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

In the Matter of	**)**	
	)	
Amendment of Parts 2 and 97 of the	**)**	**RM-_____**
Commission's Rules to Create a	**)**	
Low Frequency Allocation for the	**)**	
Amateur Radio Service	**)**	

To: The Commission

PETITION FOR RULE MAKING

The American Radio Relay League, Incorporated (the League), by counsel and pursuant to Section 1.405 of the Commission's Rules (47 C.F.R. §1.405), hereby respectfully requests that the Commission issue, at an early date, a Notice of Proposed Rule Making looking toward the amendment of Parts 2 and 97 of the Commission's Rules, as set forth in the attached Appendix B, to create an allocation, and service rules, for the use by the Amateur Radio Service of the frequencies 135.7 to 137.8 kHz and 160 to 190 kHz. As good cause therefor, the League states as follows:

I. Introduction and Background

1. The subject of a low-frequency allocation for the Amateur Service is not new. Prior to the World Administrative Radio Conference in 1979, the Commission conducted a series of proceedings in order to prepare its final allocation proposal for presentation to the International Telecommunication Union (ITU). The Commission first organized several advisory committees with jurisdiction over specific radio services. It then issued a series of Notices of Inquiry (NOIs) in Docket 20271, pursuant to which it developed its WARC-79 proposal. On December 28, 1978, it

issued a Report and Order which embodied its final determinations. This report, *inter alia,* addressed a proposal for allocation of the 160-190 kHz band for use in the Amateur Radio Service.

2. The Report of the Commission's WARC Advisory Committee for Amateur Radio, issued May 18, 1976, had stated as follows:

> There exists among some amateurs a keen desire to conduct experimentation and communication at low frequencies, as well as at vhf and uhf. The FCC authorizes the operation of low power communication devices in the band 160-190 kHz under Part 15, Subpart D, of its rules. Despite the severe restrictions of one watt power input and a total antenna length not to exceed 15 meters, experimenters have been successful in transmitting over paths of several hundred miles under favorable conditions. An amateur allocation with less severe restrictions in this band, which is now allocated to the fixed service in Region II but is little used outside of Alaska, would permit amateurs to resume experimentation in a portion of the spectrum which has not been available to them for more than 50 years.
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> *Id.* at 50.

3. There were a total of nine NOIs issued in Docket 20271. The Third Notice of Inquiry, FCC 76-1099, 41 Fed. Reg. 54309, contained an initial proposal for the International Table of Allocations. Based on public comments submitted in response to that initial proposal, the Commission issued a Fifth Notice of Inquiry, FCC 77-349, 42 Fed. Reg. 27756, May 23, 1977, which contained a revised table with comments responding to various comments received. It sought additional input regarding specific issues in the revision. A further revision of the allocation proposal was issued in an Eighth Notice of Inquiry, FCC 78-265, 43 Fed. Reg. 36139, released May 5, 1978.

4. After the release of the Third NOI, the Corporation for Public Broadcasting asked that the band 155-281 kHz be designated for use by a network of public broadcasting stations. In the

allocation table accompanying the Fifth NOI, the Commission incorporated that suggestion, but designated the 115-190 kHz band for the proposed broadcast use. That revised proposal was opposed by the electric utility industry, which claimed that the band was already used for control, monitoring, and protection functions, and that an extensive infrastructure of power line carrier terminals was operating in the band. Even though such facilities were unlicensed and functioned on a secondary basis, the Commission decided, in the Eighth NOI, to delete the low frequency broadcast proposal from the allocation table.

5. Nevertheless, the Commission sought public comment regarding two specific issues: (1) the extent to which such new radio broadcasting services are needed, and (2) the severity of the harm suffered by existing telecommunications services in the 115-190 kHz band. Specifically, it asked for comments regarding the rationale for use of that particular band, as well as the technical and economic feasibility of sharing of the band by broadcasting and existing users (power companies, railroads, and the rural telephone service). The Commission noted that the other users conducted high power operations in the band and questioned whether interference-
free broadcasting was possible. It also expressed concern over creating an international broadcasting allocation in the band.

