Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of:

Carrier Current Systems, Including	)	
Broadband Over Power Line Systems	)	ET Docket No. 03-104
	)	
Amendment of Part 15 Regarding New	)	
Requirements and Measurement Guidelines	)	ET Docket No. 04-37
For Access Broadband Over Power Line	)	
Systems	)	

To: The Commission

COMMENTS OF AMEREN ENERGY COMMUNICATONS INC.

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SUMMARY

Ameren Energy Communications, Inc. ("AEC"), which is presently engaged in a successful test of Access BPL technology, has confirmed, both empirically and theoretically, the Commission's prediction that the emissions from Access BPL systems will occur more from the individual devices and less from the power lines that carry the BPL signals. In other words, there is no "harmful antenna effect" associated with the power lines.

Based on its studies, AEC believes that fewer measurement points parallel to the line than proposed by the Commission are necessary, and that the measurements need not be maximized with respect to the vertical dimension. AEC believes as well that radiated emission limits are far more relevant than conducted emission limits.

AEC supports the proposed requirement for adaptive interference mitigation technology, but, in light of the function of such technology, opposes as unnecessary automatic shut-down features as well as notification requirements and a database of installed equipment.

AEC proposes revising some of the measurement guidelines to more appropriately account for the inherent field distribution near the line.

AEC urges the Commission to revise the use of the magnetic loop antenna for measurements near the lines and below 30 MHz. For reasons that are explained, magnetic loop antennas may yield erroneous data in proximity to power lines.

COMMENTS

Ameren Energy Communications Inc. ("AEC"), an affiliate of Ameren Corporation, by its counsel and pursuant to Section 1.415 of the Commission's Rules, submits these comments in response to the above-captioned Notice of Proposed Rule Making.

Pursuant to experimental license WC2XXK, granted in June, 2002, AEC has been operating a limited, experimental BPL system in Cape Girardeau, Missouri. The system comprises five cells, each of which serves a group of homes. Each cell consists of a BPL modem at the backhaul connection point, BPL modems acting as repeaters at points between the backhaul connection point and end users, and a BPL modem located within each user's home, which is plugged into a wall outlet and connected to the user's personal computer by means of an Ethernet cable. The experience that has been and is being gained through the operation of this system has enabled AEC to prepare its comments from an empirical, not merely theoretical, perspective.

Definition of Access BPL

Para 32: The proposed definition of Access BPL has been introduced by the Commission as a service that operates on electric *transmission* lines, which are high voltage, long-haul power lines. In most, if not all, instances, however, the BPL service would be provided over electric *distribution* lines, which are medium- and low-voltage, local power lines. While the Commission's definition correctly notes that the power lines are owned, operated or controlled by the *electric service* provider, the definition should not be construed to mean that the *BPL service* provider would be the electric utility. AEC is aware of entities that are not electrical power providers or subsidiaries of the electric power provider, who plan on being providers of BPL, under line use agreements with the electric power provider.

Access BPL Emission Limits

Para 36. AEC agrees with the Commission's statement in Par. 36: *[T]he primary source of emissions will be the individual couplers, repeaters and other devices and, to a lesser extent, the power line immediately adjacent thereto.* To confirm this prediction, AEC constructed a numerical model of a single BPL source coupled to an overhead power line and used it as a benchmark for the purpose of assessing the Commission's proposed guidelines and emissions measurement procedures.

The details of the model and numerical results are given in Appendix A hereto. The model is not intended for predicting the absolute magnitude of emissions around the line, because it is a simplified representation of the real system; rather the model is intended to derive the salient features and patterns of the field distributed around the line. AEC believes that these salient features will be maintained even by more complex models.

With reference to the results in Appendix A, the distribution of the electric field along the length of the line (moving parallel to the line) has its maximum value near the location of the source and decays as the observer moves parallel to the line and away from the source; this result is in complete agreement with the Commission's prediction mentioned above. With reference to the same results, the decay of the field amplitude is not monotonic but oscillatory—due to current reflections at the line terminals—with a spatial period of ½ of the source wavelength.

In the guideline provided in Appendix C, part 2.b, ¶ 2 of the NPRM, regarding testing along the line, the Commission proposes measuring the field by moving parallel to the line and at distances from the injection point equal to 0, ¼, ½, ¾, and 1 wavelength of the mid-band frequency used by the BPL system. This should yield two complete cycles of the spatial variation of the field along the line at the mid-frequency wavelength.

Further in the same paragraph, the Commission proposes additional measurements in the case where the lowest injected frequency is below the mid-band frequency by a factor of two or more. These additional measurements must be performed at intervals equal to ½ of the wavelength corresponding to the mid-band frequency of the BPL injection until the distance from the injection point equals ½ or more of the wavelength corresponding to the lowest frequency injected. The Commission even provides an example to clarify the procedure where a BPL system operating in the range from 3 to 27 MHz would require measurements at three additional distances from the injection point, resulting in measurements at a total of eight distances.

