LOCATING AND ELIMINATING SOURCES OF POWER LINE INTERFERENCE

W. S. Campbell, P.E.
Manager of Engineering
General Electric Cablevision Corporation

With more and more cable systems being built in industrial, urban areas, and with distant signal importation restrictions reducing the incidence of cochannel interference, electrical noise is becoming one of the most important interference problems at cable system headends.

There are many sources of electrical noise interference. They include automobile ignition, welding equipment, electric fences, neon lights; in fact, any electrical device can cause trouble if it is not operating properly. Even the sun and milky way can, under certain circumstances, degrade a system's signal to noise ratio by 5 to 7 dB.(1,2)

The first step in an electrical noise investigation is to attempt to identify the source from the characteristics of the noise it generates. In fact, a great deal can be told about the source of noise interference by observing its appearance on a television screen, its pulse train on an oscilloscope, duty cycle, time of day of occurrence and any correlation to weather or other local events. For instance, noise that is limited to hours of darkness may be a lighting fixture, noise that increases with the humidity may be high voltage corona, noise that is only present when the local bar is open may be one of their signs, etc. Reference 3 contains an excellent discussion of the pulse characteristics for some representative examples of man-made noise.

In this paper, we will limit our discussion to the electrical noise caused by power lines. The most common signature of power-related electrical noise is the fact that it moves slowly through the television picture in bands. Two bands being characteristic of single phase power and six bands indicating three phase. It is at this point that most system technicians make their first mistake -- they jump to the conclusion that the cause is "the substation northeast of town", "the factory 15 miles south of town" or some other well-known power landmark. The technician makes his second mistake when he drives to this location, hears noise on his car radio and concludes that this must be the source. These two common errors result in wasted time for the utility company engineers as they try to eliminate all noise at that facility and frustration for the technician when his efforts do not remove his interference problem.

First, a search for a problem, any problem, should never be begun by deciding what the problem is and then setting out to prove it. A great deal of time can be wasted down the wrong path if an open mind is not maintained at the very beginning. Second, the car radio technicque wastes time since 1 MHz noise usually shows very little correlation to 100 MHz noise. Also, almost any power device, including probably a third of the poles in town, will radiate measurable noise within about 20-50 feet.

This brings us to Case History Number 1 and a much more efficient, systematic method of locating the source. In this Georgia system, the noise occurred only in channel 6, occurred in two bands moving through the picture and changed radically with rainfall. From this it could be concluded that the source was an outdoor, single phase power device.

The direction of the noise source from the headend was easily determined by using the system's search antenna. In this case the noise was strong enough to use a field strength meter for an indicator. In cases of weaker noise, or noise with a very short duty cycle, the noise peaks can be observed on an oscilloscope. Figure 1 shows the bearing taken from the headend (Triangle 1) and from three other locations, where a channel 6 dipole, field strength meter and compass were used to plot the directions. It is important to take readings from several widely separated locations to avoid being confused by local noise radiators.

Figure 2 shows two additional readings taken within the heavy black rectangle in Figure 1. These bearings pointed to the pole shown in Figure 3, approximately one and a half miles from the headend. The noise at the base of this pole measured +15 dBmV on the channel 6 dipole and varied considerably when the pole was shaken. The wiring configuration (a rather nice vertical antenna) on the pole explains why the noise peaked at one particular frequency.

Figure 4 shows the problem: a lighting arrester with a cracked cap. The power company said that these are notorious noise sources if their seal is broken and any rain water enters. When the arrester was disconnected, the noise ceased.

Case History Number 2 involves a high voltage noise source in Wyoming. Figure 5 shows the same direction finding technique used in Case 1, except that a truck mounted 10 element Yagi was used for the additional bearings because the noise was not strong enough for a dipole antenna. The problem in this case turned out to be dirty insulators on a high tension tower about one mile from the headend.

In this Case, we were lucky: high voltage noise can be very difficult to track down for several reasons. First, it is unavoidable. Good engineering practice allows 2 kw of corona per mile in good weather, with this going to as high as 200 kw per mile in heavy rain. Second, the periodicity of support structures causes standing waves, which, in turn, cause frequency spectra peaks and amplitude peaks at locations removed from the actual source. Third, a high tension line can act as a single wire above ground transmission line (with a characteristic impedance for a typical 500 kV line of about 425 Ohms) and propagate the noise several miles.

The power company themselves can be of tremendous help in locating the problem if approached with courtesy and diplomacy. They are anxious to do this since the generation of electrical noise interference is a public relations problem and, in fact, represents a loss of energy - their product. Their legal responsibility is quite clearly spelled out in Paragraph 15.31 of the FCC Rules and Regulations:

> An incidental radiation device shall be operated so that the radio frequency energy that is radiated does not cause harmful interference. In the event that harmful interference is caused, the operator of the device shall promptly take steps to eliminate the harmful interference.

If the source appears to be a high voltage line, their cooperation in locating the specific component causing the problem is essential. They can help to overcome some of the problems in locating high voltage line noise sources listed earlier by their experience and the use of highly sophisticated test equipment beyond the reach of the average cable system. They usually have access to such devices as sonic corona detectors and optical pyrometers. One optical pyrometer, used to detect overheating components, such as splices with internal arcing and high resistance connections, is so sensitive that it can detect a $3\frac{1}{2}^{\circ}$F rise in temperature in a 2" diameter object 20' away.

If the source of power line interference cannot be corrected, antenna methods similar to those used to reject cochannel must be used. Log periodic antennas and tapered amplitude distribution (diamond) arrays effectively reduce noise pick up from all but the desired signal direction. If the direction finding investigation accurately determined the direction of the noise from the headend, standard Yagi phased array techniques may be employed to create a null in the direction of the noise.

To summarize, use direction finding techniques to locate the source, make a visual inspection with binoculars for loose, dirty or cracked components, and, if necessary, return after dark to look for corona or arcing. If a high tension line is suspected as the source, get help from the experts - the power company themselves.

REFERENCES

1. "Using Sun Noise" by Don Lund, QST, April, 1968.

2. "The Distribution of Cosmic Radio Background Radiation" by H. C. Ko. Proceedings of the I.R.E., January, 1958.

3. "Man-made Noise" by E. N. Skomal, Frequency, January-February, 1967.

CAPTIONS

Figure 1: Four triangulation locations. Location 1 is the headend site where the search antenna was used.

Figure 2: Enlarged view of the black rectangle shown in Figure 1. Large triangles are crossover points from Figure 1.

Figure 3: Radiating pole.

Figure 4: Close-up of lightning arrester. Arrow points to location on cap where a piece has been broken away.

Figure 5: Second noise hunt triangulations. Location number 1 is the headend search antenna.