Audit of Radio Frequency Emissions Present in Burnet, Texas During Operation of BPL System

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Overview

The purpose of this audit was to evaluate the radio frequency interference potential of a Broadband-over-Power Line (BPL) system operating in Burnet, Texas. At the time of the audit, the BPL system was connected to only a few computers in the city offices, but proponents hope that it will perform well enough to justify making the service available to many other public and private users.

Although EMC laboratory equipment was used for some of the measurements, it was not our intention to determine the field strength of the emissions from the BPL system or to find if it is compliant with FCC rules. We sought, instead, to understand the conditions under which it could interfere with communication in the 1.8 to 30 MHz part of the spectrum. We believed that doing this might help us determine how Amateur Radio communications in Burnet, Texas, would be affected if the BPL system were expanded.

Amateur Radio operators elsewhere in the U.S., in Europe, and in Japan have reported interference to communications in the 2 MHz to 30 MHz portion of the spectrum. These are the frequencies on which virtually all international amateur and commercial communication that does not involve undersea cable or satellites takes place.

Equipment and Methods used in the Audit

Several vehicles with HF receiving and transmitting equipment were present during the audit, and all were able to receive strong signals generated by the BPL system. Data from the vehicle operated by the author of this report, KV5V, will be summarized here. The following equipment was used:

ICOM IC-706 Mk II G HF/VHF/UHF transceiver (installed in light-duty truck)
ICOM AH-4 Antenna Matching Unit
11-ft. whip antenna (mounted on the left rear corner of truck bed)
Hewlett-Packard HP 8591E portable spectrum analyzer
Hewlett-Packard HP 8447E Preamplifier
EMCO 6502A Amplified Loop Antenna (150 kHz to 30 MHz)

The Hewlett-Packard equipment was powered by a gasoline generator, while the transceiver was powered from the truck electrical system. No change in the 1.8 MHz to 30 MHz radio noise floor was detected on the transceiver when the generator was started.

The spectrum analyzer, preamplifier, and loop antenna were used to measure the frequency span, duration, and pulse interval of the BPL emissions. Amplitude measurements could also have been made with this equipment, but because they would have been taken with a different kind of antenna and at bandwidths different from those used in Amateur communication, they would not have been representative of those made with Amateur Radio equipment. See “Measurement Antenna Limitations” sidebar below.

The IC-706 Mk II G transceiver used in this audit is typical of current mobile Amateur Radio equipment. The receiver was set to use a product detector in a bandwidth of 2.4 kHz.

Measurement Antenna Limitations

A vertical whip antenna was used in taking these measurements. Because BPL system interference propagates from horizontal power lines and building drops, the noise measurements could have been considerably higher if a horizontal receiving antenna had been used.

Because of its size, a horizontally polarized antenna would have been difficult to use in a mobile or portable environment. It is important to understand, however, that if BPL system noise is largely horizontally polarized, as much as a 20 dB cross-polarization reduction in measured signal strengths could apply to a vertically polarized antenna. If this reduction were eliminated by using a horizontal dipole instead of a vertical whip, as much as a 100-times increase in measured BPL noise power levels would follow. A 50 µV, S9 signal with the vertical antenna would become a 500 µV signal with a horizontal dipole at the same location. This is significant because most fixed amateur radio installations use horizontally polarized antennas in the frequency range employed by BPL.

The vehicle was parked, facing the street, in the lot adjacent to the front of the city office building. The distance from the front door of the building to the rear of the vehicle on which the antenna was mounted was 50 ft. Poles supporting the overhead power lines were approximately 30 ft. from the rear of the vehicle.

<u>Noise Levels when BPL is Idle</u>

With no users connected to the BPL system, impulse noise was audible from 3.5 MHz to over 22 MHz. The idling BPL system, with no users on-line, produced five pulses per second. The pulses appeared to be frequency-agile, because although they were visible on the spectrum analyzer at a 200 ms rate, they were not always audible in the receiver at this rate. (Pulse widths, as measured with the HP 8591E, were 20-30 ms at nominal intervals of 200 ms.)

The receiver signal strength meter indicated the amplitudes of signals were S9 (50 µV) to 20 dB over S9 from 3.5 MHz to 21 MHz. This range of frequencies includes the Amateur 75/80 meter, 60 meter, 40 meter, 30 meter, 20 meter, 17 meter, and 15 meter bands. The 20 dB over S9 levels were observed from 7 MHz to 19 MHz.

Since the idle BPL signals were comprised of pulses similar to automobile ignition pulses, the receiver noise blanker was engaged. For these “idle” pulses, the use of the noise blanker brought the S-meter indication down to the ambient level. Noise blankers work by sensing impulse noise and turning the receiver off for brief periods of time. Although this may make a somewhat noisy signal sound a bit better, it does so at a cost of some degradation of the listener’s ability to copy weak signals. Noise blankers also add distortion from other strong signals on the band, reducing the receiver’s ability to function well in the presence of strong signals outside its passband.

About S-Units and Signal Strength

Amateur Radio operators measure signal levels in S-units, from S1 to S9. An S1 signal is barely audible; an S9 signal is very strong. S-meters in communications receivers are typically adjusted to make an S9 meter reading represent 50 µV (microvolts) across 50 ohms. Each S unit is typically 6 dB.