Because frequency and wavelength are inversely proportional, the number of these additional measurements could be excessive for some BPL injection bands. For example, if the injection covers the 2-to-28 MHz band (a slight variation from the 3-to-27 MHz band used in the Commission's example), six additional measurements must be done for a total of eleven. If the injection band is the 1-to-29 MHz, 13 additional measurements are needed for a total of 18. These numbers are excessive given the Commission's proposal that measurements be performed at all BPL devices in the system.

In addition, AEC believes that the measurement spacing need not be finer than 1/8 of the wavelength at any given frequency for providing an accurate estimation of the field distribution. AEC therefore proposes to replace the current wording in that guideline with this: **“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 shall be 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 not exceeding the greater between a) 1/8 of the wavelength of the lowest frequency injected, and b) ½ of the wavelength of the mid-band frequency, until the distance of the testing point from the BPL injection point on the power line is ½ or more of the wavelength of the lowest frequency injected.”**

This guideline amendment will limit the additional measurements to four. AEC believes that this provides a satisfactory spatial sampling rate equivalent to that which the Commission proposes, based on the mid-band frequency. Furthermore, AEC believes that at low frequencies where the wavelength may equal or exceed 100 m, the natural decay of the field away from the source will result in significant strength attenuation to alleviate any concern.

Para 37. AEC agrees with the assessment of the Commission that (a) radiated emissions from Access BPL devices decrease rapidly with the distance from the devices; (b) emergency and public safety systems use receivers with relatively low sensitivity; and (c) the potential of interference caused by Access BPL is implicitly low. Therefore, we believe that the ability of Access BPL equipment to notch out suspect frequencies and to selectively shut down particular units is sufficient to prevent interference to these services and no additional restrictions are necessary.

Various operators of BPL test sites have reported, by way of the BPL NOI record, that no interference from their BPL operations has been reported. AEC's tests corroborate this experience. Thus further measures to address an unlikely problem seem superfluous.

Para 38. AEC agrees with the Commission that testing for conducted emissions on high voltage power lines poses difficult—in some cases even prohibitive—technical problems. Requiring conducted emissions tests would needlessly inhibit the development of Access BPL systems. The point of contention is the interference issues to radio services, which can only occur through radiated, not conducted electromagnetic energy. As AEC stated in response to the Commission's NOI[1], power lines are poor antennas. Thus the conversion of conducted to radiated energy does not occur in the same high degree as it does with an efficient antenna. Therefore, we agree with the Commission that Access BPL systems should be exempt from conducted emission testing.

AEC does not expect to operate BPL systems in the AM broadcast band (from 535 to 1705 kHz).

Access BPL Operational Requirements

Para 39. AEC agrees with the Commission's view that there is strong incentive to install BPL systems with care. There are internal electric utility benefits, such as monitoring and control functions, that BPL will enable and support. Utilities will thus take great care

[1] *Inquiry Regarding Carrier Current Systems, including Broadband over Power Line Systems, Notice of Inquiry,* ET Docket No. 03-104, 18 FCC Rcd 8498 (2003).

in designing and installing the BPL system to avoid problems that would necessitate shutting it down, thereby eliminating those internal utility benefits.

Para 40. AEC agrees that adaptive interference mitigation techniques should be part of a BPL system, allowing the BPL system operator to modify the system's operating characteristics to mitigate harmful interference to radio services. Incorporating adaptive interference mitigation techniques into the Access BPL devices and systems will enhance the prevention of harmful interference.

Para 41. While AEC supports the adaptive interference mitigation requirement, the language of proposed § 15.109(f) must be modified. According to the proposed rule, its purpose is "to avoid site-specific, localized use of the same spectrum by licensed services." This language can be read to mean that the equipment must be able to sense and avoid *sites* where licensed radio services are or may be present, without regard to whether any interference may actually be caused. AEC believes a more useful and accurate statement of the purpose of the requirement would be "to avoid causing harmful interference to licensed services." The rule should be modified to reflect this clarification.

Para 42. AEC disagrees that Access BPL devices should incorporate a shut-down feature that would deactivate units "found" to cause harmful interference, as proposed in new § 15.109(f). Instead, AEC believes that the new adaptive interference mitigation feature, which includes power reduction and change of frequencies, should be sufficient protection. Going beyond that to a shut-down feature that would terminate service to a broadband subscriber without warning is not warranted by the actual field experience of existing experimental systems. This additional feature would add cost and complexity that is not necessary.

Moreover, proposed rule § 15.109(f) is silent as to who must make the "finding" that harmful interference is being caused by the BPL system and what the process is for making such a finding. AEC submits that the equivalent protection afforded by § 15.5(c) of the Commission's rules, which already applies to all low-power devices and permits a Commission representative to order a person to cease operating a device until a harmful interference condition is cured, is sufficient to remedy interference that might be caused by any specific Access BPL device. Accordingly, the last sentence of this proposed section (f) should be deleted.

Para 43. AEC opposes the notification and database requirement for BPL systems, contained in proposed § 15.109(g). No other competing broadband provider, such as cable modem service or DSL service, provides to an external party the location of its infrastructure equipment, and, therefore, its customers. Moreover, disclosing the location of BPL equipment would also disclose information about the location of the electric grid and its components, which is very closely guarded for internal utility and national security reasons.