6. The League filed comments in response to the Fifth NOI. In particular, the comments requested an amateur allocation in the 160-190 kHz band. The Report and Order terminating the proceeding, issued December 28, 1978 (FCC 78-849), contained the following brief discussion regarding changes in LF band usage:

> 21. The radio amateurs were most responsive to the Notices of Inquiry in this

> Docket. Their attempts to define their spectrum needs as well as to comment on the needs of other radio services provided useful information. Although many of their needs have been accommodated, it has proven impossible to satisfy their desire for a low frequency allocation. Power line carrier (PLC) operations and the extreme difficulty of satisfactory frequency coordination due to the unpredictable nature of amateur operations are obstacles to any amateur service allocation being proposed in this spectral range.
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> * * *
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> 28. Broadcast expansion also was proposed in the low frequency (LF) spectrum, at 115-190 kHz. The LF proposal was the subject of considerable comment by broadcasters, radio amateurs, the electric power interests and the Executive Branch. These comments addressed several issues: (1) the need for such an allocation; (2) the feasibility of sharing with existing services using the band; and (3) the economics and technical feasibility of such a service.
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> * * *
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> 31. Although there was considerable technical comment, the feasibility of sharing with the power line carrier (PLC) operations in this band and the probable interference to the broadcast service due to the high power operations of other radio services in the LF band has not been proved to our satisfaction. We must acknowledge, however, the importance of PLC operations in this band. Therefore, LF broadcasting allocations have been withdrawn from the attached proposed allocation table, Appendix 5 herein.

7. In a 1982 docket proceeding (Gen. Docket No. 82-9) initiated to consider establishment of current U.S. Footnote 294 in the Allocation Table which would specifically recognize PLC systems and provide for notification to other users, the Commission held as follows:

> Based on several comments in the proceeding [which] incorrectly speak of coordination rather than notification and of maintaining existing status of PLC relative to other Part 15 users, the Commission seeks to dispel any misunderstanding concerning the intent of this proceeding. Accordingly, the Commission wants to reaffirm its position that this proceeding does not elevate the status of PLCs in any way and that their operation in the band must be on an unprotected, noninterference basis to authorized users and at the same time on a co-equal basis to other unlicensed users operating under Part 15 provisions. Cooperation between parties to the extent practicable is expected but, in any event,

> the PLC users must realize that in the event conflicts on spectrum usage cannot be resolved on a cooperative basis, their operation on an unprotected, noninterference basis must adjust to meet the requirements of the authorized radio users.

Amendment of Parts 2, 15, and 90 of the Commission's rules to provide recognition for power line carrier operations of electric utilities in the bands 10-490 kHz, Report and Order, 48 Fed. Reg. 5922, 52 RR 2d 1713 (1983). As for the particular language to be used in the footnote, the Commission decided to urge, rather than require, cooperation in preventing potential interference because the milder language was "believed to be more in keeping with the nature of a notification action. On the other hand, the stricter ... language could be misinterpreted to convey that Commission or NTIA intervention for enforcement purposes is expected if parties will not cooperate, a situation which would implicitly elevate the status of PLC operators in an unintended manner." Id., paragraph 12. Accordingly, although PLC systems are explicitly recognized with a U.S. Footnote in the Allocation Table, they enjoy no special status as against other users in the band.

8. There currently is no low-frequency (LF) amateur allocation. There is an amateur allocation in all other areas of the radio spectrum, providing for experimentation in virtually all types of radio-frequency communications. Technical self-training and furtherance of radiocommunications development in the Amateur Service, essentially an experimental-type radio service, would be greatly enhanced by a low-frequency allocation in the vicinity of 160 to 190 kHz.

9. Radio amateurs in several other countries have been accommodated in the LF bands, many in recent months. In 1990, New Zealand radio amateurs were allocated 165-190 kHz, with an EIRP of 5 watts. In March of this year, Belgian radio amateurs were permitted to utilize 135.7 to

137.8 kHz at up to 1 kW Transmitter Power Output (TPO). Finland created an amateur allocation in the same band in April of 1997, at up to 100 watts TPO. Norway permits amateur operation in the same band (telegraphy only) at up to 100 watts TPO. In January of 1998, the United Kingdom permitted amateur operation at 135.7-137.8 kHz at up to 1 watt EIRP. Other countries permit amateur operation by special authority, or by experimental license. These include Germany, Iceland, Italy, Luxembourg and Australia. Other allocations of that band for amateurs are pending in France and Switzerland. These allocations were made pursuant to the European Conference of Postal and Telecommunications Administrations (CEPT) Recommendation 62-01 E (Mainz 1997), which pertains to the use of the band 135.7-137.8 kHz by the Amateur Service. The ultimate recommendation in that document is that the band 135.7-137.8 kHz may be used with a maximum effective radiated power of 1 watt on a secondary basis by amateur stations in CEPT countries. That band is allocated to the Maritime Mobile service and the Fixed service on a primary basis, but the CEPT recommendation notes that Amateur Service stations are used to sharing frequencies with other services which have higher category frequency allocations, and that the low frequency bands are of particular interest for investigation of little understood propagation phenomena.

