RFI Mapper

Evaluate and potentially eliminate local noise sources with this wide-area noise (WAN) tool.



Sample RFI map showing acceptable areas (denoted by the green circles) and four suspect areas (denoted by the numbered labels). The suspect areas were later diagnosed as a defective lightning arrestor, a defective side-mount insulator, excess coiled-up wire, and a loose crimp on the wire jumper that connects the lightning arrestor to the pole ground wire (the vertical wire that runs up the pole).

Jeff Stuparits, W4DD

If you are lucky enough never to have had any power-line noise (PLN) problems, count yourself fortunate. I have been challenged with noise problems for years, especially after the summer lightning season. I have worked with the local power company to fix PLN, and they have been very helpful, especially when I can point them to the specific pole/part causing the problem. There are simple tools and methods for finding PLN, such as rotating your triband beam and using a vehicle equipped with an AM radio. More advanced PLN tools (listed in the order in which I use them) include:

1. RFI Mapper (RFIM) — provides the big picture on noise sources
2. VHF Yagi/attenuator/handheld — locates/confirms the pole emitting noise
3. Ultrasonic dish — locates the noise-emitting part on the pole

Understanding the RFI Mapper

RFIM is a wide-area noise (WAN) tool that helps me understand the RFI environment. Its basic structure is depicted in Figure 1. It enables me to focus on significant issues rather than ones that have minimal impact on my HF receiving ability. The map provides not only a visual of where noise is being generated, but an indication of where noise isn't being generated, which reduces the area that needs to be investigated (see the lead image). In addition, RFIM helps convey the issue to the local power company. To use RFIM, you'll need the following components:

Laptop

Just about any laptop running Windows 10 or newer will do (see Figure 2). An older Windows 10 laptop that does not meet Windows 11 requirements is a good

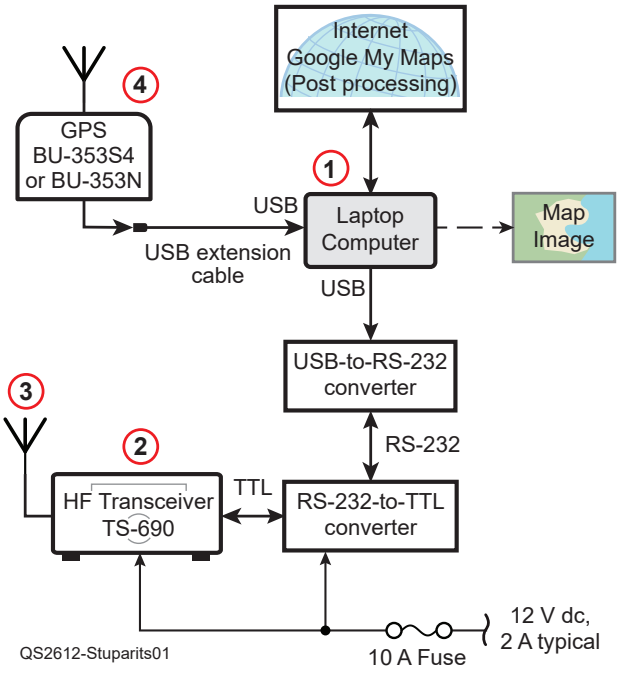


Figure 1 — Block diagram of RFIM structure.

candidate. The laptop needs to have two USB ports: one for the radio and one for the GPS. Use the same USB port for each device every time you use RFIM so the COM port assignments will remain the same in Windows.

HF Transceiver

RFIM supports approximately 20 HF radios. I use a 20-year-old Kenwood TS-690 (similar to the TS-450 and many other Kenwood transceivers) that works very well for RFI work. If your radio has an RS-232 port rather than a USB port, you will need a USB-to-RS-232 (or transistor-transistor logic) converter.

HF Whip Antenna with Mobile Mount

You will need a mobile mount on your vehicle with an antenna for the band(s) of interest (see Figure 3). I find that Hamsticks or similar antennas work well. I suggest one for a high band (10 meters) and, optionally, one for a low band (80 meters). Some vehicles generate considerable RFI themselves, so you will want to confirm that your vehicle has a relatively low RFI level. I find vehicle noise of S5 or lower to be very acceptable. As you approach an RFI noise source, it will usually be S9 or higher. On an older vehicle, I had to ground the tailpipe at the exit to get its noise level into the S2 – S4 range. I also had to install a ferrite on each USB cable near the laptop.

