40 dB per decade in Part 15 for frequencies below 30 MHz, Ameren states that it has determined the characteristics of the fields near the line support the case for assuming a 40 dB per decade decay rate of the field away from*

*the line and recommends the use of the existing 40 dB per decade extrapolation factor. Given the lack of conclusive experimental data pending large scale Access BPL deployments, we will continue the use of the existing Part 15 distance extrapolation factors in our rules, but with the slant range rather than horizontal distance. If new information becomes available that alternative emission limit/distance standards or extrapolation factors would be more appropriate, we will revisit this issue at another time.*

- 1.5 An analysis of the antenna models that the FCC used to reach its decision about the appropriate distance-extrapolation factor does not support its decision to continue to use 40 dB/decade for overhead BPL power lines. To the contrary, an analysis of the near-field regions surrounding the models shows that the maximum field strength at a distance of 30 meters distance from the emitter (generally upward from the power line) is related to the maximum field strength at the specified measurement points at 10 meters horizontally from the line at 1 meter height by approximately 20-dB/distance decade.
- 1.6 In the R&O, the FCC appropriately indicated that its goals in setting limits and measurements methodology were to protect radio services. The R&O offered the greatest protection to certain aeronautical services, indicating that the Commission understands that the emissions upward from radiating overhead power represent a significant factor in the EMC component to BPL operation. The Commission also gave consideration to the NTIA Phase II report about skywave noise that would result from the aggregate of many BPL devices. In many cases, nearby antennas, such as those in common use in the Amateur Radio Service, are located at greater height than the power lines. For these reasons, although the testing guidelines determine the method by which BPL systems should be tested, the rules set limits at 30 meters distance, irrespective of slant angle.

## **2. Analysis of Models**

- 2.1 ARRL has analyzed a number of antenna models that were provided to the FCC in the rulemaking proceeding. These include:
  - 340-meter length, 3-phase power line provided by NTIA
  - 300-meter length, 2-phase power line provided by ARRL
  - Multi-leg overhead power-line model based on description of power line provided to the FCC by Ameren
- 2.2 ARRL has intentionally chosen to analyze models of distinctly different characteristics. These include the simplified models NTIA used to reach its Phase-I conclusions to the more representative models supplied by ARRL and Ameren, representing typical imbalance and multi-legged power line installations. The conclusion that ARRL is drawing -- that 40-dB/decade is not a reasonable extrapolation factor for line emitters and that 20 dB/decade is appropriate -- is supported by a wide range of antenna models.

- 2.3 To determine that its findings were not unique to just one or two combinations of conditions, ARRL took these basic models and operated them at frequencies of 4 MHz; 10.1 MHz; 14 MHz; 21 MHz and 28 MHz. The models were fed in the following configurations:
- One phase, fed in center
  - One phase, fed 25% from one end
  - Two phases, balanced, fed differentially
- 2.4 ARRL first determined the point of maximum electric field at an actual distance of 30 meters. To do this, ARRL used the near-field function in NEC-4 and calculated the field strength along the line at intervals starting at 1 meter in height and extending to 30 meters above the power line. All of these calculations were made at a horizontal distance from the line that resulted in a slant-range distance of 30 meters from the line. This captured the maximum emission at a distance of 30 meters from the line, radially at all slant angles, along the entire length of line.
- 2.5 A separate calculation was made of the magnetic field at a horizontal distance of 10 meters from the overhead line, at a height of 1 meter. The maximum value of H field was then converted to an equivalent value of electric field by adding 51.5 dB. The measurement made at 10 meters horizontal distance was then extrapolated to 30 meters using the 20 dB/decade and 40 dB/decade respectively. The 40-dB/decade extrapolation consistently underestimated the actual field strength in any models that represented real-world BPL installations.
- 2.6 The results were as follows:

**Table 1: Comparison of calculated E fields at 30 meters distance to H fields measured at 10 meters horizontal distance and extrapolated to 30 meters using various functions.**