10. Numerous amateurs (and non-amateurs) in the United States are now utilizing the 160-190 kHz band for experimental communications on an unlicensed basis pursuant to Section 15.217 of the Commission's Rules. This section permits operation at 160-190 kHz at up to one watt input power (exclusive of filament or heater power), but with substantial antenna size restrictions.[1] These restrictions are severe, and antenna efficiency is compromised. Experimentation is either precluded

[1] The total length of the transmission line, ground lead and antenna shall not exceed 15 meters.

or inhibited, and a specific amateur allocation with more liberal operating limitations is desirable.

11. This same point was noted by the League in comments filed with the National Telecommunications and Information Administration (NTIA) in 1992. NTIA responded in a report (NTIA Special Publication 94-31, *U.S. National Spectrum Requirements, Projections and Trends,* U.S. Department of Commerce, March, 1995) which stated, in part, as follows:

> In general, we believe that current amateur and amateur-satellite allocations should be retained. Amateur requests for international reallocations would be appropriate issues for FCC private sector advisory committees addressing U.S. preparations for future World Radiocommunication Conferences (WRC's). Additional allocations at 160-190 kHz, and near 5 MHz will require technical studies to determine the availability of these bands to support amateur use.

Id. at 168.

II. Allocation Status of 135.7-137.8 kHz and 160-190 kHz

12. The band 135.7-137.8 kHz is allocated in ITU Region 2 to the Fixed and Maritime Mobile Services. A footnote to that international allocation (454) indicates that for fixed service stations in the 90-160 kHz band and maritime mobile stations in the 110-160 kHz band, only emissions A1A, F1B, A2C, A3C, F1C or F3C can be used, except that emissions J2B or J7B emissions can also be used by maritime mobile stations at 110-160 kHz. In Region 1, the band 130-148.5 kHz is allocated to the Maritime Mobile and Fixed Services on a co-primary basis, and 148.5-255 kHz is allocated to the Broadcasting Service. In Region 3, the band 130-160 kHz is allocated to the Fixed, Maritime Mobile and Radiolocation services on a co-primary basis, and 160-190 kHz is allocated on a primary basis to the Fixed Service and on a secondary basis to the Aeronautical Radionavigation Service.

13. Domestically, the band 135.7-137.8 kHz is also allocated to the government and non-government fixed and maritime mobile services on a co-primary basis. The same footnote (454) applies. As well, footnote US294 states as follows:

> **US294** -- In the spectrum below 490 kHz electric utilities operate Power Line Carrier (PLC) systems on power transmission lines for communications important to the reliability and security of electric service to the public. These PLC systems operate under the provisions of Part 15 of the Federal Communications Commission's Rules and Regulations or Chapter 7 of the National Telecommunications and Information Administration's Manual of Regulations and Procedures for Federal Radio Frequency Management, on an unprotected and noninterference basis with respect to authorized radio users. Notification of intent to place new or revised radio frequency assignments or PLC frequency uses in the bands below 490 kHz is to be made in accordance with the Rules and Regulations of the FCC and NTIA, and users are urged to minimize potential interference to the degree practicable. This footnote does not provide any allocation status to PLC radio frequency uses.

14. The allocation status of the 160-190 kHz segment is similar to that of the 130-160 kHz band, but not identical. The Region 2 allocation is for the Fixed Service only. A footnote (459) states that the aeronautical fixed service is primary in polar regions above 60 degrees North Latitude (which includes most of Alaska) and 60 degrees South Latitude. Domestically, the band 160-190 kHz is allocated to the Government Fixed and Maritime Mobile services, and on a co-primary basis, to the non-government fixed service.

