# A SIMPLE LINE NOISE LOCATOR

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Following some really bad experiences with my local power and light company with regard to trying to get them to locate and repair a source of line noise which had plagued me for nearly a year, I decided to take matters into my own hands.

I set about determining what features were important in my design of a line noise locator.

## DESIRABLE FEATURES

A line noise locator should:

> exhibit good sensitivity to the noise spikes radiated by an arcing, current-carrying circuit, while discriminating against locally- or internally-generated noise (such as atmospheric static and the hiss which is heard in most AM/FM and shortwave radios).

> have good "close-in" noise sensitivity. It should be most sensitive to line noise which is being generated at distances of one thousand (1000) feet or less. This quality permits the locator to do its job and not confuse its operator by responding to noise sources far-removed from the area of interest.

> work with a directional antenna which will permit the operator to pinpoint the location of the noise source.

> provide adequate audio level so that its operator can concentrate on the search for the noise, rather than worry about being able to hear the signal at all.

## WHAT'S GOOD AND WHAT'S NOT

Since power line noise can generally be heard over a wide range of frequencies (from the AM broadcast band well into the VHF portion of the spectrum), it would seem that anyone could pick up their nearest multi-band HF shortwave (or AM broadcast) radio and just go out walking and easily locate the noise source. Unfortunately, that's not always the case. In fact, in most instances, a "shortwave" radio is probably the WORST device you could choose for such a task:

1) Shortwave radios generally employ an internal "loopstick" or an external collapsible whip antenna as their receiving antenna. Neither type of antenna is acceptable for our application because they have virtually no directional qualities.

2) The wavelength for "shortwave" or "broadcast" signals generally implies that signals can propagate over long distances. This means that such a radio will be hearing signals which could be far distant from those that are desired. You have a good chance of having the line noise signals covered up by signals received from hundreds (or thousands) of miles away.

**A VHF radio makes a good choice for line noise location:**

1) Antenna lengths at VHF are such that hand-held directional antennas can be easily constructed.

2) Signal propagation at VHF is generally line-of sight. You have less chance of receiving skywave-propagated signals at VHF. Therefore, if you can hear a noise, it's probably relatively close.

## WHAT TYPE OF RADIO TO USE

Frequency Modulated (FM) radio receivers amplify ALL noises which they hear (including static and hiss). They do not provide good noise discrimination because ALL noises appear to be the same level. They depend upon the presence of a continuous, usually strong, signal to 'quiet' the radio and override the noise.

Amplitude Modulated (AM) radio receivers, on the other hand, respond best to varying signal levels. AM radios are relatively quiet when no signal is present for them to detect.

Since the signal produced by arcing power lines (or power line hardware) is of the amplitude-modulated type, an AM radio is very appropriate for as detector of line noise interference.

Most VHF radios designed for use by Amateur Radio operators are of the FM type. There are few VHF AM radios available for the Amateur Radio frequencies, and those that are available are usually quite expensive. However, Radio Shack offers a VHF/AM receiver (R/S 12-615) for the aircraft aviation band (108-135 MHz.) for about $25. This radio is small, lightweight, and powered by three AA cells.

## NOW THAT I HAVE THE RADIO, WHAT DO I DO NEXT?

Modifying the R/S 12-615 Airband receiver for Line Noise Locator Service:

(refer to the pictorials, separate file, for an illustration of where your attention needs to be focused).

1) Remove three (#) Phillips-head screws from the back of the case, two of the screws are inside the battery compartment.

2. Slip a thin screwdriver (or knife) blade between the two case halves at the bottom of the case and pry the case apart.

3. Unplug the connector that connects the VHF whip antenna to the radio. The lug from which this connector is removed is labeled ANT. And the lug right next to it is labeled GND. These are the two points at which you will connect your external receiving antenna(s).

4. Remove the Phillips-head screw securing the VHF whip antenna bracket to the back of the case and remove the VHF whip antenna completely. This antenna will not be reinstalled.

5. In the hole at the top of the case back, vacated by the VHF whip antenna, install a panel-mount RCA connector. Any other suitable connector may be used, but this hole is at an angle and the panel-mount RCA connector fits quite nicely.

6. Remove the four (4) Phillips-head screws that hold the receiver PC board into the front of the case and lift the PC board free of the case.

7. For the sake of ease of handling the receiver PC board, you may wish to desolder the two speaker leads and the power leads (at the case back, not the PC board, note polarities for later) so that the PC board can be handled without having to contend with the case back. This is not required, however, just makes things a bit easier at times.

8. Turn the PC board over to expose the foil side of the board, and desolder the four colored leads coming from the AM Broadcast band ferrite loopstick antenna. Once the leads are loose, remove the ferrite loopstick antenna and its plastic mounting hardware. This antenna will not be reinstalled.