A notification and database requirement would impose administrative and cost burdens on BPL providers to support such systems that are not borne by other broadband providers, in the name of resolving interference issues that are minimal and/or addressable by other means. The database requirement is a holdover from present regulations *that do not include adaptive interference mitigation requirements.* The very concept of adaptive interference mitigation, however, renders unnecessary an expensive and laborious database and reporting requirement to manually locate equipment in the field. It is safe to predict that customers will be reluctant to subscribe to a service that must list the location of their equipment in a publicly-available database.

Finally, requiring Access BPL providers to file information about proposed installations and changes to existing systems implies some form of right to protest such changes and installations, as well as liability to sanctions for failing to provide such information. The Commission has not announced any such intended use of this information and it should avoid the creation of an inadvertent inference of such uses. In short, the entire § 15.109(g) is unnecessary and should not be adopted.

Equipment Authorization and Measurement Guidelines

Par. 44: AEC supports retaining the Verification procedure for Access BPL under the equipment authorization program. AEC also agrees that the authorization procedure for BPL should be the same as for all unintentional radiators, including traditional types of carrier current systems. AEC believes that a higher degree of oversight is not necessary, especially in light of the adaptive interference mitigation techniques proposed by the Commission.

Par. 45: Regarding measurement guidelines, AEC refers the Commission to its comments under Par. 36, above, regarding measurements along horizontal distances from overhead lines.

In addition, AEC would like to discuss the issue of using a magnetic loop antenna near the line for measurements below 30 MHz. As AEC has already stated in response to the *Notice of Inquiry*, AEC believes that the use of a magnetic loop antenna near the line can introduce inaccuracies for these reasons:

a) Testing near the line measures quantities associated with the near rather than the far fields of the line;

b) A loop antenna, inherently, measures the magnetic field induction strength rather than the electric field strength;

c) The emission limits in Part 15.209 of the FCC regulations are given in terms of the strength of the electric field;

d) Conversion of the magnetic loop antenna readings from induction to electric field is impossible for measurements inside the near fields. Such conversion is possible only for the far fields where the relation between magnetic induction and electric field is a proportionality; it does not hold for the reactive field near the line. As a result, the manufacturer's antenna factors translating the reading of the spectrum analyzer (to which the antenna output connects) from voltage to the electric field are not valid for near field measurements.

For these reasons, AEC believes that using the magnetic loop antenna to perform measurements near the line and then applying the standard antenna factors to estimate the electric field from the voltage reading on the spectrum analyzer will yield erroneous data overestimating or underestimating that field (as the field distribution around the line is oscillatory). Perhaps the Commission could provide alternative limits to those in Part 15.209 expressed in µA/m (magnetic unit) rather than µV/m (electric unit), thus yielding greater correspondence with the properties of the loop antenna; or, perhaps, the Commission can specify the use of the monopole antenna which can measure directly the electric field.

Par. 46: AEC used the numerical model of the line described in Appendix A and calculated the electric field distribution in the vertical direction from zero to 15 meters from the ground at a horizontal distance of 10 meters from the line for several frequencies up to 80 MHz. Sample graphs of this study are included in the appendix.

The data show that the field varies little along the vertical dimension. The field calculated at any height, up to 15 m, above the ground rises, at most, 3.5 dB above the maximum value calculated at a height of 1 m above the ground. AEC attributes this relatively narrow variation of the field to the small relative change of the slant distance from the point of measurement to the line wires.

As an example, for a 10-meter-tall line at a horizontal distance of 10 meters, the slant distance to the line wires observed at a height of one meter above the ground is 13.45 meters; and observed at a height of 10 meters above the ground is 10 meters, a relative change of 1.345 or 2.57 dB—in good agreement with the vertical variation of the field calculated in Appendix A. Based on the oscillatory distribution of the field and its small variation among the heights, AEC believes that the requirement for maximizing the measurements along the vertical direction will put an undue burden and risk in the testing process without improving precision—especially when this process must be repeated for several distances from the tested BPL device.

General Comments Regarding the Emission Limits and Measurement Procedures

The study of the line model in Appendix A reveals that, at the BPL frequencies, the EM field around the aerial line is dominated, for several hundred meters away from the line, by the reactive near fields *where significant noise is already present*.

Specifically, the field distribution appears flat up to a perpendicular distance from the line ranging from 5 to 10 m (depending on the frequency). Subsequently, the field decays at an average rate of 40 dB per decade in the perpendicular distance from the line, demonstrating a reactive, not a radiating, behavior. Even though most of the emissions occur near the BPL source, the presence of the line distributes these emissions in the space around the line and thus the system cannot be thought of as a point radiator for the purpose of extrapolating measurements and anticipating effects.

The deployment of BPL in rural and remote areas—one of the major thrusts of this technology—will be handicapped if the system is required to operate under strict emission limits and under complex measurement guidelines. This is dictated by the greater geographic separation of customers in these areas, requiring a greater number of BPL devices to deal with signal attenuation and strict emissions limits simultaneously.

