ET Docket No. 03-104

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As the founder and original developer of Phonex, Inc., now Phonex Broadband, I have a great deal of experience with power line communications. The Phonex Wireless Phonejack is one of the first widely distributed commercial power line systems to use the frequency range between 2 to 30 Mhz. Extensive testing accompanied our product development and manufacturing efforts. Subsequent to my work at Phonex, I worked on another power line development in the same frequency range and sold the rights to that technology to a division of General Electric Corporation.

As indicated in the proposed rule making, there are numerous challenges regarding power line communication. The primary challenge being a non-uniform environment as indicated in the FCC proposal. Accompanying the environmental difficulties are the problems of applying the correct technology as allowed by the regulations and market realities.

Given that the electromagnetic spectrum is a valuable resource that needs to be properly managed for the best interests of our great country, it is essential that threats to existing services operating effectively to support the needs of our nation, be protected and preserved. Danger to these services comes from devices and services that can cause interference that impedes or limits their effectiveness. It is no easy task to evaluate all new technologies and claims that the public good will be better served by those that request additional spectrum or favorable rules. In an attempt to clarify some pertinent points in the proposed rule making and to raise some issues that I did not see being adequately covered, I offer these comments.

The history of power line communication systems consists of a very large list of "successful" demonstrations, only to find that deployment in the real world results in unacceptably low performance. In other words, once a number of units are put into actual user environments, they don't work nearly as well as the demonstration systems. The reasons for this include, first, that the non-uniform power line as a transmission medium has a much wider range of problems and variations than foreseen or demonstrated by the lab or demo models. Second, interference with existing services is just not seen or is carefully avoided or "worked around" in the demonstrations. Again, real world deployment places the "new" system into a much broader range of interference possibilities. Thirdly, some of the crucial existing services are used only when needed and are not operated 100% of the time. Yet, when needed, they must be allowed to perform their function. Thus, a demonstration system may seem to be doing very well, but may still experience excessive failures that may not be evident during the demonstration event.

It should be noted that, particularly with both in-home BPL and access BPL, the more significant tests may well be their susceptibility to interference from existing licensed services, even more than the interference levels that BPL injects into the receiving equipment of the existing services. Although, the interference to existing services is a significant concern, as well. Even, unlicenced Part 15 devices may cause significant interference or prevent effective operation of BPL devices.

The challenges to the commission from the proposed rule making include many factors beyond technological and regulatory issues. The fanfare and promise of easy low-cost broadband communication requires that the reality closely meet the promise or the disappointment will be very strongly felt. To insure that the backlash from unfilled expectations is carefully considered, fundamental laws of science, economics and communication must not be violated. Basic violations are easier than might be imagined. Those areas that need further investigation should include:

Bandwidth is not free!

Signal power is not free!

Network access is not free!

Bandwidth

Bandwidth in the case of Access BPL includes not only the data bandwidth of individual communications, but also the bandwidth required by multiple users times the individual bandwidth. Communication theory readily calculates that only so much bandwidth can be time-shared before system performance deteriorates below even minimal acceptable levels. Since Access BPL is a two-way communication link with only a single pathway per transmission line, this increases the time sharing problem. Even though power transmission is a "network,"it is still a single pathway. Two-way transmission will require time-sharing the network or frequency sharing by increasing the bandwidth to accommodate channels in both directions. Thus, bandwidth is a limited resource and a single pathway has a finite capacity. Increasing the bandwidth capabilities of a single pathway will significantly add to the system cost. It is to be expected that the cost to add more copper is exorbitant, otherwise, the current power line rights-of-way would just be used to run cables more suitable for communication than power lines, in the first place.

Access BPL, particularly, covers long distances using two conductor power lines, spaced significantly wide for the frequency range involved. The spacing values for the conductors used in low and medium voltage transmission lines are wider than would normally be used for "leaky transmission line antennas" which would provide "reduced" radiation and reception capabilities. Thus, low and medium voltage power transmission lines are better radiation and reception systems than the "leaky antenna" systems designed to transmit and receive radiation. If the communication signal for Access BPL were to be delivered between a power line conductor and ground, then the system is very close to a long-wire Beverage antenna, known for its excellent long range and directional capabilities.

First, the exposure of Access BPL communications to external interference is cause for serious concern. Lightning and other atmospheric noise is quite broadband and, at best, represents some lost data transmission time, reducing the overall bandwidth availability. The long distances covered by medium voltage power lines makes them especially susceptible to significant communication outages as a lightning storm passes through an area covered by the lines. It is also impossible to restrict power lines from close proximity to licensed services that transmit significant power or to insure that installations of such transmitting systems would not be placed in close proximity to the power lines in the future. Amateur transmitters are only one case in point.