15. A review of government frequency assignments in the 130-160 kHz and 160-190 kHz bands in the United States shows that the U.S. Navy has assignments in both bands, and the United States Air Force Groundwave Emergency Network (GWEN) has assignments in the 150-175 kHz band. On information and belief, upon inquiry of the Navy staff, it is understood that most such sites are inactive. As evidence of this, groups of Part 15 experimenters in this band have logged

signals heard in the bands 130-160 kHz and 160-190 kHz. No signals have been noted other than longwave broadcast signals, mostly from Europe. It is understood by the League that the USAF GWEN system at 150-175 kHz is to be deleted and the transmitter sites are to be used for other purposes and managed by the United States Coast Guard. Apparently, the date for that transfer has not been established.

III. Power Line Carrier Systems

16. As discussed above, the power line carrier (PLC) systems have no allocation status in the bands below 490 kHz, but are permitted access to all frequencies in those bands pursuant to Footnote US294. Interference to PLCs is apparently not a significant issue, as will be shown herein, though PLC systems are in substantial use throughout the United States. Although, as a Part 15 user, PLCs have no interference protection status, the League's interest in the proposed allocation and in the avoidance of interference to incumbent users prompted an investigation of potential interference from amateur radio stations to PLCs by a search of the technical literature. The most important function of a PLC system is the tripping of a distant relay if a fault is detected by using either the Directional Comparison Blocking (DCR) or Direct Transfer Trip (DTT) method. No signal is transmitted with the DCR method until there is a fault, and interference can cause adverse performance only if it occurs simultaneously with that fault. A continuous guard carrier is transmitted with the DTT method and it is frequency shifted during a fault. In the case of DCR, there is a low probability of the amateur station being close to a power line and transmitting simultaneously with the DCR signal. In the case of DTT, the guard emission will alert the amateur to avoid that channel. In addition to relay tripping, both data and voice are transmitted over power

lines. In the unlikely event that interference to these communications did occur, it is not as serious as interference to DCR or DTT because voice and data transmissions can be repeated.

17. One main effort was to determine circumstances, if any, of false trips of relays caused by Radio Frequency (RF) energy from licensed systems to see if any have caused a power outage. Of special concern was any instance of such an event that may have endangered the safety of power utility personnel. It was the League's plan to review any such circumstances to determine how and if the proposed amateur operation could be configured to minimize or eliminate the likelihood of any such occurrence. However, no documented occurrences of false trips were found. Therefore, as the League's investigation could not firmly establish the absence of such instances, the League would be pleased to consider and address any published or unpublished reports documenting interference to PLC receivers from licensed or authorized radio systems.

18. Not having any specific information about work practices of power line personnel, League technical consultants referred to several paragraphs of the Part 1910 of the OSHA safety standards[2] relative to working on electric power circuits. From review of those standards, it would appear that any interference that caused a hazardous condition would probably be the result of an associated work procedure not being in accord with the OSHA standard. It would not seem reasonable that a power utility would use an unallocated, unlicensed system, subject to interference from licensed or authorized transmitters, if RF interference could cause a malfunction of the PLC system and endanger the life of power utility personnel.[3]

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[2] US Department of Labor, Occupational Safety and Health Administration, standards, Part 1910, Subparts R and S. (http://www.osha.gov/; click standards, Part 1910, and subpart R or S).

[3] Subsequent research and consultation with a recognized expert in the field indicates that there is

19. Neither does it appear that PLC systems are likely to receive interference which might interrupt the functioning of the power grid or have other adverse effects. Much of the following analysis relies on the results of Farrar, et al.[4] which was developed with the participation of NTIA, the Air Force, the Federal Emergency Management Agency, the Department of Energy, and several power utilities. The power utilities were the Nebraska Public Power District, UTC/Virginia Electric Power Company, UTC/Keller and Heckman, Tennessee Valley Authority, Nebraska Public Power District, Northeast Utilities Service Company, Public Service Company of Colorado, and Southern Colorado Power Company. Farrar, et al. developed three analysis techniques to examine the potential of interference to PLC from licensed systems. These techniques were compared by modeling a GWEN system (5 kW transmitter and 90 meter (295-foot) top-loaded vertical monopole) operating on a frequency of 170 kHz relative to a 161 kV line. The required distance separation necessary to avoid co-channel interference from a licensed system to a PLC varies by method. The three methods are as follows:

1. Coupling Factor Method
2. Field Intensity Method
3. Approximate Method

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no potential impact on safety of utility personnel relative to working on live equipment presumed to be dead. However, interference to PLCs could theoretically extend the clearing time of faulted electrical equipment.

