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

In the Matter of	)	
	)	
Inquiry Regarding Broadband Over Power Line Systems	)	ET Docket No. 03-104
	)	
	)	

Via the ECFS

REPLY TO SEVERAL COMMENTS by Leonard H. Anderson

I wish to thank the Commission for providing a forum for commentary by all citizens. Please allow me to state that I am a retired electronics design engineer with no vested interest in any professional or amateur radio activity or educational institution nor communications service provider nor any of those who have commented on this docket's subject. All of the following comments are those of a private citizen fortunate to experience a half century in the radio-electronics industry and military of the United States.

I wish to personally thank several individuals who have taken the time and trouble to provide some technical insight into the subject of Broadband over Power Lines. Those in particular are Dr. Michael Keane[1], Michael C. Tope[2], W. Lee McVey[3] among several who have examined the situation from a critical technical and engineering viewpoint. I consider it important that any Notice of Inquiry on a technical subject be answered in technical terms rather than generalized, undetailed promises.

[1] Reply Comments of 20 August 2003

[2] Reply to Comments of 18 August 2003

[3] Comment of 24 June 2003

On the Comments of the American Radio Relay League

The comments of the ARRL can only be faulted in being incomplete.[4] In the exhibit radiation model computer simulation done by Mr. Ed Hare of the ARRL Laboratory, it does not consider the common three-wire distribution system nor any other conductors above or below those power wires, nor in any "drop" (colloquialism for connection to a building from a utility pole connection). The model example of asymmetric RF injection would be correct as used with any vaguely-described BPL device.

To explain the above, I cite a typical example of urban electric power distribution in the San Fernando Valley suburban section of Los Angeles, California, for older, above-ground utility distribution:[5] Utility poles are approximately 10 meters in height with a 4.4 KV three-wire distribution line set on cross-arms at the top. Those 4.4 KV AC lines have connections to pole-mounted transformers to drop the distribution line voltage to the 115/230 VAC three-wire connection to each subscriber's building. One transformer serves to supply lower-voltage electrical power to approximately 20 residences. The lower-voltage lines (3 wires) are run along the utility poles at about the 7 meter height above ground. The spacing is variable, ranging from about 8 cm to 12 cm. The 4.4 KV triad is spaced horizontally over about a 1.5 meter width. The drop, or connection from utility pole to a residence, is a twisted wire triplet, sloping downwards to a residence connection about 3 meters above ground level.

Lead-sheathed telephone cable is strung at about the 6 meter height above ground with separate drop wires to residences. Cable Access TV coaxial cables are located approximately 5 meters above ground. In the writer's location there are presently three such CATV lines to permit a choice of regular,

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[4] Multiple comments, best represented by those of 20 August 2003 including several exhibits and attachments. Case in point is the "transmission line radiating model" done by ARRL Laboratory.

[5] Municipal building and electric codes for Los Angeles County have dictated new construction's wired utility distribution to be underground for the last three decades. The example is the writer's residential area which began construction in 1961. Later sections of the neighborhood were constructed in the 1970s with all wired utilities underground. The Greater Los Angeles Area was one of the pioneers in implementing the National Electrical Code.

special subscription, or digital television distribution connections.

All of the four groups of wires are metallic conductors of radio frequencies and are in rather close proximity for frequencies in the range of 1.7 to 80 MHz. It is obvious that there will be some mutual coupling of radio frequency energy from any one set of conductors to another set under such close spacings. Since all of the drop connections are sloping and of various lengths ranging from about 8 meters (shortest) to about 24 meters (longest observed), this adds to the possibility of radiation from any RF sources at the subscriber's building or from along the utility distribution lines.

At each electrical power drop point termination, the power lines enter a grounded vertical rigid conduit fitting colloquially referred to as a "periscope."[6] A circuit breaker box is located within the building at the bottom of the periscope with an electric meter outside the building on the opposite surface of the power drop terminus wall. In the Los Angeles Electrical Codes of the 1960s, grounded-to-breaker-box rigid or flexible conduit was required for all in-dwelling electric power wiring. In other areas of the USA municipal codes allow two- and three-wire cables colloquially referred to as "romex," with or without any conduit. Non-metallic conduit is permissible in some areas of the USA.

