SECTION 8
INTERFERENCE PREVENTION AND MITIGATION TECHNIQUES

8.1 INTRODUCTION

The risk of harmful interference from any kind of radiator can usually be reduced through the use of various interference prevention measures, and the risk of sustained interference generally can be eliminated through various interference mitigation techniques. A number of possible means for the prevention and reduction of BPL interference to other services have been proposed and are presented and supplemented herein. Further study is needed of the potential effectiveness of these techniques.

8.2 POWER LEVEL

The single most effective method for reducing the potential for harmful interference from a BPL device may be to reduce the RF power it generates. As the FCC notes in §15.15 (c), "*…the limits specified in this part will not prevent harmful interference under all circumstances. Since the operators of part 15 devices are required to cease operation should harmful interference occur to authorized users of the radio frequency spectrum, the parties responsible for equipment compliance are encouraged to employ the minimum field strength necessary for communications*…" The minimum signal power necessary for BPL communications will obviously depend upon the system configuration used and the specific characteristics of the power line network. In some cases, reduction of BPL device output power may reduce data throughput. Throughput could be restored to the previous levels in existing BPL deployments by the addition of repeaters or in planned new deployments by reducing separation distances between devices. Consistent with §15.15(c), BPL systems should use the least power needed to carry out power line communications.

8.3 AVOIDANCE OF LOCALLY USED FREQUENCIES

Several access BPL systems make use of technology that can enable the avoidance of certain frequencies and frequency bands through capabilities for shifting BPL signal frequencies or notching or filtering out of BPL signals on those frequencies. Various FCC filings have indicated that this type of mitigation technique would not only be possible, but in fact has already been implemented to reduce BPL interference issues.[61]

[61] PowerComm Reply Comments at 3; Comments of the IEEE Power System Relaying Committee, BPL Inquiry, July 1, 2003 at 1; Comments of Ameren Energy Communications Inc., BPL Inquiry, July 7, 2003, ("Ameren Comments"), at 9-10.

Another, more advanced method of frequency avoidance would be *agile* or *adaptive filtering*. Unlike fixed frequency notching, systems with agile frequency avoidance would monitor frequency bands and dynamically change their frequency usage to avoid radio channels on which strong signals were detected. This is a solution that might enable increased, interference-free use of the RF spectrum by BPL systems.[62] However, there is significant concern that such a system, even if it were to work instantaneously, would not reduce the interference potential to systems operating in duplex mode or local weak-signal reception.[63] Interference to these operations may be discovered at the same time effective radio communications are needed most. Rather, this technique would protect only those radiocommunications using simplex mode and originating from a local radio transmitter.

A more basic form of adaptive filtering should be considered as a requirement. Again, it must be recognized that BPL systems may be susceptible to disabling if subjected to signals from a powerful, nearby transmitter. To the extent that this vulnerability exists, which is a vulnerability commonly found in all kinds of electronic systems, BPL systems must inherently avoid operating at frequencies used by powerful, local radio transmitters.

8.4 DIFFERENTIAL-MODE SIGNAL INJECTION

The use of unshielded, twin-lead lines for achieving non-radiating signal transmission depends upon *differential* or *balanced* line driving (as well as fundamental balance in the lines themselves). In this conceptual mode of signal injection, a signal of equal magnitude and opposite phase is placed simultaneously on both wires, resulting in cancellation of radiation in the far-field. While balanced transmission lines are usually constructed with very small wire spacing relative to the wavelength of the signal, preliminary NTIA NEC modeling of long wires using power-line dimensions, typical loads to neutral lines, and various grounding configurations has shown a decrease of several decibels in RF radiation for balanced differential BPL signal injection as opposed to non-differential injection. At least one BPL manufacturer, in its comments to the FCC, indicated that differential-mode driving should reduce signal radiation as well.[64]

It should be noted, however, that inherently unbalanced systems such as power lines (due to multiple grounds and transformer taps) will not act as true balanced transmission

[62] Some BPL proponents have indicated that during routine installation of BPL devices, existing noise sources on power lines will be repaired. *See e.g.*, Ambient Comments at 9; Reply Comments of Southern Linc, Southern Telecom, Inc., and Southern Company Services, Inc., BPL Inquiry, August 20, 2003 at 15. Thus, it should not be necessary for BPL operators to select frequencies that also avoid relatively high noise power that is generated by the power lines themselves.

[63] Reply Comments of Current Technologies, LLC, BPL Inquiry, August 20, 2003, at 15, note 33.

[64] PowerComm Reply Comments at 4.

lines regardless of the method of signal injection. Thus, this method of interference mitigation is limited in impact by the power line configuration.

Further reductions in radiated emissions may be possible using unbalanced driving of the unbalanced power and neutral lines, and there may exist ways to couple to all power lines in a manner that yields lower radiated emissions while achieving relatively high BPL signal currents and throughput. NTIA encourages further investigation of these possible solutions by BPL developers as appropriate.

8.5 FILTERS AND SIGNAL TERMINATIONS

Typical BPL signals will travel for at least several hundred meters along power lines before losses attenuate them to below useable levels. In many cases, conduction of BPL signals over these distances is unnecessary, as it means signals may continue far past the couplers, repeaters and customers for whom they are intended. Additionally, frequency re-use for BPL systems may be an issue for closely-spaced cells that renders conduction of BPL signals over extended distances undesirable.