9. Reinstall the PC board into the front half of the case, using the four Phillips-head screws you removed in step 5,above.

10. Prepare a 4½" length of RG-174 coax as follows:

    A. CAREFULLY remove ½" of insulation from each end of the coax.
    B. Using a sharp-pointed instrument (e.g. needle, or straight pin), unbraid the shield braid, move all of the braid wires to one side of the center conductor and twist them tightly together.
    C. On both ends of the coax, trim the twisted shield to a length of 3/8" and QUICKLY tin the first 1/8" of the braid.
    D. On one end of the coax, remove ¼" of insulation from the center conductor.
    E. Twist and tin the center conductor.
    F. QUICKLY solder this end of the coax (center conductor) to the ANT and (shield) GND lugs on the PC board.
    G. On the other end of the coax, cut the center conductor to a length of ¼" and remove 1/8" of the insulation.
    H. Twist and tin the center conductor.
    I. QUICKLY solder this end of the coax (center conductor) to the center pin and (shield) the ground lug of the RCA connector installed in step

11. If you removed the speaker and/or the power leads in steps 7, above, replace them now. Be sure that you have the right polarity for the power leads. Black goes to the battery compartment lug closest to the BOTTOM of the case back.

12. Reassemble the receiver, being careful to train the coax so that it lays smoothly along the far left side of the PC board (as viewed from the FRONT of the receiver) and does not interfere with mating the two case halves together.

13. On the back of the radio, set the BAND switch to AIR.

14. Install three (3) AA batteries in the battery case, connect your antenna, and continue to build your line noise direction-finding antenna.

This should complete the modification of the receiver. The only thing remaining to do is to buy/build some sort of directional receiving antenna for 108-135MHz. This can be as simple as a hand-held dipole antenna or as elegant as a multi-element yagi. Actually, the dipole works quite well and may be significantly better in general use.

Antenna theory tells us that a dipole antenna has a radiation (and reception) pattern in the shape of a fat figure-eight which is broadside to the plane of the elements of the antenna. This is to say that if the antenna elements are running north-to-south, the direction of maximum reception will be from the east AND west. Theory also states that a dipole antenna will have a very sharp null (area of minimum radiation or reception) directly off the END of each element. If the end of an element is pointed directly AT a signal source, little or no signal will be received.

In most instances, the dipoles we hams use are designed for use at HF (80/40M particularly) and are installed only a small fraction of a wavelength above the ground. In such an installation, the theoretical performance of a dipole gives way to "real life" performance which states that "the antenna radiates in any direction it sees fit!". This is not necessarily the case at VHF, because it's not difficult to place a VHF antenna several wavelengths (e. g. 8'-10') or more above the ground, even if it is hand-held. At this height, the theoretical performance of the antenna turn into reality.

Obviously, if you decide to use a multi-element directional antenna, you should have no problem using it to pinpoint a noise source. You merely point it in a direction and if the noise is from that direction, it should be heard. I have found, however, that I am able to obtain BETTER signal NULLS from a dipole pointed end-on than I can obtain distinctive signal PEAKS with a 3-element yagi. It turns out that the beamwidth of the yagi is too wide for precise positioning, but the precise null from the end of a dipole is like looking down the boresight or a gun toward the noise source.

Constructing a VHF dipole should be a pretty simple task. It doesn't have to be beautiful, but it DOES have to be sturdy enough that the two dipole halves are well-mounted on a solid insulator (even hardwood), the elements cannot move around and MUST BE STRAIGHT at all times. Two 23" lengths ( mid-band = 468 / 122MHz / 2 X 12 = 23" ) of 1/8" aluminum welding rod securely attached to a 1" X 3" X 1/2" of hardwood "center insulator" will easily suffice for securing the dipole elements. Attach the center insulator to a 1" x 1" X 3-foot length of wood (mast) and you have an easily handled dipole antenna. Use RG-58 to attach to the dipole elements and you're ready to hunt line noise. The important thing about the dipole elements is that they each MUST be STRAIGHT and the MUST be ALIGNED in a straight line with each other. Otherwise, your end nulls will not be as deep and they may be off-center as well.

Line noise location is a bit more complex when you use a dipole antenna, because the dipole receives equally well from two sides. Therefore, any noise which you hear can be coming from either of two broad directions, broadside to the plane of the dipole's elements. There must be a better way... since the dipole demonstrates a SHARP null directly off the END of each element, rotate the dipole until the signal disappears (nulls) rather than increases (peaks). Then, walk some distance (100 to 300 feet) at a right-angle to the point from where you made your first reading and where you think the source of the noise may be and take another reading. Thus, if you think the source of the noise is directly north of your present position, walk due east or west and take another reading. If the noise source is in the suspected direction, the new null should still be in a generally northern direction, but slightly off to the left or right, depending upon which direction you walked. This is called triangulation, and it usually works quite well. Repeat this operation as you walk closer to the suspected noise source. You will find that, as you approach the noise source (50 feet or less), you should be able to point the END of one element of the dipole UP (or DOWN) at the suspected source and null the received signal almost completely. At this point, the element should be pointing directly at the source of the noise. Bring back a sledgehammer and 'whack' the suspected power pole. If it has loose hardware, chances are that you'll hear a change in the sound of the line noise when the pole shudders from the strike.