Signal Power

Signal power must be very low for a BPL system to provide non-interference with existing licensed services. However, consider that once an Access BPL system is deployed, with subscribers online, and interference issues arise, then signal power becomes a critical issue. If the Access system interferes with licensed systems, then there will be pressure to reduce the level of the interfering signal. Experience with existing cable TV systems has shown that such a response is very unlikely without FCC intervention, which is costly, time consuming and also difficult to achieve. Cable TV systems interfere with licensed systems regularly with little hope for change. If the interference is to the Access system, then there is pressure for them to increase power to overcome degradation of their system. Of course, the penalty is increased interference to the existing services and these are very difficult issues that are not easily resolved, even with the assurances that were forthcoming at the inception of cable service. If these are issues with a shielded transmission medium that is uniform and relatively low-loss, how can long-line power line communication promise less interference difficulties?.

The magnitude of the interference problem is severe already for existing licensed services. Adding the Access BPL system, with its broadband signal being emitted over a very long distance will bring its signal within close proximity to existing licensed services with impunity. Thus, the signal power provided to Access BPL will be costly. Amateur radio stations, a critical infrastructure component of the HomeLand Security and emergency response initiatives, already experience S9 signal levels in most areas over the high frequency amateur bands. This interference is predominantly from unlicenced devices of all types. Access BPL, to insure it can perform adequately, without significantly increasing the existing high noise levels, will require extensive testing that is not limited in any way. Currently, the Access BPL industry is conducting its own tests. A large number of tests would have to be made to insure that the sites, power levels, and system performance actually obtained are all compatible with existing licensed services. Otherwise, a signal power battle will ensue which will not be easily resolved.

Network Access

It is hoped that Access BPL communication will deliver broadband capabilities at low cost to remote areas. The majority of the power lines in question had to meet economic realities for their installation, in the first place. That is, there had to be enough power subscribers to justify the installation of the lines. It is reasonable to expect that all power subscribers will expect equal access to the available bandwidth possible with Access BPL. Existing broadband systems have had considerable difficulty meeting the demands of their customers and responding to complaints. System outages and excessive throughput degradation have plagued these systems. It should be instructive that such problems have given rise to competition from additional systems, and the necessity to install increased network capacity. Access BPL is a very limited resource. The number of subscribers that can be served is a very finite number easily calculated from valid numbers created and verified from existing and past networking systems. Since the growth of the Internet and other broadband services has shown a very rapid rise in the number of users, a finite resource with the network access limitations of Access BPL will suffer most from its lack of scalability. It would be very embarrassing to have Access BPL become the cause for arguments that additional power lines need to be run to provide sufficient capacity for broadband access. And, of course, the fact that additional power lines for broadband access cannot be provided economically.

Bandwidth versus Signal Power

It is possible to trade bandwidth for signal power or vice versa. It is not possible to increase transmission bandwidth and signal power at the same time without paying a price in direct relation to the increase. The key issues are that you can make a reliable transmission system in the difficult power line environment by using sufficient power to overcome the losses and noise levels. Although the noise levels in the BPL frequency range are minimal, the attenuation is significant, varies as indicated in the commissions report and is frequency dependent, which varies also. So, a suitable amount of power must be applied to get the signal through these varying loses. Do the systems in question adjust their power dynamically as the losses vary with frequency? Or do the systems vary their frequency of operation dynamically to skip the high attenuation frequency ranges as they change with time? In any case, the usability of such systems is dependent on their ability to deliver sufficient bandwidth minus those portions that must be eliminated and still be able to get the job done. How much bandwidth is that? Today, minimal broadband capability might be defined as that provided by systems such as 10 Megabits per second Ethernet. Even that is too slow for many and 100 Megabits per second and 1 Gigabits per second are available. The challenge for BPL systems is to co-exist with existing services, future devices and services, and a dynamically changing environment. Additional problems are the dynamically changing bandwidth limitations over the network, and the portions of the overall bandwidth available that are lost to the existing services. After all this, BPL must still have enough bandwidth left to be useful. Only comprehensive, thorough testing can answer these questions. And then, the amount of bandwidth may still be too low to be useful. A laboratory or demonstration may not exhibit any of these problems and may even work well a high percentage of the time. A key issue is being able to operate all the time, everywhere. This is not likely to happen over the power line using a broadband system! This is a situation where the exceptions are the rule! And demonstrations avoid the exceptions!

By trading off bandwidth for signal power, the designer is trying to make a system that doesn’t transmit a signal that will interfere with other users of the spectrum that have a valid or established right to interference free operation. In such cases, wider frequency bandwidth is used to spread the information signal so that the power delivered within the communication bandwidth of the other system is minimized sufficiently to co-exist. This works only if the other service uses less overall bandwidth. The result is a reduced information bandwidth for the designers system. If BPL systems deliver Ethernet data rates, how much bandwidth do they really have left under less than ideal conditions? If they need to spread their signal to stay below interference levels, then their power density per hz is reduced. If, on the other hand, they increase power to reliably provide the signal bandwidth required to deliver sufficient throughput, they will increase the interference level from their system.