[4] Farrar, A., Dobson, H., Wentland, F, EVALUATION TECHNIQUES- FIXED SERVICE SYSTEMS TO POWER LINE CARRIER CIRCUITS, NTIA Report 85-181, NTIA, September 1985.

The field intensity method is the most conservative, worst-case method, so it will be used for purposes of calculating necessary distance separation of PLCs from amateur transmitters.[5]

20. A significant finding of Farrar et al. was that a PLC receiver connected to a representative transmission line should perform properly if the field intensity surrounding that line emitted from a licensed or authorized radio transmitter does not exceed the levels shown in a given figure. The required field intensity (expressed in dB above one microvolt/meter) for two frequencies and four categories of power lines were extracted from figure 49 of Ferrar, et al., and tabulated here.

TABLE 1

FIELD INTENSITIES (dBμv/m) ACCEPTABLE TO PLC RECEIVERS
AT THE CLOSEST PASS OF VARIOUS KV LINES

	161 kV & less	230/255 kV	500 kV	765 kV
175 kHz	80	85	90	98
136 kHz	82	87	92	98.5

[5] Before proceeding with an interference analysis, a typical 161 kV power line was modeled as an antenna to determine the coupling between a power line and various amateur radio antenna designs. An analysis determined that the power line radiation or reception behaves like a long traveling wave antenna, which is commonly called a Beverage antenna. Balanis, C.A., writing in *Antenna Theory Analysis and Designs* (Harper & Row, 1982) states: "(t)he wire antenna of (Beverage configuration), when its height above the ground is small compared to the wavelength and its main beam is near the ground, is not an effective element for horizontal polarization. Instead, it is usually used to transmit or receive waves that have an appreciable vector component in the vertical plane." That is, a long power line has predominantly vertical polarization.

Several designs of antenna that might be used with an amateur radio station were analyzed, and it was determined that a tall vertical monopole would be a more efficient radiator than various horizontal designs. Therefore, it is concluded that the predominantly vertical polarization of the PLC power line and a vertically polarized amateur radio station antenna would provide the worst case. In addition, the analysis of Farrar, et al., relates the potential of interference from a vertically polarized emission to a horizontal power line and is, therefore, directly applicable to this interference study when the difference of the transmitter power is considered.

It remains to apply a propagation model and antenna efficiency calculations to determine at what distance an amateur station may be located from the closest pass of a power line carrying a PLC transmission and not trigger interference.

21. The tallest vertical monopole that should be reasonably considered for an amateur station is 61 meters (200 feet) because above that level, the amateur station would be required to obtain prior FAA authorization; and it would have to comply with FAA painting and lighting requirements. Very few amateur stations incorporate antennas of that height. Typically, a well-equipped amateur station would employ a vertical monopole of between 15 and 31 meters in height. Many other amateur stations would use shorter antennas, which need not be considered herein due to the severe reduction in efficiency that would result. The following table lists the EIRP from amateur stations that could be expected for various transmitter power outputs from three antenna heights. The table gives a range of possible EIRP. The highest value of EIRP is based on an unrealistic ground loss of zero. Only the inductor losses in the antenna tuner are considered. The smaller value is 6 dB less than the larger: a value that might be achieved at a high-end amateur station. The algorithms used to generate TABLE 2 can be found in APPENDIX B.

TABLE 2

A RANGE OF EIRP (Watts) FOR VARIOUS TRANSMITTER OUPUT POWERS (Watts) AND THREE VERTICAL ANTENNA HEIGHTS.
meters feet efficiency %

Tx PO	61m 200ft 1%	31m 100ft 0.2%	15m 50ft (0.02%)
1,500	4 - 15	0.8-3.0	0.08-0.3
500	1.3-5.0	0.25-1.0	0.03-0.1
200	0.5-2.0	0.01-0.04	0.001-0.004
50	0.13-0.5	0.03-0.01	0.003-0.01
10	0.03-0.1	0.005-0.02	0.0005-0.002
1	0.002-0.01	0.0005-0.002	0.00005-0.0002

A standard propagation model is:

$$E = \frac{300 \sqrt{P} \quad A}{D} \qquad (1)$$

Where:

E is field intensity, millivolts/meter
P is the EIRP power, kilowatts
D is the distance to the nearest point to a power line with a PLC system, meters
A is an attenuation factor based on earth characteristics, unitless

Solving for D:

$$D = 10^{\text{LOG}(300 \sqrt{P} \quad A) - (E'/20)} \qquad (2)$$

Where:

E' is E is from TABLE 1, dB relative to 1 microvolt/meter
P is radiated power, kW
A=1 (Earth is lossless)
D is distance between amateur station and power line, in meters

The assumption that A=1 means that the earth between the amateur transmitter and nearest power

line with a PLC receiver has no losses which will result in a overstatement of the potential of interference from the amateur station to the PLC system. Substituting into and solving equation 2 results in the following table of distance separations (in meters and feet) that is predicted to limit the field intensity of the licensed ARS at the specified power line at a level that has been accepted by the power utilities.

TABLE 3

SEPARATION DISTANCE TO AVOID INTERFERENCE TO PLC SYSTEMS OPERATING ON THE INDICATED KV POWER LINES
Based on no propagation path ground loss. Actual distances will be less.

Distance in Meters/Feet

EIRP - W	=<161 kV	230/245 kV	500 kV765 kV	
2	1300/4400	750/2500	400/1400	170/550
1	950/3100	530/1700	300/980	120/400
0.5	670/2200	380/1200	200/700	80/280
0.1	300/980	170/550	95/310	38/120

22. Hohn, et al.[6] reported on a survey in the IEEE Transactions on Power Delivery of power utilities that shows that licensed or authorized RF systems are not an interference problem for the PLC systems. Hohn examines the applications, maintenance, and problems of PLC systems in a survey of 150 utility engineers representing more than 13,000 PLC transmitters. The report indicates that PLC system operators have little concern about interference from licensed systems. The following are direct quotes from the survey.

[6] Hohn, J. W., et al, POWER LINE CARRIER PRACTICES AND EXPERIENCES, IEEE Transactions on Power Delivery, Vol. 10, No. 2, April 1995.

> "Eighty six percent of the utilities responding to the PLC survey have not developed a written procedure for the selection of frequencies."
>
> "A majority of the responding utilities (88 percent) indicated that they have experienced no interference problems from LF stations."
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> "Forty-six percent of the respondents indicated that they do not consider the location of low frequency radio facilities when selecting their PLC frequencies."
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> "Thirteen percent of the respondents indicated that their PLC systems have caused interference to other low frequency facilities (those in the 30 to 300 kHz band)."
>
> "Interestingly, the future use of power line carrier appears to be decreasing." " … 44 percent plan to use PLC less often."

23. A further search of the literature indicates that an increasing number of PLC systems uses synthesized transmitters that allow easy frequency change and allow the PLC to make more effective use of the LF spectrum. Also, many systems now employ forward error-correcting digital transmissions of data, which makes their systems nearly immune to interference. Voice transmission via digital means can produce "broadcast quality" audio with much less signal-to-interference than required by obsolescent analog systems. Other articles indicate that electric utilities increasingly prefer use of fiber optic circuits with associated higher speed and reliability, and which also provide the utility with the opportunity to lease the surplus bandwidth.

24. Amateur operation in a band with incumbent PLC systems would be similar to amateur operation in High Frequency bands shared with other services. The Amateur Service has proven its ability to share spectrum without causing interference to other services. New Zealand amateurs report to the League's representatives that their experience has been that the Amateur Service has not interfered with PLC facilities in New Zealand, though PLC facilities have

interfered with reception of amateur signals. However, the relatively wide band available there (165-190 kHz) has allowed amateur stations to find a clear frequency, away from the narrowband PLC signals.

25. From the foregoing analysis, the League concludes, and the Commission should find, that the potential of interference from an amateur station to a PLC receiver is indeed minimal. Only a small distance separation is needed to avoid interference. Based on the above information, provided by surveys of some 150 utility engineers, interference from licensed systems (even existing licensed systems, operating at ERP levels orders of magnitude greater than those proposed for amateur stations herein) to PLCs is not a significant problem. It is concluded therefore that amateur operation in the 135.7-137.8 kHz and 160-190 kHz will not likely cause interference to PLC systems.

