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Comments on FCC 03-104

The utilities industry has looked at power line communications (PLC) as a technique to solve the "last mile" problem bedeviling the telecommunications providers. At first blush, the use of power lines for data transmission seems feasible. However, the widespread use of PLC would cause interference to wireless applications that occupy the same spectrum as the PLC signals.

Recently, the IEEE Communications Society devoted much of two issues of IEEE *Communications Magazine* (April and May 2003) to the topic of PLC. While a wide variety of PLC-related topics were covered, the issue of interference to existing spectrum users was mentioned in only one article [1]. Gebhardt et al. [1] consider the issue of electromagnetic compatibility with other users of the MF/HF spectrum. They point out that

> Due to the used frequency ranges [for PLC] there might be considerable contributions to the far field, as wire structures carrying the PLC signals form an antenna array. Thus, it can be expected that certain portions of the transmission power are radiated via ground wave and sky wave, respectively. This new scenario may affect extremely sensitive shortwave services such as amateur radios, wireless security services, or military surveillance stations. With a mass deployment of PLC, a noticeable rise in overall background noise appears probable.

While most articles ignored interference to other services, some did consider interference by HF spectrum users to PLC signals. Abad et al. [2] made measurements of background noise present on power lines between 0 and 40 MHz. Between 2 and 30 MHz, the range envisioned for PLC, the background noise level drop from –120 dBm/Hz at 2 MHz to –150 dBm/Hz at 30 MHz. The noise spectrum shows several sharp peaks at approximately 5, 8 12, 13, 18 and 22 MHz. These peaks rise approximately 30 dB above the background. The authors attribute these peaks to ingress of signals from HF broadcasters located in Europe, based on the distribution of frequencies. I agree with their conclusion, but they have not taken it far enough. If there is signal ingress from other users, then by the reciprocity theorem, there must also be PLC signal egress.

One might argue that the signal egress is quite small because house wiring is essentially a 3-wire parallel transmission line composed of #12 or #14 conductors spaced very closely. However, a parallel transmission line must be balanced to ground in order to limit radiation. That is definitely not the case for home AC wiring. It would be very difficult to maintain electrical balance on AC mains wiring in a complex electrical environment such as a home. The possibility exists for greater PLC signal egress than one might expect by considering only the construction of the cables.

One might also argue that the interference resulting from PLC signal egress would be below the noise floor and therefore would not present a problem. Abad [2] states that the synchronization scheme they propose will permit high QoS levels for PLC data transfer at a SNR of –25 dB on the power line. However, a relatively large RF signal must be applied to the power line to overcome losses due to radiation from aerial MV lines and dielectric and conductor losses in residential wiring. I have estimated some of these losses in the following paragraphs.

I modeled the MV aerial lines in my neighborhood using antenna simulation software. I chose to model a straight section 1 mile long that has the wires 30 feet above ground. At frequencies above 5 MHz, the power lines act like a narrowly spaced array of long wire antennas. Losses at HF can be as much as 20 dB/mile at the higher frequencies. The loss is due primarily to radiation because the conductors have too large a perimeter for skin effect to be significant. This result is consistent with comments about radiation from aerial power lines [1]. By comparison, expected losses in buried cables have been determined by Gebhardt et al. [1] to be approximately 250 dB per mile at 10 MHz.

Residential wiring consists of three #12 or #14 wires in a common sheath, two of which are covered with PVC insulation. The two insulated wires form a transmission line with a PVC dielectric. Amateur radio operators have measured the attenuation of "zip cord", consisting of two #16 or #18 Cu wires separated by a PVC dielectric [3]. Attenuation for this cord averages about 5 dB per 100 ft in the HF region, and it would be reasonable to expect residential wiring to have similar HF attenuation.

It appears that widespread implementation of PLC could adversely affect other users of the MF/HF spectrum. The best outcome for existing spectrum users would be a delay in the implementation of wideband PLC until interference issues can be studied more thoroughly.

REFERENCES

[1] M. Gebhardt, F. Weinmann, and K. Dostert, "Physical and Regulatory Constraints for Communication over the Power Supply Grid", *IEEE Communications Magazine,* May 2003, p 84

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[3] *THE ARRL Antenna Book, 16th Edition,* American Radio Relay League, Newington, CT, 1991