ANALYSIS OF COMPATIBILITY BETWEEN 135.7-137.8 kHz AMATEUR RADIO COMMUNICATIONS AND CO-CHANNEL POWER- LINE-CONTROL SYSTEMS

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Abstract

The compatibility between Power Utility Transmission Line PLC (Power Line Control) Systems and Amateur Radio transmitters operating in the International 2200 meter Amateur Radio allocation (135.7-137.8 kHz) is examined. The technical operating characteristics and typical deployments of PLC Systems are outlined. This paper concludes that there is a significant potential for compatible sharing of the same spectrum between the PLC, which communicates through signals conducted by power transmission lines, and licensed radio transmitters which use signals radiated over the air.

Introduction

(PLC) is a technology used on electric power lines for control, automatic protection, communication and telemetry. PLC uses signals below 490 kHz that couple to and propagate via transmission line conductors. A typical PLC system includes a 10- to 100-watt transmitter, a transmitter coupler, powerline isolators which decouple the power transmission line from adjacent sections, a receiving coupler and a receiver.

Applications of PLC include protective relaying, telemetry, voice communications, supervisory control, etc**.** The technique of protective relaying control is used for both protection relay activation and activation veto.

PLC System Protection

The Federal Communications Commission, in its Notice of Proposed Rule Making and Order in ET Docket No. 12-338, states: "...we would only consider adding an amateur allocation [of 135.7-137.8 kHz] if we were comfortable that amateur radio and utility PLC systems could successfully co-exist in the band.". In order to analyze the potential for interaction between Part 97 Amateur Radio operations to PLC Systems, two basic parameters must be examined: the noise floor of the PLC System and the amount of signal that an amateur operation will induce onto a transmission line that is reasonably terminated for PLC operation.

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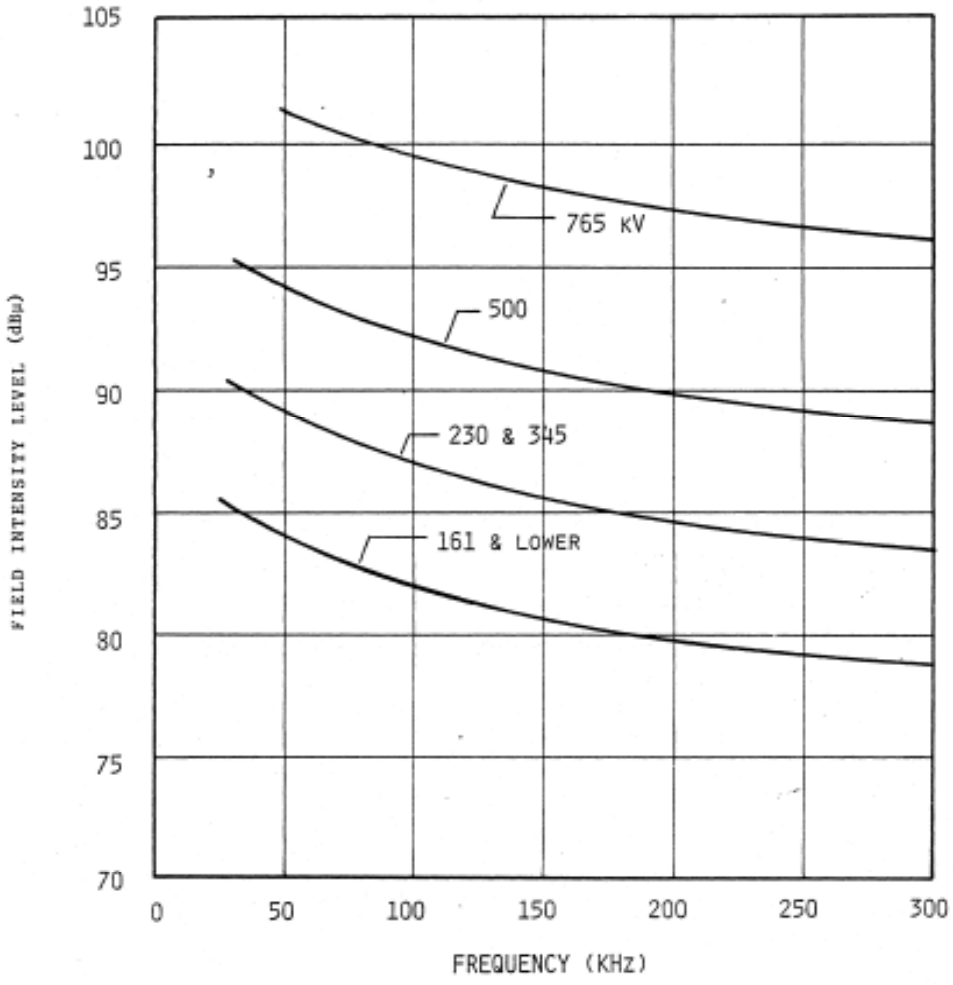

