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Comments on ET Docket No. 03-104 (FCC NOI 03-100), Inquiry Regarding Broadband Over Power Line (BPL)

As a degreed electrical engineer actively employed as a Principal Engineer in the development of RF and microwave hardware, as well as an Extra Class licensee (N3IW) in the Amateur Radio Service, I submit the following comments for ET Docket No. 03-104. These comments specifically address the 5 issues highlighted by the Commission.

Amateur Radio along with other licensees of the HF spectrum provide a valuable resource for worldwide communication. Governor Ed Rendell of Pennsylvania had declared June as "Amateur Radio Month" in recognition of the thousands of PA citizens that **volunteer** for disaster, local emergency, and public events communications. Hams are prohibited by federal law from receiving any compensation for their services, yet are often the first ones on the scene to provide communications. Recent events have shown a need for emergency communications that works "when all else fails" and hams are a national resource that fills a large portion of that need. This resource along with other HF spectrum licensees must be protected from unlicensed, harmful interference.

1. Current State of High Speed BPL Technology

While it is true that current technology allows for high speed data transmission, it remains to be seen whether a cost effective solution can be achieved to transmit high speed data through transformers and other utility equipment designed to be efficient at 60 Hz. It is not a trivial task to transfer signals spread across 2 to 80 MHz while maintaining the desired characteristics at 60 Hz and also ensuring the safety of the public and utility workers.

2. Potential Interference Effects on Authorized Spectrum Users

The Commission asks about Access and In-House BPL. Essentially, there will be no significant difference in the potential for interference to authorized spectrum users. Access BPL will be carried along the distribution system - an efficient antenna at HF frequencies and will require higher power levels to travel significant distances. In-House BPL, while likely at lower power and mainly restricted to building wiring, will produce roughly the same interference potential due to the greatly increased number of radiators. The American Radio Relay League (ARRL) has performed analyses examining various scenarios of BPL ⁽¹⁾.

These calculations are based on sound engineering principals and laws of electromagnetics. Essentially, BPL is a large HF phased array with the accompanying power combining properties of array systems. So, even if many, low power radiators are used, the effect can be as devastating as fewer, higher power radiators.

Current Part 15 limits for HF Radiated Emissions are $30\mu\text{V}/\text{m}$ at 30 meters. Given the proximity of most radio installations to power lines, the potential for interference is enormous for entire frequency bands, not just a few frequencies. For example, a typical Amateur Radio Service antenna installation can easily be found within 30 meters of a power line or building wiring. At 3.5 MHz with a half-wave dipole, $30\mu\text{V}/\text{m}$ would result in a $338\mu\text{V}$ signal across 50 ohms at the antenna feed. Even allowing for a few dB of cable loss, the receiver would see a signal greater than S9 + 10 dB. With the broad banded nature of BPL, this effectively renders HF communication impossible. In Japan where more extensive testing of BPL has occurred, the government came to the conclusion that the risk of interference is too great and has shelved any plans for implementation of BPL in that country ⁽²⁾. The ARRL calculations agree well with measurements and calculations performed in Japan on BPL.

Interference potential for frequencies above 80 MHz is also a very real possibility. Not only will there be harmonic and non-harmonic spurious arising from the modulation scheme and non-linearities of the electronics in the system, environmental factors creating corrosion on the power lines will cause spurious from diode junctions. The resulting interference could wreak havoc on VHF/UHF low-signal operations located well above the BPL operating frequency. Harmful noise resulting from faulty power distribution equipment often results in a letter from the FCC to a power company documenting interference to licensed users ⁽³⁾. This is just from the 60 Hz line frequency.

Spread-spectrum modulation schemes are sometimes claimed to prevent interference to other occupants of the same spectrum. This is true for a small number of spread-spectrum radiators as the contribution to the overall noise background is also small. However, for a large number of users as would exist in a BPL implementation, the effect on the noise power cannot be ignored and will become more significant as more users are added. Again, in lieu of any cooperation in testing BPL, the ARRL has calculated the effects of the increase in background noise due to BPL. These calculations also agree with Japanese and Dutch measured studies of BPL. Not only will weak-signal and low-power operation become infeasible, but the need for higher transmitted power to overcome the higher noise will increase the interference to BPL from authorized spectrum users.