IV. The Proposed Amateur Allocation and Service Rules

26. The League proposes, based on the foregoing, a domestic allocation on a non-interference basis to any non-amateur licensed station in the Fixed or Maritime Mobile Services in Region 2, an allocation at 135.7 to 137.8 kHz, and at 160-190 kHz. These allocations will permit experimentation with equipment, antennas and propagation phenomena in a small segment of the radio spectrum that has not been available to the Amateur Service for many years. It will provide the only low-frequency allocation for amateur use, and will accommodate more flexible experimentation than is permitted under current Part 15 regulations. It can be done without interference to PLC systems, and without interference to government assignments in the band, and without interference to facilities in other services internationally. The Amateur Service

would accept any geographic limitations necessary to protect government facilities remaining in the band.

27. It is proposed to limit transmitter power output from amateur stations in both LF segments to 200 watts PEP, but in any case limited so as to maintain a total EIRP not greater than 2 watts.[7] In most cases, at that transmitter power level, an EIRP of less than one watt is expected due to antenna efficiency and ground loss characteristics at those frequencies. Emissions would be limited to telegraphy, RTTY, data, SSB telephony, and image, which are the same emissions permitted in the 1800-2000 kHz amateur band.[8] This method of power limitation is unique in the Amateur Service, and it is inapplicable to amateur operation except in this context. The Commission normally measures amateur power by transmitter power output only, and for good reason: it is easily measured by Commission personnel for compliance purposes, and is conveniently monitored by licensees for general self-regulatory purposes. Antenna efficiency is not regulated in the Amateur Service generally, since the Amateur Service is an experimental radio service. However, in this one case, given the anticipated significant negative antenna efficiencies and ground losses expected, the measurement of power in both TPO and EIRP is unique, but appropriately so. It is proposed to allow amateur operation by licensees holding General, Advanced and Extra Class licenses.

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[7] The League notes that more than 2,500 systems are licensed or authorized to use the 10 to 490 kHz band with some transmitter powers over one million watts. Hohn, et al., notes that 88 percent of the PLC engineers surveyed have experienced no interference problems from LF stations. Since the documented stations that have an EIRP of thousands of watts have been shown not to be a significant interference problem for PLC systems, amateur radio stations emitting less than 2 watts EIRP appear to have interference potential several orders of magnitude less.

[8] See Appendix A hereto.

V. Conclusions

28. The League requests that the Commission proceed without delay to propose a domestic allocation for the Amateur Service, secondary to the Fixed and Maritime Mobile services in the 135.7 to 137.8 kHz band, and secondary to the Fixed Service in the 160-190 kHz band, with limitations in the Part 97 rules as set forth hereinabove, and in the attached Appendix B. Such is consistent with the basis and purpose of the Amateur Service, and it will further the technical self-training in the radio art that is a principal obligation of the Amateur Service.

Therefore, the foregoing considered, the American Radio Relay League, Incorporated respectfully requests that the Commission issue a Notice of Proposed Rule Making containing the elements proposed herein.

Respectfully submitted,

THE AMERICAN RADIO RELAY LEAGUE, INCORPORATED

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APPENDIX A

It is necessary to determine what ERP can be expected to be radiated from an amateur antenna system in the 160-190 kHz band. No calculations will be shown for operation on 136 kHz because the interference criterion is relaxed by about 2 dB on 136 kHz and the transmitting antenna is less efficient for the same physical size.

Hagaman (Hagaman, B.G., Low Frequency Antennas, Chapter 24, ANTENNA ENGINEERING HANDBOOK, second edition, McGraw-Hill, 1984) provides the following equations that will be useful in determining the radiation efficiency of a vertical monopole antenna. The variables are defined at the end of this APPENDIX. The equations are:

$Rr = 160\ \pi^2\ (h/\lambda)^2$	ohms of radiation resistance	(1)
$Zo = 60\ (\ln (h/a)-1)$	ohms of impedance	(2)
$Xa = -\ Zo \cot (2\ \pi\ h\ /\ \lambda)$	ohms of reactance	(3)
$Eff = Rr\ /\ (Rr + R)$	percent of radiation efficiency	(4)

Hagaman (Ref. 8) lists the system losses (R) as consisting of tuning loss (Rt), ground loss (Rg), antenna conductor loss (Rc), equivalent series dielectric loss (Rd), and losses in the structural support system (Rmisc). Of these losses he states that the principal loss in most systems occurs in the ground system and tuning network inductors so only Rr, Rt, and Rg will be considered. That is,