One way to prevent unnecessary signal conduction is to make use of terminations or blocking filters on the transmission line. Since BPL signals are much higher in frequency than the 60 Hz power carrier, such terminations might range from the very simple (a large ferrite bead placed around the power line) to complex (for example, a system that inductively retransmits the signal out-of-phase with the original in a manner that does not disrupt BPL signal reception). Ideally, such a filter would absorb, rather than reflect, the incoming signal.

Additionally, the installation of filters on low-voltage distribution wiring before it enters a premises could help to prevent in-house interference to radio reception from BPL signal leakage. At least one relevant patent on such a filter was recently issued.[65]

Although NTIA's studies were focused on outdoor wiring and Federal Goverment radio systems, it should be recognized that in many cases filtering techniques may reduce interference to other radio receivers that may be vulnerable to interference from signals radiated by indoor LV wiring.

8.6 IMPLEMENTATION OF A "ONE ACTIVE DEVICE PER AREA" RULE

Several manufacturers have noted that BPL devices in a given area tend to transmit one at a time, and their signals therefore do not aggregate.[66] Making such a

[65] *System, device, and method for isolating signaling environments in a power line communication system*, United States Patent No. 6,590,493, Rasimas, et al., July 8, 2003.

[66] *See*, for example, Ameren Reply Comments at 13.

configuration standard practice (*i.e.*, only using one power line phase in a given area and only one signal injection point per wire) would help to ensure such were the case, at least for a local receiver.

8.7 JUDICIOUS SIGNAL CARRIER CHOICE

Due to the specific physical and electrical characteristics of a given section of power line, it is conceptually possible to find one or more frequency bands at which BPL signal radiation is relatively low. Specifically, on a case-by-case basis during installation or operation, it is theoretically possible to consistently preclude worst-case radiation conditions through avoidance of combinations of certain frequencies and coupler placement geometry (relative to power line impedance discontinuities) that yield worst-case radiation. NTIA's studies have only partially addressed frequency selective characteristics of BPL radiation, but work to date indicates that less than 50% of possible operating frequencies will exhibit this low-radiation characteristic.

To implement this concept, detailed measurements may be needed at every installation site to reliably identify frequency and coupler placement combinations that should be avoided. It likely would be found that use of a substantial amount of bandwidth would be precluded at each segment of a BPL network. NTIA welcomes further investigation of this concept by BPL proponents because if practicable, BPL devices could operate at higher signal power levels while still complying with field strength limits.

8.8 MAINTENANCE OF A SINGLE POINT OF CONTROL

In order to improve the resolution of actual cases of harmful interference, it would be prudent to have one entity in a service area controlling all the devices in that area, as well as one contact point for that entity. This contact point should be capable of addressing cases of suspected interference and resolving actual harmful interference through any and all means available to the BPL provider, without government intervention.

8.9 WEB-BASED ACCESS TO RADIO LICENSE INFORMATION

Knowing what radio operations are located in their immediate environment should facilitate BPL operators in selecting frequencies, power and other technical parameters that minimize interference. The FCC and NTIA both maintain databases of licensed/authorized radio systems across the radio spectrum, including the 1.7-80 MHz frequency range. The possibility of making parts of the NTIA database available to appropriate persons via a web-based mechanism will be further investigated by NTIA. However, it should be recognized at the outset that such an approach could, at most, be only a partial solution due to the nature of such data bases. For example, many frequency

assignments are registered for nationwide use rather than use at a specific location. Also numerous uses are not publicly releasable.

8.10 INSTALLATION AND EQUIPMENT REGISTRATION

By centrally registering their current and planned BPL deployment details in a central, publicly accessible data base, BPL operators will have equipped local radio users with information they need to alert the BPL operator of potential interference problems. Such a registry could assist local radio users in diagnosing suspected interference, which in turn may preclude unfounded complaints of BPL interference. Furthermore, in the event of actual interference that is believed to originate from a BPL system, the radio user could consult the registry to determine the cognizant point of contact with the organization of the BPL operator. By keeping potential requirements for filing of an interference complaint with the FCC to a minimum, the registry would expedite elimination of actual interference should it occur and avoid the buildup of an unfavorable track record at the Commission. Unfavorable track records could precipitate further Inquiry and Rulemaking actions that, in actual fact, may be unnecessary. NTIA will further study and recommend the BPL deployment parameters that should be included in the registrations.

8.11 CONCLUSION

NTIA suggested several means by which BPL interference can be eliminated; some of these and others may be used to reduce the risk of interference. Mandatory registration of certain parameters of planned and deployed BPL systems would enable radio operators to advise BPL operators of anticipated interference problems and suspected actual interference; thus, registration could substantially facilitate prevention and mitigation of interference. Consideration should be given to BPL frequency agility (notching and/or retuning) and power reduction for elimination of interference. NTIA further recommends consideration of the following interference prevention and mitigation measures:

- Routine use of the minimum output power needed from each BPL device;
- Avoidance of locally used radio frequencies;
- Differential-mode signal injection oriented to minimize radiation;
- Use of filters and terminations to extinguish BPL signals on power lines where they are not needed;
- Use of one active device per frequency and area;
- Judicious choice of BPL signal frequencies to avoid efficient radiation;
- Maintenance of single points of contact and BPL network control;
- Use of web-based access to radio license information to avoid locally used radio frequencies.