A Line Noise "Sniffer" That *Works*

Tracking down power leaks by radio is easier with a receiving setup designed for the job. Here's how to build one.

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As mentioned in an editor's note in Max Trescott's "Basic Steps Toward Tracing and Eliminating Power-Line Interference" (November 1991 *QST*), details of Bill Leavitt's line noise sniffer were reported in the August 1991 *Potomac Valley Radio Club Newsletter*. Prompted by requests from noise-bedeviled hams nationwide, Bill describes his system for *QST*.

I had a serious power line noise problem. It was more than a minor annoyance; it had reached the point where it was interfering with my normal operation on the 14, 21, 28 and 50-MHz bands. To make matters worse, the noise was intermittent and appeared to come from two directions.

I tried to find the source by using an AM broadcast receiver, but I could only determine a general location. My AM radio picked up the standing-wave power-line noise over a substantial distance along the line. In addition, the directional characteristics of the receiver's built-in antenna were insufficient to pinpoint the source. There had to be a better way!

I found that the noise source could be defined with greater accuracy at higher frequencies—VHF in particular. Directional antennas are much smaller at VHF as well, making highly directional antennas practical for a hand-carried unit. I began experimenting with various components, and the result is an accurate, inexpensive *noise sniffer*. With sniffer in hand, it's much easier to locate noise sources.

Construction

The sniffer consists of three parts: an antenna, an attenuator and a receiver. A block diagram of the sniffer is shown in Fig 1. You'll notice that the antenna is connected to the receiver through an attenuator. The attenuator is very important to the proper operation of the sniffer. When you're in the vicinity of a strong noise source, the receiver AGC attempts to keep the receiver output at a fixed level. Since the AGC tends to smooth out any fluctuations in the signal strength, it's nearly impossible to pinpoint the noise location. By using the attenuator, even a very strong signal can be reduced sufficiently to provide an obvious peak indication when the antenna is aimed at the noise source. The receiver volume control should be set to maximum at all times. A signal-strength meter would be a handy addition to the sniffer, but it isn't necessary. To keep things simple, the sniffer relies on the sound level from the receiver speaker to indicate the maximum-signal direction.

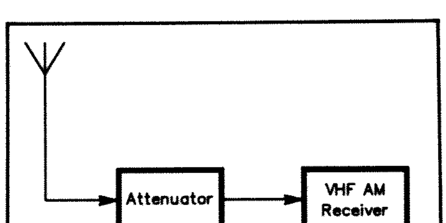

Fig 1—A block diagram of the power-line noise sniffer. It consists of three components: antenna, attenuator and 130-MHz AM receiver.

The Antenna

The sniffer frame uses a piece of 1- × 2-inch lumber (actual dimensions ¾ × 1½ inches) to support the antenna. A second piece of 2 × 6-inch lumber—in the shape of a rifle stock—is attached to the antenna support.

The antenna is a 130-MHz three-element Yagi with ¼-inch copper refrigeration

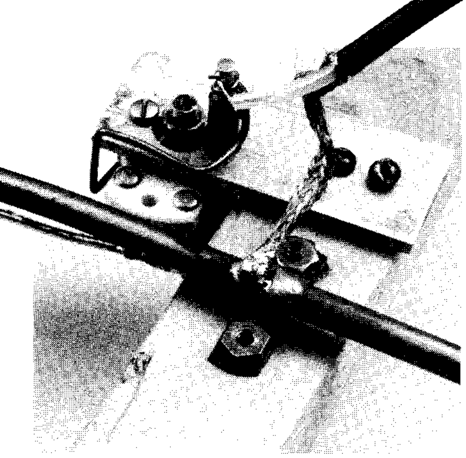

Fig 2—The driven element is soldered to a small metal clamp fastened to the boom with #6 machine screws. *(photos by Kirk Kleinschmidt, NTØZ)*

tubing elements. Copper tubing can be easily straightened as necessary without breaking. Drill holes through the wood boom to accommodate the elements. (Choose a hole size that provides a snug fit for the copper tubing you use.) Insert each element half-way through the boom. I wrapped a small amount of electrical tape around the director and reflector elements on each side of the boom to hold them in place. Epoxy, or another suitable adhesive, can be used if you want a more permanent installation.

