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QST
OFFICIAL JOURNAL

OFFICE OF THE GENERAL COUNSEL
5101 Wisconsin Avenue, N.W., Suite 307
Washington, D.C. 20016
(202) 686-9600 telephone
(202) 686-7797 facsimile
W3KD@arrl.org

January 16, 2001

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Via Hand Delivery

Magalie Roman Salas, Secretary
Federal Communications Commission
445-12th Street, S.W.; Room TWD-204
Washington, D.C. 20554

Attention: Mr. Julius Knapp
Office of Engineering and Technology

Re: *Written Ex Parte Presentation*, RM-9404
Amendment of Parts 2 and 97 of the Commission's Rules to Create a Low Frequency Allocation for the Amateur Radio Service

Dear Ms. Salas:

Attached hereto on behalf of ARRL, the National Assocation for Amateur Radio, also known as the American Radio Relay League, Incorporated (ARRL), are five copies of a written *ex parte* presentation to the Office of Engineering and Technology, to be associated with the above-referenced pending Petition for Rule Making. The Petition, filed October 22, 1998, seeks a Low-Frequency (LF) allocation for the Amateur Radio Service at 135.7-137.8 kHz and 160-190 kHz.

The attachment is a report, submitted in response to some concerns on the part of the Commission's staff that there might be some potential for interaction between Amateur stations in the 160-190 kHz segment and unlicensed power line carrier (PLC) systems at separation distances of less than one mile. The report establishes that the interference potential to and from Amateur stations relative to PLC systems is such that, at distances approaching the threshold of interference from an Amateur transmitter to a PLC receiver, the interference to an Amateur receiver is so severe that the Amateur licensee will of necessity avoid the PLC operating frequency in order to establish and maintain Amateur communications.

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The report is submitted in order that the Commission might proceed with a Notice of Proposed Rule Making in this proceeding. There has been no progress in this matter since the close of the date for reply comments on the Petition, which closed January 7, 1999, two years ago. It is submitted that the Amateur Service has patiently awaited some Commission action on the ARRL Petition, and that such is overdue.

Should any question arise concerning this matter, kindly contact the undersigned.

Yours very truly,

Christopher D. Imlay
General Counsel

attachments
cc (by hand):
Mr. Julius Knapp, OET

OPERATING PROCEDURE THAT WILL ENSURE THAT ARS LF TRANSMISSIONS DO NOT INTERFERE WITH PLC RECEIVERS

by

Richard L. Wilder

Prepared by the
Richard L. Wilder Co
913 Shore Acre Rd
Arnold, MD 21012-1724
wilder@abs.net

for the
American Radio Relay League, Inc.

January 16, 2001

OPERATING PROCEDURE THAT WILL ENSURE THAT ARS LF TRANSMISSIONS DO NOT INTERFERE WITH PLC RECEIVERS

By Richard L. Wilder

EXECUTIVE SUMMARY

This report looks at the differences of interference potential between an LF amateur station and a Power Line Carrier (PLC) system. It shows that at distances approaching the threshold of interference from an Amateur Radio Service (ARS) transmitter to a PLC receiver, the interference to ARS receiver will be so severe that an ARS operator will need to avoid the PLC frequency in order to be able to communicate. This action by the ARS operator would ensure that the ARS emission would not cause interference to the PLC receiver.

INTRODUCTION

On December 6, 2001, representatives of the the American Radio Relay League ("the League") met with Mr. Julius Knapp at the FCC to discuss the request for LF bands at 135.7 to 137.8 kHz and 160 to 190 kHz. Mr. Knapp requested more information about the potential of interference if the ARS station were located appreciably closer than one mile from a power line used by a PLC system.