- = underestimates field by N dB

+ = overestimates field by N dB

Antenna model	Frequency MHz	Feed-point	Actual dBuV/m at 30 m distance	Actual H field at 10 meters horiz.E field equiv dBuV/m	H field extrapolated to 30 meters using 20 dB / decade	H field extrapolated to 30 meters using 40 dB / decade	Error when extrapolated at 20 dB / decade	Error when extrapolated at 40 dB / decade
NTIA-340m <sup>1</sup>	4	1-phase, center (50%)	29.54	40.4	32.8	25.2	+3.3 dB	-4.3 dB
NTIA-340m	10.1	1-phase, center (50%)	29.54	35.3	27.7	20.1	-1.9 dB	-9.5
NTIA-340m	14	1-phase, center (50%)	29.54	35.7	28.0	20.4	-1.5	-9.1
NTIA-340m	21	1-phase, center (50%)	29.54	35.1	27.5	19.9	-2.1	-9.7
NTIA-340m	28	1-phase, center (50%)	29.54	33.3	25.6	18.1	-3.9	-11.5
NTIA-340m	4	1-phase, offset (25%)	29.54	41.5	33.9	26.3	+4.4	-3.2
NTIA-340m	10.1	1-phase, offset (25%)	29.54	36.1	28.5	20.9	-1.1	-8.7
NTIA-340m	14	1-phase, offset (25%)	29.54	36.8	29.2	21.6	-0.3	-7.9
NTIA-340m	21	1-phase, offset (25%)	29.54	34.9	27.3	19.7	-2.2	-9.8
NTIA-340m	28	1-phase, offset (25%)	29.54	31.8	24.2	16.6	-5.4	-13.0
NTIA-340m	4	2-phase balanced <sup>2</sup>	29.54	46.7	39.1	31.5	+9.6	+2.0
Antenna	Frequency	Feed-	Actual	Actual H	H field	H field	Error when	Error when

<sup>1</sup> This model was described in the NTIA Phase I report. It modeled a 3-phase power line, fed in the center of one phase. None of the phases were grounded. The height was 8.5 meters. This is a slant-range distance of 12.5 meters to the measurement point.

<sup>2</sup> Although no power lines are nearly as well balanced as this model, these data were included to be complete. The results for balanced feed represent an ideal best case that will not exist in real-world installations.

model	MHz	point	dBuV/m at 30 m distance	field at 10 meters horiz.E field equiv dBuV/m	extrapolated to 30 meters using 20 dB / decade	extrapolated to 30 meters using 40 dB / decade	extrapolated at 20 dB / decade	extrapolated at 40 dB / decade
NTIA-340m	10.1	2-phase balanced <sup>3</sup>	29.54	38.0	30.4	22.8	+0.8	-6.7
NTIA-340m	14	2-phase balanced	29.54	37.9	30.3	22.7	-0.8	-6.9
NTIA-340m	21	2-phase balanced	29.54	35.0	27.4	19.8	-2.2	-9.8
NTIA-340m	28	2-phase balanced	29.54	33.2	25.6	18.0	-3.9	-11.5
ARRL-100m <sup>4</sup>	4	1-phase, offset (25%)	29.54	42.8	35.8	28.8	+6.3	-0.7
ARRL-100m	10.1	1-phase, offset (25%)	29.54	36.6	29.7	22.7	+0.1	-6.8
ARRL-100m	14	1-phase, offset (25%)	29.54	36.6	29.6	22.7	+0.1	-6.9
ARRL-100m	21	1-phase, offset (25%)	29.54	33.0	26.1	19.1	-3.5	-10.4
ARRL-100 m	28	1-phase, offset (25%)	29.54	32.6	25.6	18.7	-3.9	-10.9
Ameren multi-legged <sup>5</sup>	4	1-phase fed 25 meters from one end	29.54	35.9	28.9	21.9	-0.6	-7.6
Antenna model	Frequency MHz	Feed-point	Actual dBuV/m	Actual H field at	H field extrapolated	H field extrapolated	Error when extrapolated	Error when extrapolated

<sup>3</sup> At 10.1 MHz, any near-field effects that would increase the extrapolation to slightly greater than 20 dB/decade are no longer seen even in this ideal balanced model.