As shown in Fig 2, the driven element is soldered to a small metal clamp that's fastened to the boom with #6 machine screws. This clamp—obtainable from a plumbing supply store—provides a means to connect the braid of the RG-58 coaxial feed line to the center of the driven element. The driven element uses a simple gamma match.

The antenna element dimensions were derived from a scaled W2PV design:[1]

Reflector	45 inches
Driven element	44-1/16 inches
Director	41-1/8 inches

The element spacing is as follows:

Reflector to driven element	12-1/2 inches
Reflector to director	25 inches

Make the gamma match from a piece of #12 wire using the dimensions shown in Fig 3. A 50-pF variable is fine for the tuning capacitor. A 25-pF variable should also be adequate.

I was fortunate to have a means of adjusting the gamma match using a bridge and a signal generator. If you don't have access to test equipment, I suggest that you build the gamma match using the dimensions shown in Fig 3. Adjust the capacitor for maximum signal strength using a strong noise source. Make sure to use the attenuator to reduce the receiver output as you make the adjustment. If you're in need of something noisy, try your computer, a fluorescent light, television set or anything else that provides a decent signal. You'll find there are plenty of noise sources to choose from!

The Attenuator

The attenuator (see Fig 4) provides 6, 12 and 24-dB switch settings, allowing you to increase the attenuation in 6-dB steps up to a maximum of 42 dB. A photo of the completed box is shown in Fig 5. The box is a Radio Shack 270-239 and the switches are Radio Shack 275-652 units. The resistors should be ¼-watt carbon types.

A piece of double-sided printed-circuit board is mounted inside the cover and held in place by the switches. A shield partition of double-sided PC board is also soldered between each switch. A ¼-inch hole in the partitions allows the wire to pass from one switch to the next. The ground side of each resistor is soldered directly to the PC board. The circuit board is connected at each end to lugs immediately beneath the BNC input and output connectors. This attenuator is available in kit form from Circuit Board Specialists.[2]

The Receiver

An AM receiver must be used for best noise reception. One low-cost receiver in the VHF range is the Radio Shack Jetstream AM/VHF-Air receiver (12-601). Unfortunately, the Jetstream receiver lacks shielding. This is a serious liability when it's used in the vicinity of a strong noise source. To solve the problem, I placed the receiver in a 5-1/4 × 3 × 2-1/8-inch minibox (see Fig 6). Slots are cut into the box for the tuning and volume controls. A cutout is made in the top for the dial and small holes are drilled in the cover where the receiver speaker is located. The width of the receiver had to be reduced slightly—through the *gentle* application of a belt sander.

Remove the headphone jack and the whip antenna. This operation can be difficult and must be done with the greatest care. Route a wire from a ground point on the receiver PC board at the headphone jack to the shield box wall. This serves as the RF ground. Mount a BNC connector on the box wall and attach a lead from the center conductor to the whip-antenna connection point.

If a larger box is used, a more elegant installation is possible. The receiver dial can be tuned to a quiet frequency around 130 MHz and the volume control set at the maximum level. The receiver can be secured to the box cover with holes drilled above the speaker area. If you use this approach, bring the positive lead from the receiver battery out to a switch mounted on the box wall. This allows you to easily turn the unit on and off. The ground lead from the box to the receiver can be connected to the outer conductor of the headphone jack. (Keep this lead as short as possible.)

A BNC connector can be mounted on the box wall close to the retracted whip antenna. You could connect the center conductor of the BNC connector to the antenna with a short piece of wire, or by using a small clip.

Tracking Down the Noise

As you begin hunting power-line noise on a regular basis, you'll want to do some background reading to familiarize yourself with the subject. Hams have been grappling with this problem for decades and quite a bit of information is available to help you understand the causes and cures.[3]

Before starting your noise hunt, be sure that you've eliminated every possible culprit in your own home. Also, make sure the noise isn't originating from one of your neighbor's houses. About 80% of the noise complaints received by power companies are found to originate from sources within houses—not on power lines.[4]

Prior to taking your sniffer into the field, you should determine the direction of the noise using your station equipment. If you're equipped with a beam antenna, you can use it to do this. Point your beam in the direction of the strongest noise. Move the beam until the noise drops to a convenient reference point on your receiver S meter. Note this reading and the beam