**FINAL THOUGHTS**

Be sure to tune the receiver to an empty frequency on the end of the tuning range which appears to give the best sensitivity to the noise signal. In any case stay away from active airport frequencies and FM broadcast stations. Don't forget that you are using a radio designed for receiving aircraft transmissions and other broadcast bands as well. Make sure that you always have the band selector switch, on the back of the radio, set to AIR, and ALWAYS be prepared to tune around on the band to find a clean frequency. This radio responds not only to transmissions from aircraft, but also to direct radiation and images from nearby FM stations, so you expect to find multiple signals anywhere on the band.

Line noise is generally not 'tunable' in that it will not have a specific frequency. Therefore, if you think you are receiving line noise on your receiver, tune off-frequency a bit to confirm that the signal doesn't immediately disappear when you vary the tuning.

Do a lot(!) of listening for line noise. Do enough listening that you develop a 'feel' for what sounds line noise like and what other signals (e.g. TV carriers, etc.) sound like. Don't let yourself become fooled by in-band signals which may sound similar to line noise, but may mask its tell-tale characteristics. Line noise will be very staccato ('*spike*y') in sound.

You will probably encounter cases where there appears to be line noise 'all around' you… it may well be so! If you hear line noise, but no matter where you walk, the noise refuses to null, or just about the time you think you're in the process of nulling it, it seems to reappear, chances are that you may well be nulling one source and PEAKING another one nearby. Again, do some walking around the suspected sources, quite often you will find a spot where you can get a good bead on the particular source you are looking for (at that moment). Also, if you suspect multiple noise sources, try tuning to a different spot on the dial… although line noise is broadband, sources can sometimes be separated from one another by a little 'tuning around' for another instance of the signal.

Hold the antenna (particularly a dipole) at least 6 to 10 feet above the ground, and as far away from your body as is practical.

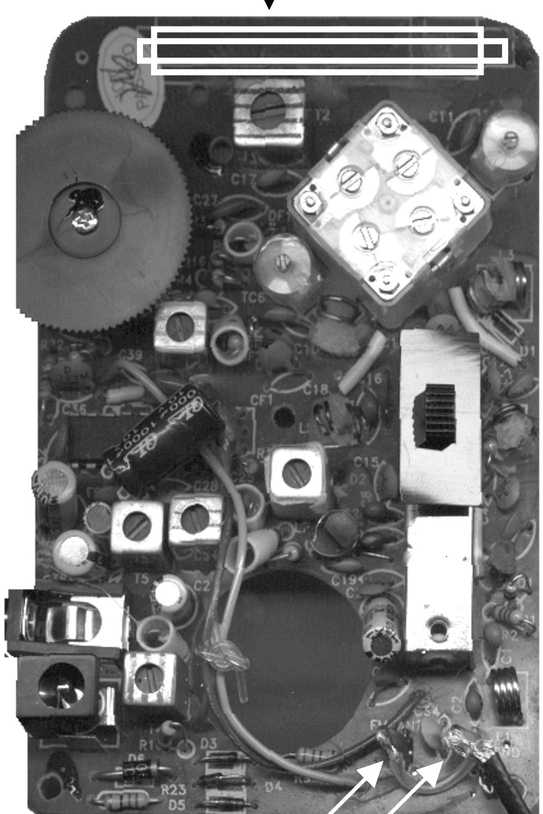
Wear headphones when hunting noise sources. This allows you to exclude other nearby noises from your area of attention. As you approach the noise source, slip the headphones back on your ears so you may also hear nearby noises. This allows you to take note of possible arcing which might be heard coming directly from the problem area.

Remember, a line noise source IS NOT going to be located in the middle of a wire span! It will (generally) be located at a power pole or at (or close to) a service entrance. Dirty/cracked/loose pole hardware probably accounts for 90% or more of line noise problems.

With a little practice and experience, you will be amazed at how easy it is to locate line noise sources.

# Modifications required to the Radio Shack 12-615 VHF AM Airband Receiver for use as a line noise locator

Remove AM loopstick antenna
located at top of receiver PC board



VHF antenna input & GND.
Disconnect VHF whip and attach
a short length of RG-174 coax as a
jumper to the (RCA) input connector for
the external line noise locator antenna.

Desolder and remove four
wires from the AM loopstick