FDM (Orthogonal Frequency Division Multiplexing), for example, uses a number of carriers to deliver information. (Other modulation schemes have similar constraints, therefore OFDM provides a useful picture.) The intent being to numerically control the selection of generated carriers so that frequencies are eliminated that do not provide effective communication or will obviously interfere with established services. This is fairly easily accomplished digitally within a semiconductor chip. The reverse problem is to filter out frequency blocks where interference to the BPL system may be located in the bandwidth range. This is a harder task, requiring hardwired analog filters or the capability to use DSP (Digital Signal Processing) on a number of interfering frequencies simultaneously. (The task is increased when the real signal power from licensed systems is considered. Up to 1500 watts PEP from an amateur HF transmitter with a dipole antenna parallel to a nearby transmission line, for example. For Access BPL, the exposure of long lines magnifies the problem potential.) Such capability costs money and increases price per node of the system. When all this dynamic response is going on at each node, the information must be coordinated between communicating nodes so they remain compatible. This overhead communication also takes up bandwidth. Both the lost bandwidth from interference and from overhead must be deducted from the available bandwidth. What's left in real world deployment of the system may not be enough, in enough locations or enough of the time. This is the real question for all power line systems, and has always been the case. This reality has killed most all broadband attempts over the power line. They all worked quite well in demonstrations! The problem with BPL, and particularly Access BPL, is that the actual a available bandwidth is limited, and the practical limitations are real and severe. Lots of tests under lots of conditions will be required to prove the viability of BPL, particularly Access BPL. The only way to go to provide more bandwidth is to higher frequencies with increased losses, radiation and susceptibility to outside interference. Narrowband signals can easily overload broadband system. Who will pay for the band-reject filters?

The Future

It is axiomatic in the computer world that the appetite for memory is insatiable. Likewise, the appetite for bandwidth is insatiable. Broadband access has already significantly changed the way people live, business and institutions operate, and the trend is on a fast track for increased usage. The future is that much more will be done using broadband and at an exponential rate. The infrastructure costs are minimal compared to the traditional costs for information and entertainment delivery. Printing, postage and delivery costs go away with effective broadband delivery. Brick and mortar facilities are being replaced by virtual facilities connected directly to users who no longer have to travel to personally access, deliver or obtain what they can online. And this change has occurred with what will soon be viewed as archaically small amounts of bandwidth. My first computer had 4k of user memory with cassette tape storage. Its value lasted a few weeks before a larger system was essential. We are on the verge of terabyte systems for home use becoming the norm. Each increase in performance of communication and information systems puts extreme pressure on the other portions of the system to keep pace. It is very probable that Access BPL will be archaic before it is deployed in sufficient quantity to pay for itself, and any problems uncovered in its deployment will be painfully obvious. The probability of problems increases with any effort to fast-track deployment. And the time required to properly insure minimal, solvable problems will reduce the ability for such a limited bandwidth system to be viable in the marketplace. Similar time, expense and effort on already proven delivery systems is a far wiser choice. After all, the major cost to deploy bandwidth is "right-of-way' expense. Adding fibre to existing power distribution rights-of-way has all the benefits of providing bandwidth and none of the unknown or insufficiently tested problems with Access BPL.

The Case for Fibre

Fibre is a proven, safe, secure, scalable broadband delivery system. Its costs are known and can come down with even greater volume. It can be expected that technological improvements will increase the benefits of fibre communication for many decades, at least. The demise of the Internet was predicted because no-one expected that sufficient network capacity could be deployed in time to accommodate all the users and their bandwidth needs. In fact, more fibre was installed than could be utilized and much of the nations fibre capacity sat idle, and the term, dark fibre, became commonplace. Local cable companies in many areas have added fibre to their coaxial cable systems. It can be expected that significant improvement in low-cost fibre capability will soon achieve cost/performance equal to the "last-mile" requirements of the most demanding users, at very acceptable costs. Many new companies are deploying fibre as the Commission is well aware. Any assistance to the fibre industry will pay numerous dividends to this nation. In a time when security of both personal and institutional data is a major concern. Particularly, infrastructure safety, which is very vulnerable with regard to overhead power lines, makes Access BPL a very suspect investment. Overhead power line data transmission is not sufficiently secure, either from intercept or system damage from sabotage or intentional interference. Add the security issues to the lack of scalability, which will kill it anyway, and Access BPL is a poor investment. Fibre doesn't interfere, can be secured easily by burial, is not readily susceptible to interference, is low-cost, with all costs and performance issues well known and is not bandwidth limited nearly as much as BPL. It is readily scalable! And fiber communication capability will only get better!

Summary

I wish to commend the Commission on its efforts to be visionary and open-minded to the needs of our country, to the changes taking place and what might be done to expand and accelerate growth and to build a stronger nation. Hopefully, the proposal on BPL has led to a great deal of comment and discussion. This can only add to the information base required to make good decisions. I appreciate this opportunity to comment and to indicate the severe weaknesses of Access BPL. A lot of time and effort will be required, along with a lot of effective cooperation that will be difficult to achieve, to be able to sufficiently test Access BPL. In the meantime, the same effort on the use and deployment of fibre will pay tangible, already proven benefits.

Sincerely,

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