The break-out of the three-wire drop of electrical power from the breaker box to various outlets and connections in the building depends on the desired voltage at outlets and connections. The three wires are often described by various names (depending on locality) but can be said to be "Phase A," "Neutral," and "Phase B." For nominal 230 VAC building distribution, connections are made to the two "Phases." For the vast majority of outlets and connections in a dwelling, connections are made between one of the "Phases" and "Neutral" to provide a nominal 115 VAC.

The point of this elaborate explanation is that any device connected to a 115 VAC outlet is <u>not</u>

[6] The grounding is a metallic connection to an earth ground rod as specified in Los Angeles Electrical Code. The actual grounding for RF considerations is highly variable in quality of conduction since the soil in the region runs a gamut from seawater-aided conductivity near beaches to arid desert soil.

symmetric to the external electric power line connection. That must always be considered for devices that either generate RF energy or are susceptible to RF energy. Asymmetry in connection destroys the concept of power wiring as a balanced transmission line for radio frequency energy.

Is electric power wiring an actual *transmission line?* Only in the most general of terms. Under the NEC in the USA, electric power wiring does indeed transmit 60 cycle alternating current very well with low internal losses.[7] However, the same is not true for radio frequencies. A radio frequency transmission line requires a uniform characteristic impedance.[8] The characteristic of an RF transmission line depends on physical uniformity of conductor shapes, sizes, and spacings, the dielectric constant of insulating material among other things. *Discontinuities* along a transmission line that disturb the characteristic impedance will result in a loss of RF power transfer.[9] In the case of unshielded RF transmission lines, discontinuities or asymmetry of RF energy feed or pickup result in radiation or RF energy.[10]

Is the electric power wiring within a building uniform enough to be considered a radio frequency transmission line? Far from it! In the more common method of construction of electric wiring within a conduit of some sort, individual wires are inserted or pulled-through without regard to any uniformity in physical spacing (to conduit walls or other wires). Electric power wiring in a building has **never been specified in any way as a radio frequency range transmission line!**

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[7] The National Electric Code (NEC) of electric power construction standards and regulations should not be confused with the Numerical Electromagnetic Code (also NEC) which is the computer coding for the Method of Moments algorithms used in radiating structure computer analysis programs.

[8] The properties and theory of radio frequency transmission lines is explained in a host of electronic texts available on the market today as well as in libraries.

[9] A *discontinuity* is any abrupt change of characteristic impedance, conductors other than the transmission line connecting to parts of the line, or any number of other connected transmission lines which are not terminated in their characteristic impedance. Such conditions are common in microwave to HF systems and very familiar to engineers and technicians working with those systems.

[10] This is particularly true in RF transmitters having asymmetric connections while using *balanced lines*. The result can be considerable RF energy reflected back down the line and re-radiating from the feedline. That has been a typical condition with radio transmitters all throughout the previous century.

In the Exhibit 1 attachment to the Comments of Main.net Communications, Professor Holger Hirsch improperly critiques the ARRL for their Exhibit A simulation model.[11] Professor Hirsch should be chided for not recognizing the common USA urban distribution methods and in the presumption that an above-ground utility pole distribution wiring system is a symmetric radio frequency transmission line equivalent. **There is hardly any data available to the electronics community in general proving that United States electric power distribution wiring is suitable for a radio frequency transmission line over the range of 1 to 80 MHz.** Even so, there is **no government code** requiring that electric power distribution lines be uniform radio frequency transmission lines in the 1 to 80 MHz range or at any other radio frequency range.