BACKGROUND

The basis for interference analysis in RM9404 [1] was from the most conservative of three analysis techniques developed by a Special Working Group (SWG) at the National Telecommunications Telecommunications and Information Administration (NTIA)[2] in agreement with power utilities and others. (References are on the last page.) The twelve persons making up the SWG were from the NTIA, USAF, non-military Government agencies, UTC, power utilities, and various consultants which includes the author.[1]

[1] Representation included the Nebraska Public Power District, UTC (Virginia Elect. Power Co), UTC (Keller & Heckman), UTC (NUSCO), and the Department of Energy.

The most difficult aspect of the NTIA analysis was to model the coupling loss at the power line interface.

The conclusions in the NPRM suggested that if an ARS station employed a 200 watt transmitter, a 200 foot tower, and an unrealistic ground loss of zero, then co-channel interference may occur at a PLC receiver connected to a 161 kV line at a distance up to between 1,300 and 4,400 feet. The model would predict a shorter distance if (1) the power line were rated at a higher voltage (higher masking noise), (2) either of the two less conservative analysis techniques were used, or (3) where a more typical (shorter) ARS antenna were employed. Therefore, it appears that the analysis in the NPRM could be considered the most extreme distance at which interference from the proposed ARS system to a PLC system could occur. If more typical characteristic were used to model the ARS station (0.1 watt ERP) then the calculated required distance separation for co-channel interference would be less than 980 feet on 161 kV lines and less than 120 feet on 765 kV lines.

SYSTEM DESCRIPTION - POWER LINE CARRIER

The power utilities send radio frequency (10-490 kHz) energy over their power transmission lines for communications and relay control. Typically 10 watt and 20 watt transmitters are used though some circuits use 100 watt amplifiers. Institute of Electrical and Electronics Engineers (IEEE) standard 643-1980 notes that RF energy is coupled into lines with impedances typically between 200 to 800 ohms with typical coupler losses of one or two dB.[3] Loss along the transmission line is mostly the result of radiation. The necessary received power is essentially dictated by the noise riding "on every power line" resulting from thermal agitation in the conductors, certain atmospheric and static discharges, and low level corona discharges.[2] The IEEE standard gives graphical representations of power line noise level verses frequency. In the vicinity of 150 kHz the noise level is typically at -30 dBm on lower voltage lines and can be as high at -5 dBm on 765 kV lines.

It appears that an important factor that allows PLC systems to operate with little concern about interference from a radiating system is that their receivers are directly connected to a transmission line that is connected to a distant transmitter. The result is the high received power is usually more that -30 dBm.

[2] One can confirm that noise rides along ALL POWER LINES. While traveling in an area with power lines, set the car radio to 530 kHz or other unused channel in the lower part of the AM band. This writer did this and observed that 12 out of 12 lines passed under produced receiption of a loud noise.

It is understood that PLC systems operated in the 150-175 kHz band along with an USAF system with 2,000 watt ERP (the USAF system is now off) and on other LF frequencies with systems operating with more than 10,000 watts of ERP. The IEEE paper noted in the NPRM stated that 46% of the PLC operators don't consider the location of LF facilities and 88% of the PLC operators have had no interference even during prior years when there were more LF high power radiating systems than now remain.

SYSTEM DESCRIPTION - AMATEUR RADIO SERVICE.

It is expected that low frequency operation by the ARS will focus on developing advanced techniques to communicate during adverse conditions with limited facilities. (Short distance communications could be more easily accomplished with FM VHF channels and long range communications by HF bands.) Some ARS operators may be interested in development of digital modulations suitable for penetrating the atmospheric noise. Both the digital enthusiast and others will be expected to attempt long distance communications on days with minimal atmospheric noise. Others may experiment with antenna tuners and antenna designs in an effort to raise their overall antenna system efficiencies. ARS operators in Europe are reporting that antenna efficiencies are less than 0.1%. Most ARS stations will use a separate active antenna for receiving with essentially a gain of 0 dB.