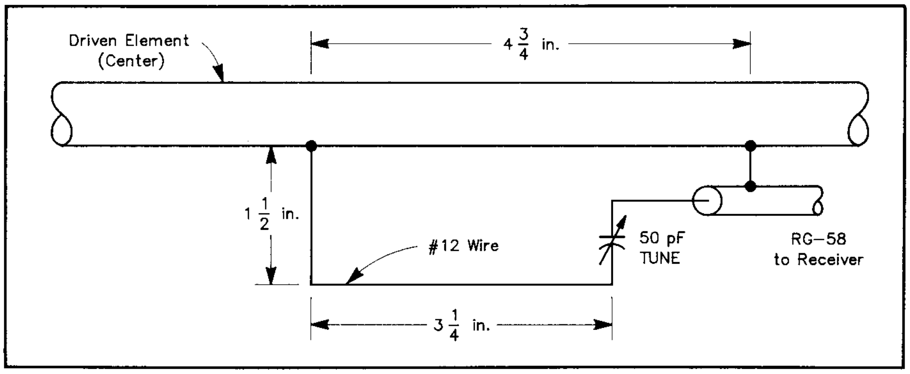

Fig 3—An illustration of the gamma match design. If you don't have the test equipment to tune it properly, use a nearby noise source and adjust the variable capacitor for maximum signal strength.

[1]Notes appear on page 55.

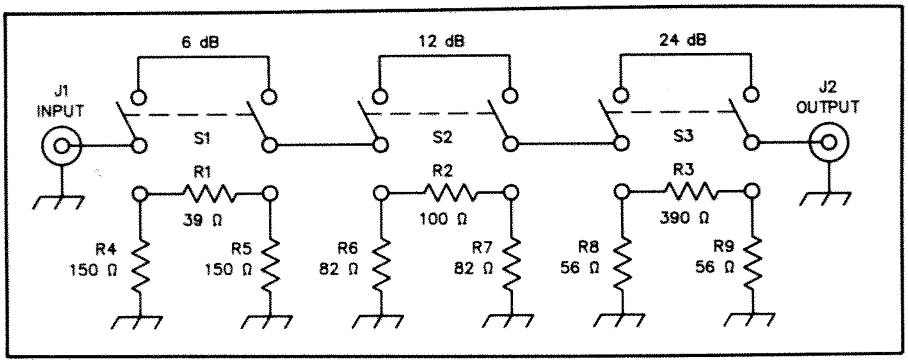

Fig 4—Schematic of the signal attenuator. All resistors are ¼-W, 5% carbon-composition or film.
J1, J2—BNC chassis-mount jacks (Radio Shack 278-105)
S1, S2, S3—DPDT (Radio Shack 275-652)

heading. Now, turn the beam in the *opposite* direction, past the peak point, until the noise drops off again. Keep turning the beam until the strength of the noise falls to the *same* S-meter reading you noted before. Once again, note the beam heading. The midpoint of these two headings indicates the approximate direction of the noise source.

This technique works only for relatively steady noise sources. Even with a steady source, it's a good idea to perform this measurement a number of times to determine the repeatability of your readings. If there's backlash in your rotator, try to take all your readings while turning the beam in the same direction.

Use the main lobe of the beam instead of the sides or back; the sharper the beam, the more accurately you can determine the direction of the noise. In many cases my 6-meter beam has pointed right at the offending power pole!

Beams are handy when it comes to getting an initial bearing, but what if you don't own a beam antenna? Make your best guess and use the sniffer. Begin by walking around your yard with the sniffer.

POWER-COMPANY RESPONSIBILITY

Who should find and *who* should fix a power-line interference source? Most of us never consider the question. We just assume any EMI that sounds like arcing with a 60-Hz component should be fixed by the power company (let's call it the utility). In fact, much of the noise arriving via power lines comes from appliances attached to those lines in a customer's home. It's important to know *who* is responsible for what in the electric-supply system. When annoying "hash" drowns out a rare DX country, it becomes essential to know whether the EMI is "home made" or "imported."