In the NPRM the Commission recognizes that rules for such a complex system may need to be revisited after a body of operating experience of BPL has been accumulated. Therefore, AEC proposes the adoption of more affordable emissions limits, in accord with the near-field effects discussed above, for the initial rule period in order to facilitate the deployment of, and defuse industry hesitation in, this technology. Specifically, AEC proposes the following guidelines concerning measurement of EM emissions resulting from BPL devices operating on aerial lines:

> First, define the boundary of the EUT as the boundary formed by all imaginary points situated at a horizontal perpendicular distance of 10 m from the line.
>
> Second, the measurements should be performed at or outside the EUT boundary—the proposed 10 m distance by the Commission is appropriate.

Third, the extrapolations of the field should be calculated using a 40 dB per decade rate in the horizontal perpendicular direction outside the EUT boundary and using a 0 dB per decade inside the EUT boundary.

Fourth, the distances used to define the limits in Section 15.109 and Section 15.209 should be measured from the EUT boundary as this boundary is defined above.

Conclusion

AEC supports the adoption of rules to govern Access BPL Systems, but urges the Commission to avoid some requirements that are not warranted at this time and that could unnecessarily inhibit the development of this technology.

APPENDIX A: Field Distribution from BPL Signals

Fig. A1 describes the overhead distribution line simulated. The line length is 200 m; the conductor height is 10 m from the ground; the distance between the conductors is 1 m. The ground below the line has a specific conductance of 0.01 Sm, a relative permeability of 1, and a relative permittivity of 5. With reference to Fig. A1, a rectangular coordinate system is defined at the center of the line with x, y, and z coordinates representing respectively the longitudinal, horizontal and vertical dimensions; the ground is the z=0 plane.

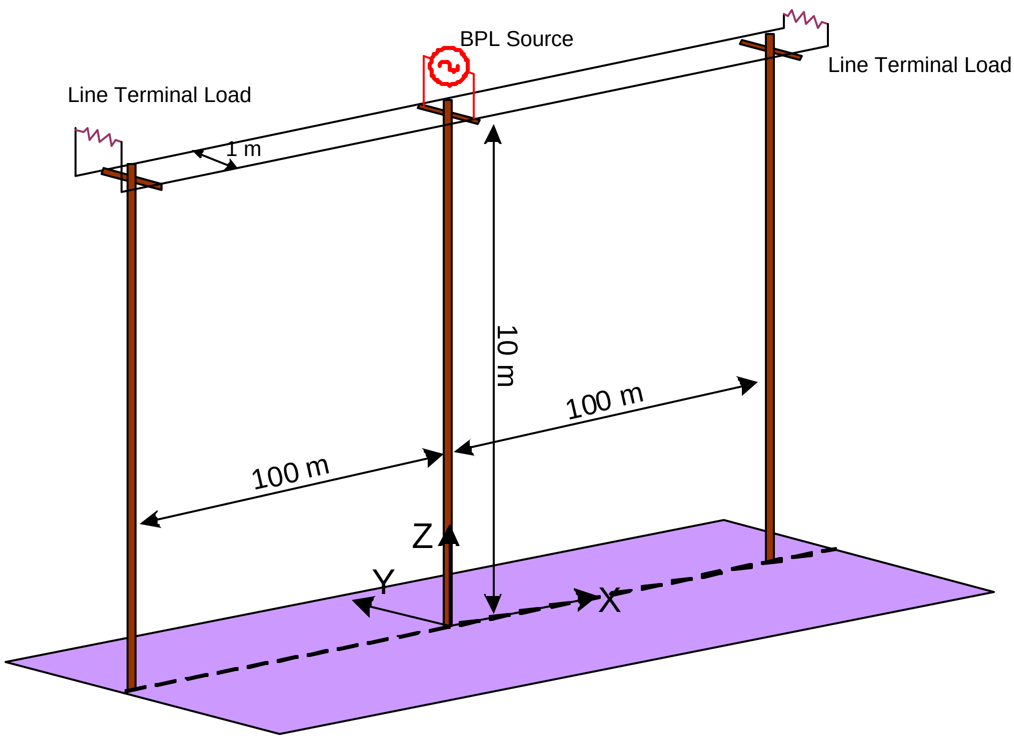


Fig. A1. Line Configuration.