Receivers used by LF hobbyist in the US and by licensed ARS stations in Europe usually consist of a receiver designed for HF that also tunes down to 100 kHz or less but with a degraded sensitivity performance. The present trend is to add an external preamplifier to bring the receiving capability of typically -150 dBm. In an article in a monthly publication [4], the author reported on sensitivity measurements made on several off-the-shelf, and military and commercial surplus receivers. He made measurements on twelve receivers and reported that the noise floor ranged between -185 dBm and -137 dBm in bandwidths of a one to three kHz.

ARS operators are often efficient when dealing with interference. First, if interference is experienced in other than the ARS, the station may be assigned to specific frequencies and the operator is given little choice but to struggle with the interference. However, specific frequencies are not assigned in the ARS with the result that an ARS operator has the freedom to search throughout an allocation band and shift to a clear frequency. Such a procedure is widely used by the ARS operator in the 7.15 to 7.30 MHz band, which is shared with broadcast stations with transmitter

powers up to 500,000 watts. Before transmitting, the ARS operator will usually search for a unoccupied channel. The diligent operator using the 7.15 to 7.30 MHz band may keep a record of broadcating schedules so the operator will know which frequencies will be useless for ARS communications. In cases where a split operation (receiving on a different frequency) is used, the ARS operator often maintains a listening watch on his transmit frequency to be certain that interference has not come that may cover his transmissions. LF ARS operators can be expected to attempt long distance communications on days with minimual atmospheric noise and at receive levels near the noise floor of their receiver.

ANALYTICAL APPROACH

The following analysis will determine the difference in loss required to mitigate interference from the ARS transmission to the PLC receiver and from the PLC transmitter to the ARS receiver. This will be done by comparing received power noise levels at the PLC and the ARS receivers. The analysis will assume imposing a signal greater than the existing noise level at the victim receiver will be considered as interference regardless if that receiver has sufficient S/N to cover the interference.

Required loss is that loss necessary to be in an interference path so as to reduce the interfering signal in the victim receiver IF to an acceptable level. The required loss can be achieved by off tuning to another frequency or by inserting additional path loss by increasing the distance between the source and victim. The below analysis is based on co-channel tuning with off tuning considered to be implemented only after the ARS operator receives a PLC signal.

ANALYSIS

The classical wave propagation model to determine the received power is

$$P_R = P_T + G_T + G_R - L_P$$

where

P_T is the transmitter power,
G_T is the transmitter antenna gain,
G_R is the receiver antenna gain, and
L_P is the propagation loss.

However, in the case of a radiating (ARS) system verseus a conducted (PLC) system, the coupling loss (L_C) across the interface

at the power line must be considered. Therefore, the classical equation is modified to:

$$P_R = P_T + G_T + G_R - L_P - L_C$$

where

L_C is the coupling loss factor at the power line interface.

The definition of the variables to be used in the following have a subscript of lower case "p" appended to indicate it is relative to a PLC system and an "a" is relative to an ARS system. Reciprocity is assumed (the losses are not affected by the direction of propagation) so hence the loss variables (L_P and L_C) do not have the additional system subscript.

The received power at the ARS receiver input:

$$P_{Ra} = P_{Tp} + G_{Ra} + G_{Tp} - L_P - L_C$$

but:

$$R_a = L_P + L_C$$

so:

$$R_a = P_{Tp} + G_{Ra} + G_{Tp} - P_{Ra}$$

The received power at the PLC receiver input:

$$P_{Rp} = P_{Ta} + G_{Rp} + G_{Ta} - L_P - L_C$$

but:

$$R_p = L_P + L_C$$

so:

$$R_p = P_{Ta} + G_{Rp} + G_{Ta} - P_{Rp}$$

Where:

P_{Rp}, P_{Ra} = received power, dBm
G_{Tp}, G_{Ta} = Transmitter antenna gain (includes tuner losses), dB
G_{Rp}, G_{Ra} = Receiver antenna gain, dB
L_P = Pass loss based on the distance between ARS and PLC, dB
L_C = Coupling loss at the power line interface, dB
R_p, R_a = Required loss (L_P+L_C) to avoid interference, dB