How can we determine which portion of the electric system is our responsibility and which is owned by the local utility? There is a well defined point at which the change of ownership occurs, but it is defined differently for overhead and underground connections. The definition may also vary somewhat from one utility to the next. First, let's determine the type of *drop*.

Almost all suburban homes built before the early 1970s and virtually all rural homes are supplied from overhead distribution systems. Most urban and suburban multiple occupancy buildings, and suburban single-occupancy buildings erected after the early '70s, are supplied from underground electric facilities or drops.

If you have an *outdoor* electric meter, you can determine which type of supply you have by looking at the area above this meter. Is there a cable going up the side of the house to a point either on the house side near your roof line or to a mast attached to your house? Does this cable connect to another *electric* (not telephone, CATV and such) cable spanning the distance from a nearby utility pole? If so, you are served from an overhead electric distribution system. If you find no overhead cable, but rather one or more pipes or cables that lead directly from the electric-meter box into the ground beneath it, your service is most likely from an underground system.

If your electric meter is *indoors*, examine the outside of the building for an electric cable coming from a nearby pole. Overhead electric-supply cables usually attach to a wall or mast at least 16 feet above ground level and connect to another cable that enters the building. If you don't find an overhead feed as described, the electric supply is *probably* underground.

If, after doing all this, you are uncertain, call your local utility. Their records should show which kind of electric service you have.

Overhead Electrical Service

On *overhead* electric service, virtually all US electric utilities identify the point of ownership change as the set of connectors at the upper end of the cable entering the top of the meter panel. These splices connect the ends of *the customer's* service entrance cables to the utility service drop (coming in from the pole). The *electric meter* is the only utility-company equipment on the customer side of this point. (A few utilities also own the cabinet or *meter socket* where the meter is mounted.)

Underground Electrical Service

US electric utilities define the point at which ownership changes on *underground service* in various ways. Most commonly, this location is one of the following:

1) The point where the cables between the main breaker/fuse panel and the electric meter are connected to the electric meter.
2) The point where the underground cable crosses from public jurisdiction onto private property. This location is generally referred to as the "Property Line."

If it becomes necessary to define this point more accurately, contact the local utility for help.

The utility is responsible for locating and correcting interference sources on their side of the ownership change point. Responsibility for all such sources on the *customer* side falls to the customer.—*Harry D. Thomas, KA1NH, Windsor, Connecticut* (from *Radio Frequency Interference: How to Find it and Fix It*)

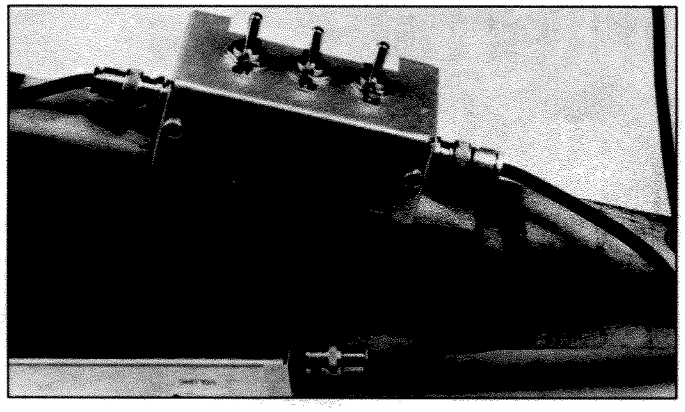

Fig 5—The signal attenuator secured to the sniffer and ready for action. Switches select 6, 12 or 24 dB of attenuation. By using various combinations of switch settings, other attenuation levels can be achieved. For example, by activating the 6- and 12-dB switches, you'll have a total attenuation of 18 dB.

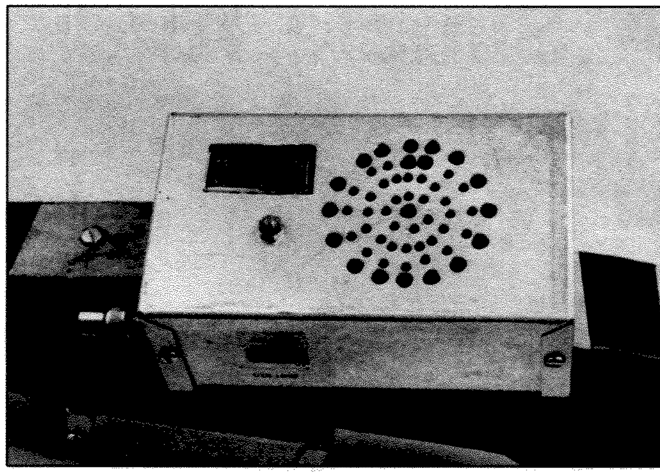

Fig 6—The AM aircraft receiver must be mounted in a shielded enclosure (see text).