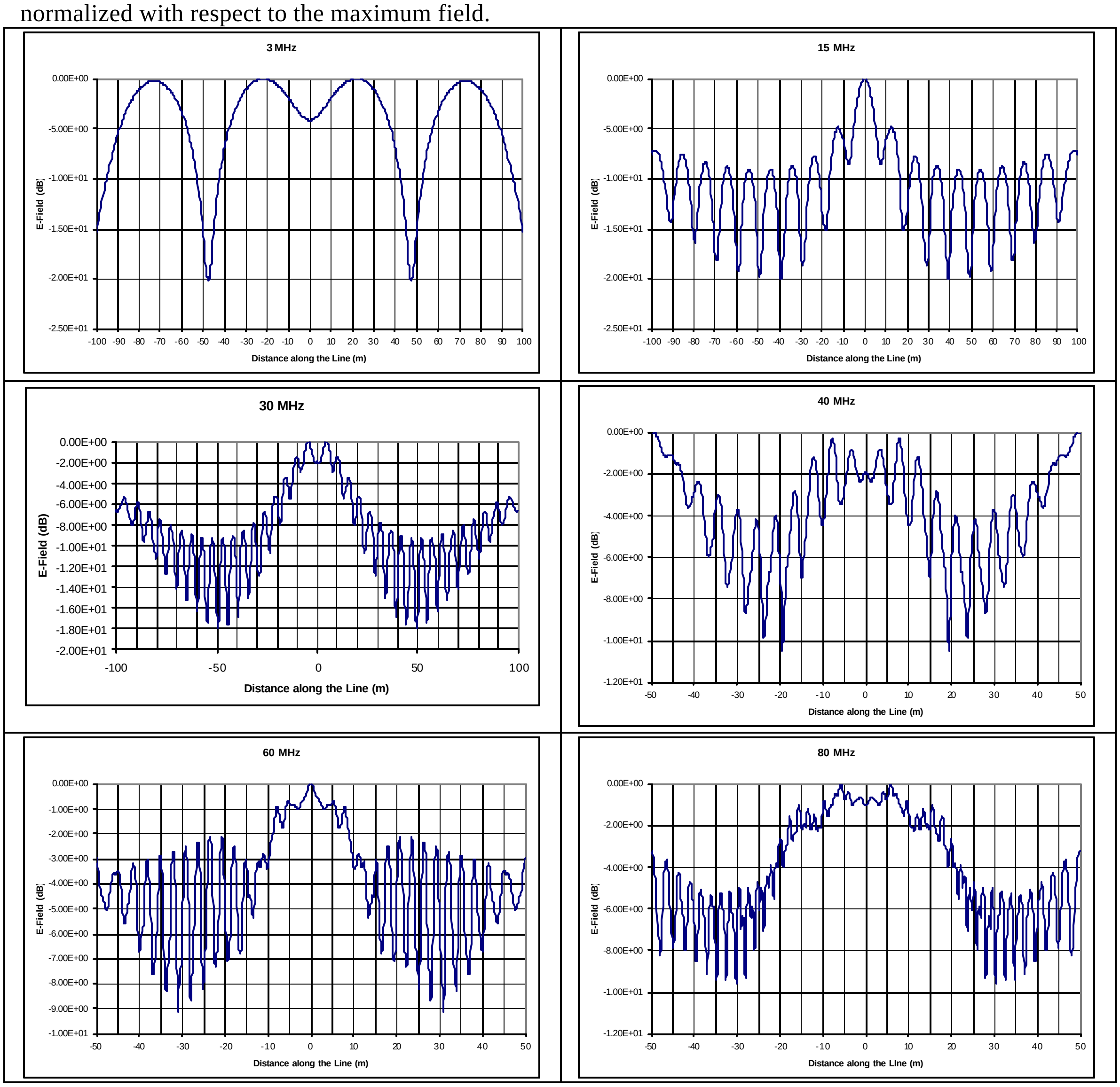
The BPL source is located at the center of the line at z=10 m. The source impedance is 50 Ω. The line terminates at two equal resistive loads. The value of the resistance is varied to vary the reflection coefficient at the line terminals and achieve different standing wave ratios.

The above line was simulated using the method of moments. The studies conducted using this model are intended to investigate the distribution behavior of the EM field around the line resulting from BPL injections—rather than the quantitative behavior of the field—in order to assess the FCC's proposed measurement procedures. The line was simulated for six frequencies of the BPL source 3, 15, 30, 40, 60, and 80 MHz. The results are described next.

1. <u>Field Distribution along the Line.</u>

The electric field is calculated as function of x for y=10 m and z=1 m. These coordinates correspond to the proposed procedure requiring that measurements be done 10 m away from the line with an antenna height of 1 m. The results are shown in Table 1. It is evident from the shapes of these graphs that the field is stronger near the source (around x=0). This is in agreement with FCC's prediction that most of the radiation will result near the injection point. The spatial oscillations of the field are due to the standing wave of the current on the line. The results in Table 1 were obtained terminating each line end with a 250 Ω resistor. Fig. A2 shows the effect of the terminal load (and, therefore, SWR) for three values of the resistor. It is seen that the load affects—as expected— the amplitude of the spatial oscillation of the field, but it does not modify the salient characteristics of the field distribution (i.e. the median of the graph).

Table 1: Electric field v. x for y=10 m and z=1 m, for 3, 15, 30, 40, 60, and 80 MHz: The values are normalized with respect to the maximum field.