Substituting some typical values except for Gta:

P_{Ta} = 200 watts = 53 dBm
P_{Tp} = 20 watts = 43 dBm
P_{Ra} = -130 dBm
P_{Rp} = -25 dBm
G_{Ta} = 1 % = -30 dB (Value for a high end ARS station)
G_{Ra} = 0 dB (An active antenna)
G_{Tp} = G_{Rp} = 0 dB

$$R_p = P_{Ta} + G_{Rp} + G_{Ta} - P_{Rp}$$
$$= 53 + 0 + (-30) - (-25) = 48$$

$$R_a = P_{Tp} + G_{Ra} + G_{Tp} - P_{Ra}$$
$$= 43 + 0 + 0 - (-130) = 173$$

Then the difference in the required loss is:

$$R_a - R_p = 173 - 48 = 125 \text{ dB}$$

That is, for the described interference couplets, the amateur radio receiver is 125 dB more susceptible to interference than the PLC receiver.

Some details omitted in this simple analysis are coaxial cable losses at both system, tuner losses at the PLC, the effect of using the 100 watt PLC amplifier (+7 dB relative to 20 W), and the probably that many ARS receive sensitivities could be better than -130 dBm. It is felt that no attempt need be made to model the radiation patterns of either the ARS or the PLC radiation because, due again to reciprocity, the antenna gains or losses would not be part of the (R_a - R_p) difference calculation. It is emphasized that the driver in the above analysis is the large difference in the typical operational received powers, which results in the other substitutions becoming relatively insignificant.

CONCLUSIONS

As shown in RM-9406, if an ARS station used an exceptionally tall tower and unrealistic low system losses were assumed, the separation distance to avoid co-channel interference would be less than one mile. Also from RM-9406, if the ARS station used a more typical tower height resulting in 0.1 watt ERP, the distance separation would be less than 980 feet on 161 kV lines and less than 120 feet on 765 kV lines. Remaining is to quantify the interference potential at distances less than shown in the NPRM.

Based on the above analysis, when the ARS is located sufficiently close to the PLC system to be at the threshold to cause interference to a PLC receiver, the PLC transmission will be at least 125 dB above the ARS receiver interference threshold. The interference received by the ARS could be some 125 dB above the receiver noise floor and be so severe that co-channel communications with other ARS stations would not be possible. In such a case, the diligent ARS operator would need to change his operating frequency to improve the ARS communications which would result in a mechanism that would ensure that the ARS station would not interfere with the PLC system. Also, it is reasonable to expect that future ARS LF operators (as experienced by HF ARS

operators that use 7.15 to 7.3 MHz) would maintain lists of PLC frequencies heard and avoid those frequencies so as to maximize the ARS station communications capability.

Implementing an ARS service in both the 135.7-137.8 kHz and 160 - 190 kHz bands is desired. The lower band would be harmonized with allocations of the CEPT, the European Conference of Postal and Telecommunications Administrations. The higher band is wider and would give sufficient spectrum to allow for an ARS operator to select a frequency that could be free of interference in either direction.

Notice that the above interference mitigation procedure is independent of the distance separation between the two systems. It is applicable to any distance to the extent that the ARS operator can hear the PLC signal.

REFERENCES

[1] RM-9404, "Amendment of Parts 2 and 97 of the Commission's Rules to Create a Low Frequency Allocation for the Amateur Radio Service"

[2] A. Farrar, H. Dobson, F. Wentland, "Evaluation Techniques - Fixed Service System to Power-Line-Carrier Circuits," NTIA Report 85-181, September 1985

[3] "IEEE Guide for Power-Line Carrier Applications," The Institute of Electrical and Electronics Engineers, Inc, ANSI/IEEE Std 643-1980, July 6, 1982

[4] John Reed, Ph.D., "Receiver Sensitivity at Low Frequencies," *The LOWDOWN,* The Longwave Club of America, December, 1998.