If you're not receiving the noise, slowly widen your search pattern until you get close enough to the source to get a fix on its direction. With any luck, the noise will have a peculiar sound that you'll be able to separate from anything else you may hear. If the source is distant, you may need a friend to drive you around the neighborhood as you conduct your search. The AM car radio may be helpful in locating the general area of the noise.

Start your hunt by checking the closest power line in the direction determined by your beam (or by your initial sniffer sweep), and work outward from there. When you think you've found the location, listen to the noise from various positions and see if the sniffer points to the same spot. Use the attenuator to reduce the signal strength as much as necessary to obtain an accurate fix.

In some cases, interference propagates along power lines, making it difficult to identify the exact source. If you think that power-line propagation is causing false readings, try walking directly away from the line at a right angle. At some distance from the line you should be able to get true readings to the source if you're close enough. Now walk *parallel* to the power line and see if the sniffer still gets its strongest noise from the suspect pole. If so, you've found the source!

Be careful of false indications, especially if you move into wooded areas or areas with lots of buildings. At times, noise peaks can be obtained 90 to 180° from the true heading. On one occasion, I found a peak about 150° from the correct direction—at an elevation of about 45°! (An electric tree?)

It should be emphasized that my noise-hunting method is not a cure-all. It's been proven to work well for 7- and 8-kV lines where arcing causes wideband interference. In many instances, the power company found that the noisy poles had insulators with numerous burn marks. (These poles were usually silent when it rained.)

When a number of adjacent poles are buzzing simultaneously, pole identification becomes more complex. Pinpoint as many as you can and get the loudest ones fixed first. Each pole must be identified and fixed in turn until they are all silenced.

Intermittent noise sources can be a real headache to find. Noise sometimes appears and disappears depending on temperature or humidity. Locating a noise source on power lines carrying higher voltages is another challenge. Noise at 130 MHz seems to propagate quite a distance over these lines, making it difficult for the sniffer to obtain a true heading.

Dealing With Your Local Power Company

It's important to maintain good relations with the power company and not to involve them in false alarms. Take your time and be sure of your findings before picking up the telephone.

Show your power company representative how your sniffer works. You'll reinforce your credibility by demonstrating that you really know what you're doing! Before the noise problem is solved, the power company may have to make several visits. This is particularly true when the noise is intermittent and the power-distribution equipment is old.

Be patient with the power company. Removing that terrible noise from your receiver is a high priority to you, but it's a low priority to the company. They'll attend to the noise when a crew is free—assuming they don't have to tangle with power outages and other messy problems!

Notes

[1]J. Lawson, W2PV, *Yagi Antenna Design*, Table 8.22, p 8-28. Available from your local dealer or from ARRL HQ. See the ARRL Publications Catalog elsewhere in this issue for ordering information.

[2]The power line noise sniffer attenuator kit is available from Circuit Board Specialists, PO Box 951, Pueblo, CO 81002-0951, tel 719-542-4525.

[3]W. Nelson, WA6FQG, *Interference Handbook*. This is *the* definitive reference for power-line noise interference. WA6FQG was an RFI Investigator for Southern California Edison Company. Available from your local dealer or from ARRL HQ. See the ARRL Publications Catalog elsewhere in this issue for ordering information.

[4]If the interference changes with weather, the source is likely to be outdoors. If it regularly changes with the time of day, it's probably an indoor phenomenon related to human activity. One exception was a pole that began buzzing at sunrise and stopped at sunset!

First licensed in 1936 as W9YFD, Bill has been a ham ever since. Bill spent 35 years working for the Naval Research Laboratory doing moonbounce research and communication satellite system design. After leaving NRL, Bill was employed by Satellite Business Systems and MCI. He's been enjoying an active retirement at his Maryland home for the past two years.

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