$Eff = Rr\ /\ Rr + Rt + Rg$	%	(5)

The most significant loss in the antenna tuner will be the series inductor to resonate the capacitive reactance of the antenna and it is assumed that is the only tuner loss. The required series inductor (Xt) will be a conjugate of Xa, that is, Xt =. -Xa. . The reactance of the inductor is $Xt = 2\ \pi\ f\ Lt$ while the resistance of the inductor is found from Q =Xt/Rt or R = X/Q. Solving for Lt,

$Lt = Xt\ /\ 2\ \pi\ f$	millihenry	(6)
$Rt = Xt / Q$	ohms	(7)

Calculation of the ground loss (Rg) is very complex and will vary widely at each site depending on ground constants and the ground screen system employed. Laport (Laport, Edmund A., RADIO ANTENNA ENGINEERING, McGraw-Hill, 1952) states that the ground loss value may well exceed the value of the radiation resistance (Rr) for many antenna types. For the purpose of this report following calculations will consider the case of a perfect ground (Rg=0) for the initial

calculations and then the resulting EIRP will be reduced by 6 dB to approximate the results that may be obtained by a well equipped ARS station.

Laport stated that a coil with a Q of 500 was representative for a commercial installation. An analysis of various coil configurations suggested that a Q of approximately 300 could be expected when made from standard materials. Therefore, a compromise Q of 400 was used in this analysis.

The definitions and values used in the above equations are:

Rr	is the radiation resistance of the vertical monopole, ohms
H	is the height of the antenna, 61, 31, &15 meters (200, 100, & 50 feet)
λ	is the wavelength, 1714 meters (5623 feet) at 175 kHz
a	radius of a cylindrical monopole, 0.25 meters (10 inches)
Zo	is the impedance of the antenna, ohms
ln	is the natural logarithm operator; a logarithm to the base of 2.718
Xa	is the reactance of the antenna, ohms
cot	is the cotangent operator for degrees
Eff	is the radiation efficiency of the overall antenna and ground systems
R	is the sum of all antenna and ground system losses, ohms
Rt	is the resistive loss in the tuner circuit, ohms
Rg	is the resistive loss of the ground, ohms
Xt	is the reactance of the tuner, ohms
Lt	is the inductance of the coil in the tuner, mH
f	is frequency, kHz (175 kHz)
Q	is the quality factor for the coil Lt, unitless, (400)

APPENDIX B

1. Section 2.106 of the Commission's Rules is amended in part to read as follows:

Band kHz	Government Allocation	Non-government Allocation	Remarks
130-160	FIXED MARITIME MOBILE US294 454	FIXED MARITIME MOBILE Amateur US294 454	The Amateur Service allocation is limited to 135.7 to 137.8 kHz
160-190	FIXED MARITIME MOBILE US294 459	FIXED Amateur US294 459	

2. Section 97.3(b) is amended to add a new definition, to read as follows:

(*) LF (low frequency). The frequency range 3 kHz to 300 kHz.

3. Sections 97.301(b),(c) and (d) are each modified to add, at the beginning of the table in each subsection, the following:

Wavelength band	ITU Region 1	ITU Region 2	ITU Region 3	Sharing requirements See §97.303, paragraph
LF	kHz	kHz	kHz	
2200m		135.7-137.8		(r)
1700m		160-190		(r)

4. Section 97.303 is amended to add a new frequency sharing requirement to read as follows:

(*) No amateur station transmitting in the 135.7 to 137.8 kHz segment or the 160-190 kHz segment shall cause harmful interference to any Government fixed or maritime station; any non-government fixed station; or, in the polar regions above 60 degrees North latitude, any aeronautical fixed station; nor is any amateur station protected from interference due to the operation of any such station.

5. Section 97.305(c) is amended to include, at the beginning of the table, the following:

Wavelength band	Frequencies	Emission Types Authorized	Standards See §97.307(f), paragraph:
LF:			
2200 m	entire band	RTTY, data	(3)
-do-	-do-	Phone, image	(1) (2)
1700 m	entire band	RTTY, data	(3)
-do-	-do-	Phone, image	(1) (2)

6. Section 97.313(c) is amended to include the following:

(*) The 135.7-137.8 kHz and 160-190 kHz segments, and the total Effective Isotropic Radiated Power (EIRP) shall not exceed 2 Watts.