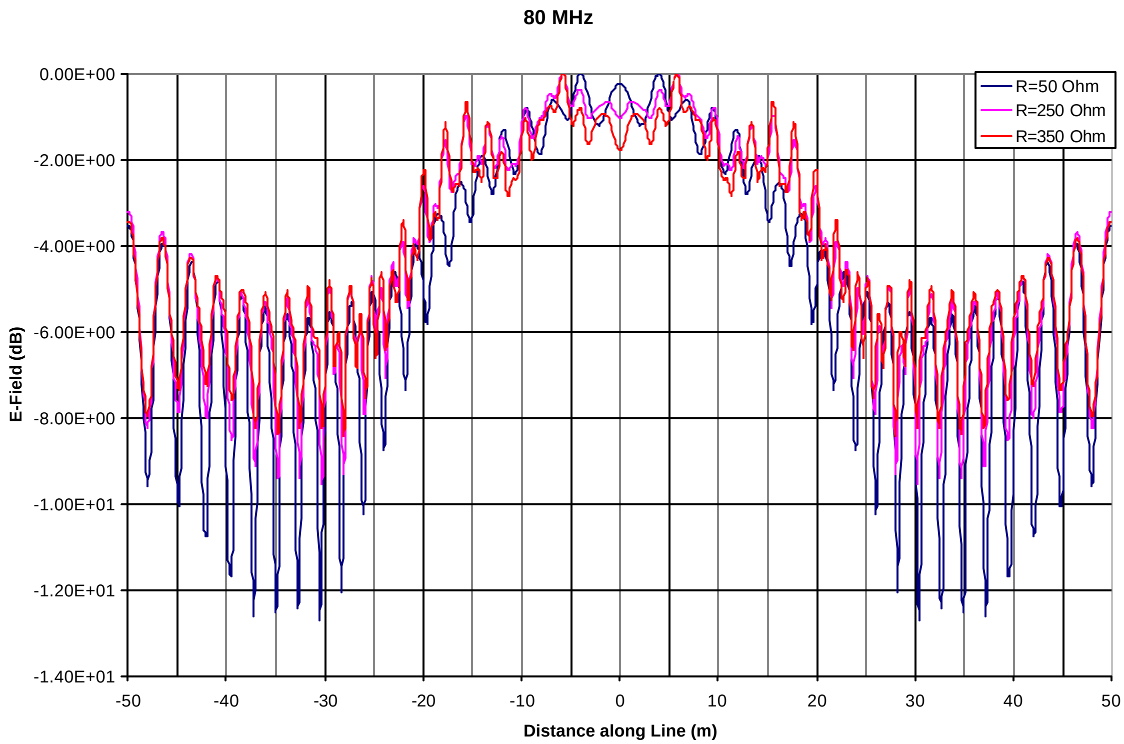


Fig. A2 Effects of the line terminal load on the field distribution.

2. Field Distribution in the Transverse Direction

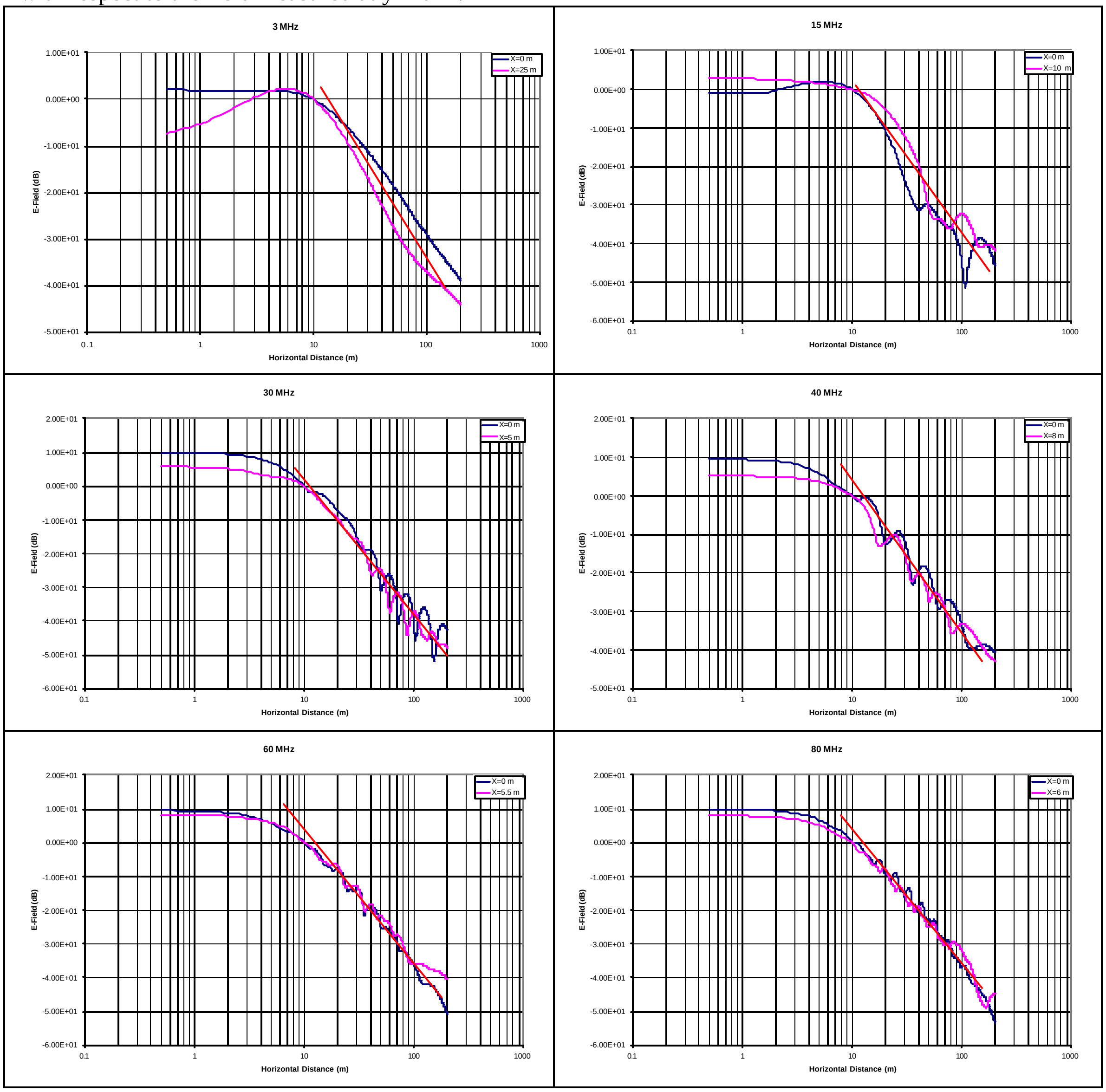
The field was calculated as function of y at z= 1 m and x=0 and x=½ of the wavelength. The results, shown in Table 2, were normalized with respect to the field measured at y=10 m.