The common USA electric power distribution system in residential areas is three wires, not two, and there is no requirement that such electric power wiring is either uniform or terminated at its ends sufficient to reduce discontinuities to a minimum at radio frequencies of 1 to 80 MHz. The ARRL model was an attempt to compensate for finite physical and memory limits in the available computer analysis modeling program. **Any elevated wire conductors that are unterminated at radio frequencies will become radiators of those same radio frequencies.**[12]

It is highly improper to presume that any elevated pair of wires will magically become just a non-radiating transmission line over an 8-octave radio frequency span. The electric distribution lines close to the electric power end-users are triplets, not pairs. The electric power distribution wiring within a dwelling almost always connects to only two of those three wires, thus creating an asymmetry and thus, a

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[11] Reply Comments of Main.net Communications Ltd, 20 August 2003, Exhibit 1.

[12] Those are called "antennas." That is axiomatic to anyone who has either studied the subject of antennas or worked with them and considered their transfer characteristics to *free space* (or the rest of the universe). All wire antennas are elevated conductors which are not terminated as transmission lines.

discontinuity.[13]

On the Document Posted on the ECFS by OET on 16 Sep 03

This document is apparently from a group member of the International Electrotechnical Commission and is identified in the upper right corner of page 1 as "CISPR/WG3/ISN Task Force (Martin) 03-01rev1, September 15, 2003." It is unclear whether the document author is with the FCC or the IECQ-CECC; the document author is not fully identified although, from the text, the author is not with the FCC.

In the second paragraph on page 1 there is this sentence: "A conducted test is being considered for frequencies below 30 MHz because of the difficulty of building a representative test fixture for radiated testing when wavelengths may be 10's or even 100's of meters." This is puzzling because of the established fact of testing done by the FCC and NTIS on Radio Frequency Levels below 30 MHz as they apply to amateur radio installations. Such testing was used to determine the required maximum human exposure levels to be incorporated into Part 97 CFR.

It is even more puzzling in that the testing, supposedly done by the FCC, is not immediately visible on the FCC website. Either that is an oversight or the test information is, for some reason, kept out of public viewing.

If anything, the technical information contained within the document indicates that residential electric power wiring is far from being any sort of transmission line (Figure 8, "Magnitude of Mains Impedance," page 8). Asymmetric Mains impedance magnitude varies from about 1.8 Ohms to 200 Ohms depending on frequency from 0.1 to 30 MHz. Symmetric Mains impedance magnitude varies from 3 to

[13] True for the nominal 115 VAC wall receptacle devices.

about 300 Ohms over the same frequency span.[14]

Any RF transmission line with impedance magnitude characteristics varying 100:1 highest to lowest over a frequency span is not considered as a stable medium to use in RF energy propagation device. Considering that both residence and business buildings have unique electrical power wiring arrangements and circuits, none of them terminated at radio frequencies, it beggars the imagination why electric power wiring within the home can ever be considered as a marginally-stable for conducting any RF energy.[15]

To reiterate, USA electric power wiring has never been standardized or regulated as any sort of radio frequency transmission line beyond the 60 Hz alternating current electric power frequency . Pretending that the enormous base of installed building wire in the USA is in any way suitable for an RF transmission line application is technological folly. Pretending that the utility company electric power wiring external to buildings is suitable for an RF transmission line simply compounds the folly.

Telephone, television, wired local-area network wiring does work well over very wide bandwidths because all such wiring is fabricated to controlled characteristic impedance specifications with source impedances of generators matched to the lines and load ends properly terminated. USA electric power wiring was never so characterized or manufactured over anything but 60 Hz AC.

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[14] The definition of "symmetric" and "asymmetric" are given in the document. This is confusing when applied to USA residential electric power wiring to NEC standards with nominal 115 VAC definitely being asymmetric as to the dual-phase voltage of the drop line.

[15] This is exacerbated by circuits which are switched in and out of electric power circuits, resulting in a highly-variable equivalent length of differing line lengths in parallel with un-switched distribution wiring. The effect is known to microwave and UHF technologists as "stub tuning." While stub tuning is usually done to effect a better impedance match between source and load, improperly-tuned stubs can cause an immense change in impedance in such circuits.