The electromagnetic Theory of Reciprocity for antennas guarantees that as efficiently as the power line will radiate a signal, it will just as effectively receive one. The electric utility industry itself recognizes the potential for this kind of interference in its own comments regarding a recent Commission action on a low frequency allocation for the Amateur Radio Service ⁽⁴⁾. The power grid is less efficient an antenna (both transmitting and receiving) at 136 KHz than it is at the HF spectrum, yet the utility industry recognizes the interference potential at 136 KHz from just the Amateur Service while denying the likelihood of more extreme interference to BPL from any of the licensed users of HF spectrum. The utility's usage of control signals via the power lines are likely a low duty cycle type of usage;

however, BPL will have 100's or 1,000's of users at any given time increasing the likelihood of service disruption due to legal, licensed use of the HF spectrum. Additionally, the alleged interference from the Amateur Service at 136 KHz would arise from a low power transmitted signal, while the Amateur Service is allowed to use 1500 W of output power and high gain antennas in the HF spectrum. Surely, if interference from licensed users at 136 KHz with low power was a concern, interference from licensed users of the HF spectrum is a certainty. As an unlicensed Part 15 user, BPL must accept any and all interference from properly operating licensed users. Will the consumer understand this and will the utility industry make this known to the consumer?

3. Test Results from BPL Experimental Sites

While small scale testing has been on going, no coordinated effort between the utilities and licensed users of the spectrum has occurred. Most users of the spectrum were unaware that any testing was occurring and most likely did not know how to identify any interference that may have occurred. Test sites were generally unpublished and no useful statistics can be inferred from the tests to date. For meaningful data, testing between the utilities and organizations such as the ARRL must be coordinated and reviewed by all parties; particularly all authorized users of affected spectrum. Test results from Japanese and Dutch studies have conclusively shown harmful interference to users of spectrum where BPL is present⁽²⁾.

4. Measurement Procedure

Because BPL involves wideband modulations and multiple emitters with efficient arrays of radiating elements, typical testing for Part 15 compliance does not adequately address the interference potential. Multiple measurements along transmission paths must be made to ensure that a null was not measured since any transmission line or antenna will have a standing wave associated with it. The power line looks like an antenna to HF frequencies and as such will have a certain radiation pattern. This pattern must also be taken into account for field strength measurements. The pattern and standing waves will vary with frequency, thus many frequency points or swept-frequency measurements across the band will be needed. Measurements outside the BPL band will also need to be performed to ensure no harmful spurious emissions are generated either through the BPL circuitry or the power distribution equipment. Power levels and spectral density will vary with the number of users on the BPL system. Measurements of linearity and spectral power density similar to those used in the cellular phone industry for CDMA signals may be more appropriate in the case BPL. Noise power cannot be overlooked as an insignificant contribution to the interference equation. Current measurement standards are not meant to address these situations and the ARRL is formulating a measurement methodology based on criteria to allow for accurate measurement of the various interference configurations to ascertain the harmful interference to authorized users of the spectrum.

5. Changes to Part 15 Rules

By asking for changes to the existing Part 15 limits, the BPL industry seems to be acknowledging that BPL cannot effectively be implemented at this time. Should one technology be given special treatment where many others are abiding by the rules and not producing harmful interference through cooperation with licensed users of the spectrum? Even with existing limits under which BPL can be deployed today, harmful interference will most certainly result to and from authorized users of the spectrum as well as potentially harmful interference to spectrum users outside the BPL frequency range.

Given the incompleteness of testing carried out to date in the US and the proven potential for harmful interference to **all** licensed users of the HF spectrum (based on measured data in other countries and ARRL calculations), it is premature to consider granting wide scale usage of BPL. Much more coordinated testing needs to be conducted with better test methods than currently specified in Part 15 Rules. It is especially premature to consider any relaxation of the Part 15 Rules for BPL and, according to documented studies and calculations, it will be necessary to tighten BPL emission levels to prevent harmful interference to licensed HF spectrum users.

Sincerely,

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Footnotes:

- (1). www.arrl.org/tis/info/HTML/plc/files/C63NovPLC.pdf
- (2). [www.arrl.org/tis/info/HTML/plc/#Amateur Interference Studies](http://www.arrl.org/tis/info/HTML/plc/#Amateur_Interference_Studies)
- (3). www.arrl.org/news/enforcement.logs
- (4). FCC Report and Order FCC-03-105