With reference to Table 2, the field is approximately constant and it does not begin to decay until 5 to 10 m away from the line, depending on the frequency. The decay of the field is at a 40 dB/decade rate. The field profile indicates that the emissions around the line are reactive even to a distance of 200 m away from the line. This finding is consistent with the near field behavior of large radiators. Accordingly, the near fields of a radiator extends to a distance found from $0.62\sqrt{D^3/l}$, where D is the largest dimension of the radiator[A-1]. For a 200 m long line the near field region, calculated at 15 MHz (λ=20 m), it extends to 392 m around the line[A-2]; and at 80 MHz, it extends to 905.6 m.

[A-1] Constantine A. Balanis, "Antenna Theory: Analysis and Design", Second Edition, John Wiley & Sons, INC., 1997 (ISBN 0-471-59268-4), page 33.

[A-2] The far fields of the same radiator begin at a distance found from $2D^2/\lambda$ (see Balanis in footnote A-1); for a 200 m long line this distance is 4,000 m at 15 MHz.

Table 2: Electric field v. y for z=1 m and x= 0 and ½ of the wavelength. The field values are normalized with respect to the field measured at y=10 m.



3. <u>Field Distribution in the Vertical Direction</u>

This study was done to investigate the effect of additional measurements at different antenna heights. Accordingly, the vertical distribution of the field was calculated at x=0, ¼, ½, ¾, and 1 wavelength; the field was calculated as function of the height (z) varying the height from 0 to 15 m above ground. The locus of points where the field is calculated is shown in fig. A3; the distance of the point from the line is 10 m; this study setting corresponds to the measurement guidelines of the Commission. The results, shown in Table 3, are normalized with respect to the field at z=1 m.

The variation of the field with respect to the height is not monotonic. However, the rise of the field above the value measured at z=1 m over all the distances from the source (x values) is no greater than 4 dB.
A more meaningful assessment of the field at different heights is comparing to the maximum field over the five distances from the source (x=0, ¼, ½, ¾, and 1 wavelength) measured at z=1 m. This comparison is shown in Table 4.

The maximum value of the field calculated at each of the five distances at z=1 m is used as base reference to derive the values in Table 4. The first series in Table 4 is the field calculated at z=1 m at each of the five distances from the source. The second series is the maximum field calculated between z=0 and 15 m at each of the five distances. As it can be seen, the maximum field calculated at any height, up to 15 m, 10 m away from the line and at the recommended by the Commission five distances from the source rises only 3.5 dB above the field calculated only 1 m above ground.

An explanation of this apparent insensitivity of the field with respect to height is that the slant distance of any point 10 m away from the line and the source varies only slightly. With respect to Fig. A3, that distance is maximum at 1 m above ground equaled to 13.45 m, and it is minimum 10 m above ground equaled to 10 m. This represents a ratio of 1.345 or 2.57 dB, which is satisfactorily close to the calculated field variation along the height at y=10 m.