That cannot be done effectively simply by plugging into some building's wall outlet with a test fixture and measuring RF radiation as in the IECQ-CECC document. That needs to be done on many different buildings, each at many different outlet locations, all taking into account the various electric power wiring differences that exist in the USA. That needs to be done also on the exterior electric power wiring at various USA locales with a varying arrangement of near-field parallel conductors such as MV distribution lines, telephone, and television cables in-place, either all or partial.

Such testing must be done by independent organizations having no stake in either BPL future manufacture or the competitors in broadband data communication providers.

Accepting the BPL advocates' claims that "BPL works well with an installed base of devices which work well" is not technically viable. Phonex makes such an implication on its products as well as for BPL devices.[16] By example, this writer is on a second pair of Phonex power-line coupled remote telephone couplers which do not work at all in certain locations of my home. The reason for their not working may be explained by the outlets desired to be used are on different branches of the three-wire split-phase electric power feed to the residence. There is a great deal of attenuation at HF between the two outlet locations in the same dwelling.[17]

Of the many Comments and Replies on Docket 03-104, not a single one of the BPL advocates had any technical information on the efficacy of their BPL devices. Only generalized, non-quantitative phrases were used throughout. Current Technologies' reply comment contains several glaring errors on the

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[16] Reply Comments of Phonex Broadband Corporation, undated but listed as 20 Aug 03 on ECFS.

[17] Measured with a Hewlett-Packard 606 and 608 RF signal generators and Hewlett-Packard 432 power meter using suitable 60 Hz AC blocking filters and accounting for test filters' attenuation alone measured at HF. That attenuation measured in excess of 40 db over much of the HF, the limit of this testing setup.

technologies of fields and waves and random noise power.[18] On page 2 of their document they state: "Because transformers are usually spaced hundreds of feet apart, only a few devices in total can operate simultaneously over a block-sized area. This fact, coupled with the rapid drop-off of signal strength from a point source emitter (due to free-space attenuation), means there is no harmful aggregation of emissions." Far-field (greater than 5 wavelengths) RF power varies as the inverse square of the distance; that is a physical fact. Whether or not that is a "rapid drop-off" depends upon individual subjectivity. Regulations on RF radiation levels are not subjective.

All random noise sources' power, including pseudo-random noise sources, add. That is basic and in all electronic texts dealing with noise and signals. If two or more Current Technologies' BPL devices are operating at the same time, their RF radiation powers will add presuming they employ some means of pseudo-randomness to their operation.

The environment of above-ground utility pole distribution is hardly a far-field one. With typical utility poles at about 10 meter height and wires, cables at the topmost elevation, a 5 meter maximum spacing would be a full wavelength at about 60 MHz. For a 1.7 to 80 MHz frequency span, the entire spectrum can be considered to be in the near-field of above-ground utility pole wire and cabling. This indicates intuitively that there will be some parasitic effects from close-in conductors such as other cable. There is no real "point source" for any of the unidentified Current Technologies devices mounted on utility poles since the asymmetry of RF from BPL devices sources from within the house.

Current Technologies document repeats the same basic RF knowledge mistake on page 12 of their document: "And emissions drop off rapidly with distance. As a result, emissions cannot accumulate in a victim receiver." There is no quantitative data on RF radiation levels from the BPL devices that it states it has, yet we are all required to take their word for everything while undergoing a great revision of EM fields

[18] Reply Comments of Current Technologies, LLC, dated 20 Aug 03.

and waves. In three sentences on page 19 of their document, Current Technologies says the following: "BPL will be less subject to both technical and economic limitations. BPL rides on the existing electrical distribution infrastructure, which already reaches every computer-using home and business in the country. And the incremental cost of equipping a power system for broadband delivery is relatively low."