Figure 47. Field Intensity Levels From a Radio Transmitter Near a Transmission Line.

Figure 47 from NTIA TR-85-181 **[1]** *Adverse Weather Noisefloor Presented as F.I. (Field Intensity in dbu/m) versus Frequency. This shows the field intensity resulting from adverse weather present at power lines of different configurations*

Maximum Part 97 Power

In Part 97 rules, the normal method of determining the maximum power for an amateur station is by transmitter output power, but in several sections of Part 97, a maximum ERP is used to describe the maximum permissible transmitted power, e.g. the 60 meter maximum transmitted power as described in §97.313 (f) and the 611 watt ERP limitation for earth telecommand stations operating from specific locations §97.313(i).

The International power limit for Amateur Operation in the 135.7-137.8 kHz band is 1 watt E.I.R.P. (Equivalent Isotropically Radiated Power) pursuant to ITU Radio Regulations Footnote 5.67A:

5.67A *Stations in the amateur service using frequencies in the band 135.7-137.8 kHz shall not exceed a maximum radiated power of 1 W (e.i.r.p.) and shall not cause harmful interference to stations of the radionavigation service operating in countries listed in* No. 5.67. **[2]**

At a free-space distance of 1 km from the source, a 1-watt EIRP signal will present a field intensity of 5.48 mV/m (74.8 dBuV/m) **[3]** [2]**.** A field intensity of this level corresponds to a signal that is 6.4 dB below the 81.2 dBuv/m adverse- weather noise floor of a PLC system operating on a 161-kilovolt (or lower) transmission line and 23.4 dB below the adverse weather noise floor of a PLC system operating on a 765 kilovolt transmission line.

PLC System Noise Floor

The noise power induced onto a transmission line configured for PLC during adverse weather sets the noise floor of the PLC System's link budget. In footnote 45 of the NPRM and Order, the Commission notes:

> *NTIA Technical Report TR-85-181, titled "Evaluation Techniques – Fixed Service Systems to Power-Line-Carrier Circuits," U.S. Department of Commerce, Sept. 1985, at pp. 2-1, 5-77 suggests that in-band amateur service radio transmitters can operate compatibly with PLC systems if the electric field strength from the amateur service radio transmitters in the vicinity of the transmission lines does not exceed 81.2 dBμV/m.*
>
> *Specifically, using Figure 47, 81.2 dBμV/m is the threshold field intensity level for the frequency 136 kHz at which interference occurs to PLC systems on transmission lines with 161 kV and lower voltages.* **[4]**

A field intensity of 81.2 dBuV/m corresponds to the level from a 1-watt EIRP transmitter at a distance of 475 meters from the source, conservatively assuming far-field conditions.

At 1 km distance, the free-space field intensity of the 1-watt EIRP international limit is more than 6 dB lower than the interference-free operating levels determined by NTIA, thus affording sufficient protection to PLC systems from amateur transmitters operating in the 135.7-138.7 kHz band. Similarly, by limiting a transmitted Field Intensity to 74.8 dBu/m at the location of a power transmission line a transmitter operating at a distance separation less than 1 kilometer could reduce power below the 1-watt E.I.R.P level in order to achieve the needed degree of protection .