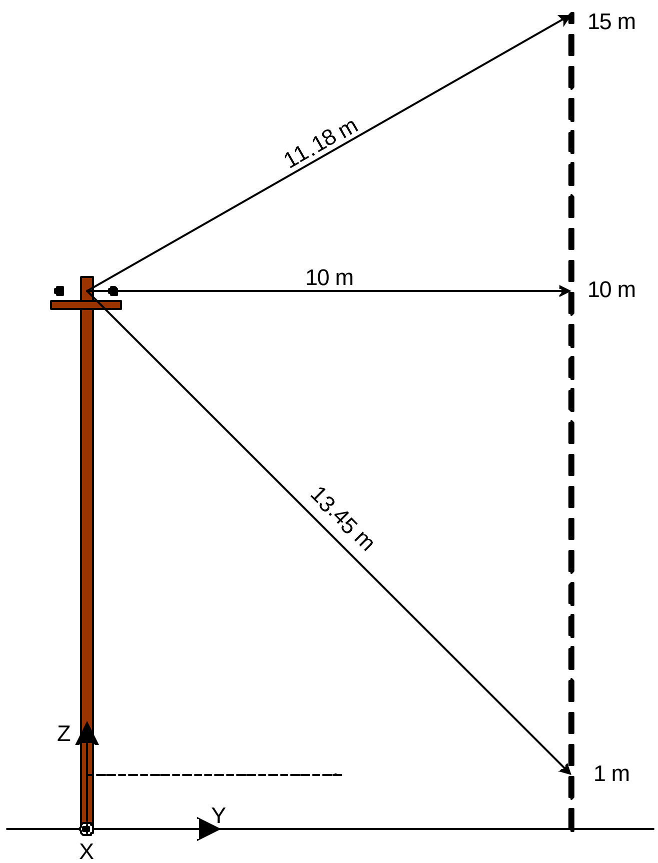


Fig. A3. Line Profile for measurement along different heights.

Table 3: Electric field v. z at y=10 m and x=0, ¼, ½, ¾ and 1 wavelengths: Values are normalized at the field measured at z=1 m.

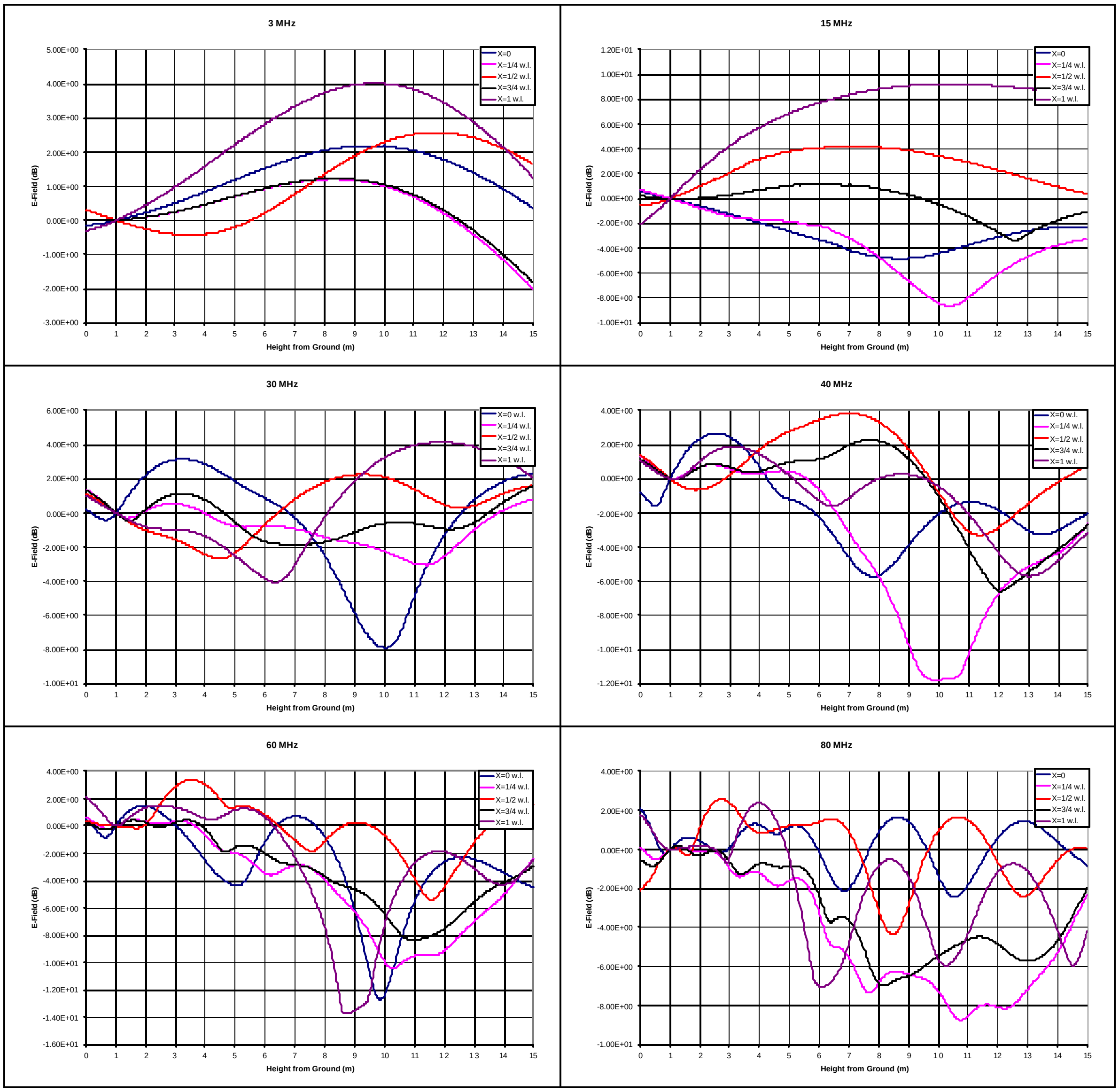


Table 4: Electric field tabulation at x=0, ¼, ½, ¾, and 1 wavelengths, y=10 m: first series represents the field at z=1 m; the second series is the maximum field calculated from z=0 to 15 m; all field values are relative to the maximum field measured at z=1 m.