The first sentence is apparently relative to existing broadband provider systems. There is no data presented as to the cost, exact or relative to other providers. In the second sentence there is a huge unknown as to whether or not any wideband HF-VHF signal will "ride" on wires never categorized for such use. While every computer-using home and business does require electric power to operate, those same homes and businesses are also connected to telephone and, for the majority of homes, television cable providers...as well as fresh water and waste water connections. In the third sentence, there is again no data on any "incremental" cost...or a "relative" cost...provided that their BPL signals can actually be carried on existing electric power lines.

The preceding examples show the dearth of quantified technical data from BPL advocates as well as the technical mistakes or oversights they make. That is insufficient in meeting the Commission's apparent intent on 28 April 2003 issuance of the NOI to seek information that could lead to regulations.

On the "New and Exciting Future" as Promised by BPL

The Internet became public just a dozen years ago. The Internet has become an everyday fact in most Americans' lives. Over 15% of American residences have an Internet-capable computer and 1 in 5 have some form of Internet access.[19] That explosive growth in information technology came about largely through ordinary wired telephone line wired access running at a maximum of 56 KB rates.

While we Americans do have a great variety of Internet providers and ways to access the Internet,

[19] U.S. Census Bureau publications of 2002 available through NTIS.

none of those ways impact the MF-HF-VHF electromagnetic spectrum that BPL can be expected to pollute. All of the ways to access the Internet have already been proven in various ways that are definitive in technology and technological standards before being available to the public. They did not require expensive testing working in an environment that was never designed for communications purposes of any kind.

While the ability to deliver broadband (Internet) service to rural regions is desirable, there is some question as to what "rural America" of 2003 lacks in the way of such service. This isn't the time of rural electrification being some new, high-technology thing for 1934, the first year of the FCC's existence.

Granted, there are areas of the USA where only electric power is available (if then) to very remote areas. It is a noble and good cause to let such locations enjoy the benefits of fast communications via computer. However, such good wishes must be tempered with the effect that new provider systems such as BPL will have on the majority of Americans who live in urban areas. Will BPL actually be a potential MF-HF-VHF noise polluter? If so, what are the expected levels of such radio noise? Such levels can never be quantified with vague, generalized promises of "no interference."

A Conclusion

Based on the 4,630 Comments in the ECFS database on Docket 03-104 as of Sunday, 28 September, 2003, none of the BPL advocates contributed anything in the way of quantitative data on their BPL systems' operation nor of any theoretical or actual measured performance data insofar as radio frequency radiation levels. None of the BPL advocates submitted any data as to their BPL systems' configuration, method of operation, or references to other publications containing such information.

On the other hand, at least three separate individuals or organizations, all of whom have no direct connection with BPL or competitive broadband providers, submitted theoretical information from computer

analysis programs or actual calculations indicating that there can be a serious problem with radio frequency radiation above and beyond current regulations for unintended radiation devices.[20]

Without any technical explanation of future BPL systems and their installation or even of independent agency measurement of an installed BPL system, it is impossible to reasonably evaluate any quantitative data on radio frequency radiation levels that might result. The several millions of Americans who will be affected directly by 1.7 to 80 MHz incidental radio frequency interference will not be satisfied by generalized promises.[21]

Broadband over Power Lines has been described as a "nascent technology." Based on the dearth of technical information on BPL systems, I am tempted to change that description to *vaporous technology.* FCC regulations cannot be done on vaporware.

Respectfully submitted this 30th of September, 2003

Leonard H. Anderson

Life Member, Institute of Electrical and Electronic Engineers

Leonard H. Anderson
10048 Lanark Street
Sun Valley, California
91352-4236

Internet: LenOf21@aol.com

[20] ARRL, Keane, Tope comments as already noted.

[21] These will include over 600 thousand licensed U.S. radio amateurs, over 200 thousand model aircraft flyers, an unknown number of shortwave broadcast listeners, and a probable three million or so Citizens Band Radio Service users (very approximate estimate), all using the EM spectrum of 1.7 to 80 MHz.