[2] Based on the formula in Reference **[3].**

Transmitter Power Limit as an Alternative to an EIRP Limit

ITU-R Recommendation M.1732-1 describes the typical Amateur Radio emission in this 137 kHz frequency range : **[5]**

Mode of operation	Slow Morse ≤ 1 Bd CW
Frequency band (MHz)	0.136
Necessary bandwidth and class of emission (emission designator)	1H00A1B 1H00J2B
Transmitter power (dBW)	23
Transmitter line loss (dB)	0.0
Transmitting antenna gain (dBi)	–22
Typical e.i.r.p. (dBW)	1
Antenna polarization	Vertical
Receiver IF bandwidth (kHz)	0.4
Receiver noise figure (dB)	13

The Federal Communications Commission in footnote 40 of the Notice of Proposed Rule Making in Docket ET 12-338 notes that in 2002, it considered limitations on the maximum PEP (Peak Envelope Power) transmitter power output of an Amateur station in this band;

> *The Commission also stated that it believed that sharing of this spectrum would be facilitated if the amateur station is limited to an EIRP of 1 W and the transmission bandwidth is limited to 100 Hz. Because of possible difficulty in measuring the EIRP of an amateur station in this frequency range, the Commission also proposed to limit amateur transmitter output power in this band to 100 W peak envelope power (PEP).* *Amendment of Parts 2 and 97 of the Commission's Rules to Create a Low Frequency Allocation for the Amateur Radio Service, ET Docket* No. 02-98, *Notice of Proposed Rule Making*, FCC 02-136, 17 FCC Rcd 8954, 8963 ¶ 25 (2002) (*2003 Amateur Radio NPRM) (FCC 02-136).* **[6]**

The nature of electrically short antennas that are used at wavelengths of 2200 meters will result in low radiation efficiencies such as indicated in ITU-R Recommendation M.1732-1. A 200 watt PEP output transmitter feeding an antenna with the -22 dBi gain used as an example in M.1732-1, coupled with a matching network with significant losses required to match the transmitter to the antenna, will provide an EIRP of no more than 1 watt (0 dBW). A PEP limitation of 200 watts is consistent with the international limitation of 1 watt EIRP. If a transmitter power limit is used as a method of controlling the field intensity of licensed signals that is simple to calculate, this limit should be calculated considering the definition of PEP in the FCC Rules (47 CFR § 2.1(c)).

Conclusions

The NTIA TR-85-181 Study has approached the compatibility of PLC systems and relatively high-powered licensed transmitters operating in the same frequency range as PLC systems. When the methodology of that study is applied to proposed amateur allocations near 136 kHz, the potential for interference is determined to be very low and only for amateur stations that may be located closer than 1 km to an existing transmission line. At distances of 1 kilometer or greater amateur operation at the 1-watt EIRP level, will be at least 6 dB lower than the field intensity that the NTIA determined would allow PLC systems to function reliably in the presence of licensed emitters. The same 6 dB margin can be achieved at distances closer than 1 kilometer by limiting the transmitted Field Intensity to 74.8 dBu/m at the location of a power transmission line. In this context it is noted that Section 15.3(t) of the Commission's Rules permits PLC systems to operate only on transmission lines, which are defined so as to *exclude* those electric lines which connect the distribution substation to the customer or house wiring.

This 6 dB safety margin is based on worst-case assumptions. The polarization difference between typical amateur vertical antennas that will be used on this band and horizontally configured power lines will provide an additional but indeterminate margin of interference protection.

Based on the NTIA Study TR-85-181, amateur operation at the 1W EIRP level will not cause interference to PLC systems used on transmission lines as defined in Section 15.3(t) of the Commission's Rules which are operating within the 135.7-137.8 kHz band, provided that separation distances from the Amateur station exceeds 1 km. from the PLC-carrying transmission line.

References

[1] Andrew Farrar et al., Evaluation Techniques—Fixed Service Systems to Power-Line-Carrier Circuits, NTIA Report 85-181 (1985).

[2] ITU Radio Regulations, Edition of 2012, No. 5.67A.

[3] National Telecommunications and Information Administration, Manual of Requirements and Procedures for Federal Radio Frequency Management, May 2010 revision of the 2008 edition, at 10.20.

[4] *Notice of Proposed Rule Making*, FCC 12-140A1, FCC Rcd. (released November 19, 2012), ET Docket 12-338, n.45

[5] ITU-R Recommendation M.1732-1, "Characteristics of systems operating in the amateur and amateur-satellite services for use in sharing studies", 03/2012, Table 1, at 3.

[6] *Notice of Proposed Rule Making*, *supra*, n.40.