Signals stronger than S9 are indicated in decibels above S9. Thus, an S9+20 dB signal is 50 µV plus 20 dB, or 500 µV. Most S-meters are calibrated in this way up to S9+60 dB. Signals at the +60 dB level are seldom found on Amateur frequencies, the exception being when a powerful transmitter is very close—less than a mile or two from the receiving station.

Many amateurs do weak-signal communication at and below S1 levels, when the atmospheric noise level is low enough to permit this. Typical amateur communications are done at S5 to S9 levels. Broadband signals at S5 or greater would make a significant amount of normal Amateur communications impossible.

Noise Levels when BPL is Active

To learn how user activity on the BPL system affected noise emissions, three transactions were initiated on the single computer to which we had access in the city office building. The first transaction was a streaming video download. Two others were FTP file transfers. The display screens for each of the latter indicated that they were occurring at 11.9 to 16 kbps.

When the system was operated to download information, noise emissions increased significantly. At 7.2 MHz, the receiver S-meter reading rose from S9+20 dB for each impulse to a continuous S9+60 dB. Attempting to suppress continuous interference, the noise blanker no longer had any effect, because the interval between noise impulses was less than the blanking period. If by design it were allowed to operate under these conditions, it would have continuously shut off ("blanked") signals received by the radio.

Next, the two FTP sessions and the streaming video were shut down, in sequence. The S-meter remained at S9+60 dB until the second FTP session was terminated. The meter reading varied between S9+40 dB and S9+60 dB with the streaming video running and the noise blanker turned off. Turning on the noise blanker reduced the reading to a steady S9+20 dB. The S-meter reading fell to S7, the ambient level on this frequency in this location, when the streaming video was stopped. The measurements are summarized in Table 1. The Noise Floor is the ambient noise reading when BPL and other signals are absent.

Frequency (MHz)	Noise Floor	BPL Active-Blanker Off	BPL Active-Blanker On (S9+)
7.200	S7	S9+40-60 dB	S9+20 dB
10.116	S6	S9+40 dB	S9+10 dB
14.200	S6	S9+20 dB	S9
18.130	S4	S9+10 dB	S9
21.204	S4	S9+10 dB	S9+S6

Table 1. S-meter readings with streaming video session operating. The transceiver and antenna were located in the parking lot in front of the city office building.

<u>Noise Levels at Other Locations</u>

The measurements reported above were taken near the power line and the building in which the PC was located. The distances were roughly the same as those that would separate residences in an urban or suburban neighborhood. To find how far the BPL signals would propagate, we moved the mobile receiver to locations 25 and 200 yards from the lot in which the initial measurements were made.

Table 2 shows the readings taken in a parking lot across the side street from the city office lot, approximately 25 yards from the power line. BPL noise was clearly discernable at 7.2 MHz and at 10.116 MHz, and it was not discernable from the ambient noise on 14.2, 18.13, and 21.204 MHz.

Frequency (MHz)	Noise Floor	BPL Active-Blanker Off	BPL Active-Blanker On
7.200	S7	S9 +10 dB	S9+10 dB
10.116	S6	S9+10 dB	S9+10 dB
14.200	S6	S6	S5
18.130	S4	S4	S4
21.204	S4	S4	S4

Table 2. S-meter readings with streaming video session operating.
Where readings are the same, regardless of whether BPL is active or inactive, interference could not be separated from ambient noise. The transceiver and antenna were located 25 yards from the power line, across a street from the city office building.

Table 3 shows the readings taken in a park across the main street, roughly 200 yards from the power line. The BPL noise was nearly inaudible at 7.2 MHz, but it exceeded S9 on 10.116 MHz, in the 30 meter band.

Frequency (MHz)	Noise Floor	BPL Active-Blanker Off	BPL Active-Blanker On
7.200	S7	S7-S8	S7
10.116	S6	S9+10 dB	S9+10 dB
14.200	S6	S6	S5
18.130	S4	S4	S4
21.204	S4	S4	S4

Table 3. S-meter readings with streaming video session operating.
The S-meter readings on 14.2, 18.13, and 21.204 MHz are lower with the noise blanker on because some components of the ambient noise are being removed by the blanker. The transceiver and antenna were located 200 yards from the power line, across a highway from the city office building.

Observations

Several conclusions can be drawn from this audit of BPL system operation in Burnet, Texas:

1. Interference generated by the system varies with the amount of Internet activity. Idle system interference within 20 yards of the building served was significant but could be partially reduced by turning on the receiver noise blanker. Even this level represents harmful interference to many communications occurring in the Amateur Radio Service. Adding a single streaming video download, equivalent to one user visiting a web site, changed the interference from periodic to continuous. The levels were in the S9+40 to +60 dB range, and they could not be suppressed by turning on the noise blanker or reducing the receiver bandwidth. Only communication with strong, nearby stations would be possible under these conditions.

2. When an FTP file transfer was added to the streaming video download, the meter reading rose to S9+60 dB, which is full-scale. Communication with stations more than a mile or two away would be virtually impossible.

3. BPL system noise was considerably reduced when the receiver was moved across the side street on which the city office was located. The 7 and 10 MHz bands were the only ones on which interference was noted. At S9+10 dB, the interference on these bands was very strong and prohibited normal communication.

4. BPL system noise was detectable across the main street from the city office. The 7 and 10 MHz bands were affected, and noise on the 10 MHz band was significant and prohibited communication with all but the strongest stations.

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