<sup>4</sup> This antenna model was described in a number of ARRL filings in the BPL rulemaking proceedings. It consists of two phases, one of which is grounded. The height is 10 meters. The slant-range distance to the measurement point is 13.45 meters.

<sup>5</sup> This model was described in ARRL's paper, "Exhibit A – NEC Analysis of Power Lines as Radiators". This report can be downloaded from the ECFS web page at [http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native\\_or\\_pdf=pdf&id\\_document=6516214646](http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6516214646). The height is 10 meters. The slant-range distance was presumed to be 9 meters – the worst case of the distance between the measurement point and overhead sections of the legs.

			at 30 m distance	10 meters horiz.E field equiv dBuV/m	to 30 meters using 20 dB / decade	to 30 meters using 40 dB / decade	at 20 dB / decade	at 40 dB / decade
Ameren multi-legged	10.1	1-phase fed 25 meters from one end	29.54	34.6	27.7	20.7	-1.9	-8.9
Ameren multi-legged	14	1-phase fed 25 meters from one end	29.54	31.7	24.8	17.8	-4.8	-11.8
Ameren multi-legged	21	1-phase fed 25 meters from one end	29.54	31.9	25.0	18.0	-4.6	-11.5
Ameren multi-legged	28	1-phase fed 25 meters from one end	29.54	36.4	29.4	22.4	-0.2	-7.1

### 3. Conclusions

3.1 These data show the following:

- A 40-dB/decade extrapolation underestimates the maximum field strength at 30 meters by as much as 11.5 dB. Although some near-field effects can be seen at lower frequencies, applying a 40-dB/decade extrapolation results in a significant error. The original statements made in the NTIA Phase I report and the engineering conclusions drawn by ARRL were correct – a 20-dB/decade distance extrapolation should be applied to measurements made closer than 30 meters distance.
- These data also show that the information provided by ARRL, NTIA, Ameren and others that an extrapolation for height for frequencies below 30 MHz should be applied. These data generally support the ARRL and Ameren position that 3.5 dB should be added to H field values measured at 1 meter in height.
- The data also show that it would be reasonable to apply a slightly greater than 20-dB/decade factor at lower frequencies.

- 3.2 It is not possible to disassociate height extrapolation, distance extrapolation and frequency effects. Throughout the proceeding, the FCC and BPL proponents have consistently asked for the most simple possible test procedures. To that end, the easiest distance and height extrapolation would be to add a reasonable number to measurements made at 1-meter in height<sup>6</sup> and then extrapolate for distance using a 20-dB/distance decade function.
- 3.3 However, the following extrapolation for height, distance and frequency combined provides a reasonable fit for the data provided in this analysis of available antenna models:

$$\text{Equation 3.1 } 3.5 \text{ dB} - 20\log(30/\text{slant range distance}) - 10*\log(\text{FMHz}/15)$$

- 3.4 It is critical that the actual emissions at 30 meters from BPL-carrying power lines not exceed 30 uV/m. All of the NTIA Phase II conclusions were based on the premise that the field strength at 30 meters distant from the radiator is actually at 30 uV/m. So was the NTIA premise that 20 dB of attenuation in the 13 BPL restricted bands is sufficient to generally protect government operation.<sup>7</sup> If 40 dB/decade is used to extrapolate measurements made as described in the FCC BPL test procedures, the field strength at 30 meters distance will exceed 30 uV/m. This would have the effect of invalidating all of the assumptions put into the skywave and interference analyses done by NTIA.

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<sup>6</sup> ARRL could accept either the 5 dB height factor that NTIA proposed or the 3.5 dB height factor proposed by ARRL and Ameren.

<sup>7</sup> Reception in the Amateur Radio Service generally uses a very low noise margin. 20 dB is not sufficient to protect all radio users and NTIA was speaking only for government spectrum users when it determined that 20 dB of suppression in the prohibited bands would meet its needs.