GPS Receiver

Several GPS models are supported by RFIM. I purchased my GPS unit on Amazon for $29 years ago. I recommend the GlobalSat BU-353S4 (see Figure 4) or BU-353N. The GPS connects to the laptop via a USB port; you may want to order a 6-foot USB-A-male-to-USB-A-female extension cable to mount the GPS on the roof of the passenger side of the vehicle. Use a quality shielded USB cable (unshielded cables will generate RFI). By using the passenger side of the vehicle roof for the GPS, you will be able to see both lanes of data coming and going. The GPS may take up to 60 seconds after power up to acquire satellite sync and start reporting position.

Software

RFIM software is a simple .exe program that collects GPS and S-meter data while you drive a pre-planned route with your vehicle. When the program starts, the following 12 steps occur:

1. The program reads the configuration file (RFIM.cfg) that has the radio and GPS parameters, like radio type and Windows COM port assignments. The .cfg file parameters are displayed on the screen.
2. It tests the radio and reports whether successful communication is established.
3. The program changes the GPS speed from the default 4800 bits per second to 115.2 kilobits per second, tests the GPS, and reports whether it was successful. The higher speed is needed to minimize serialization delay caused by the long GPS data strings.
4. It asks the user to enter the name of the file where the data will be stored. If it's not already on the laptop, the program will create a directory called C:\RFIM_DATA. The data file will be in a simple .csv format ready for importing into other applications like Google My Maps or Microsoft Excel.
5. It initializes "talker," the module that will announce (via the laptop speaker) the S-meter values.
6. After step 5, the GPS sends a data string to the laptop every second. It contains latitude and longitude along with other useful information like elevation.
7. The laptop queries the radio for the S-meter level.
8. A line of summary data is displayed on the screen.
9. If the S-meter level is higher than S9, the level is announced via the laptop speaker. It also does this every 10 seconds.
10. The data line is appended to the data file, and a backup file is created.



Figure 2 — Laptop connected to a transceiver for running RFIM.

11. After completing a run, the user must enter **Q** to quit the data collection.
12. The program provides a summary of the data collected, including the highest S-meter reading.

Mapping is done after data collection via My Maps (not Google Maps). You can use the map to decide which areas need further attention and which areas do not. Sometimes, RFIM allows me to locate the actual offending pole, but I always follow up with verification using the VHF Yagi and ultrasonic dish. The data collection screen is shown in Figure 5.



Figure 3 — Example of a mobile antenna mounted on a vehicle for locating noise. Any small HF antenna will work, but Hamsticks work especially well for locating noise while driving. To mount this one, the author used an aluminum trailer hitch antenna mount, along with a quick-disconnect bayonet-style connector at the base of the antenna. For a solid connection to the vehicle frame for ground, he installed short straps that run from the vehicle frame to the trailer hitch mount, and he secured it with a bolt and wing nut for quick removal.

Testing

RFIM has an option in the configuration file allowing the operator to test the program without a radio or GPS (simulation mode). A radio can then be added and tested, and then a GPS can be similarly added and tested. These options can be enabled in the .cfg file by setting the variables **RADIO_CONNECTED** and **GPS_CONNECTED** equal to 0 rather than 1. The .cfg file can be changed via Windows Notepad. If you have trouble getting data from the radio or GPS, you can use Tera Term to diagnose problems. If your radio or GPS isn't communicating, a mismatch in baud rate settings or some other COM parameter is usually the cause.

Preparing to Make a Data Run

Once you've set up and tested RFIM, it's time to plan your drive route. Print a map using Google Maps, and lay out a route that covers all public roads in the desired area. I try to design a route that uses mostly right turns, and I try to do the run when traffic is low — typically on Saturday or Sunday mornings. The data run should be done when no lightning storms are in the area, as lightning will produce false positives. Pick a seldom-used frequency. For PLN work, I usually set the transceiver to an unused frequency high on the 10-meter band (approximately 28.650 MHz). I also set the mode to AM (not SSB), the automatic gain control to fast, and the noise blanker to off.

Remember that safety comes first! Never look at your laptop or radio while driving. I mounted my radio and laptop in the back seat to resist the temptation of looking at the screen. Once the system is running, you shouldn't need to look at the screen. The talker module will announce the S-meter level under two conditions: when the S-meter level exceeds S9, and every 10 seconds to let you know that RFIM is still running. When RFIM data collection starts, the program will initialize talker with S0. If you don't hear this S0 announcement, check to make sure your speaker is on and the volume is set high enough. I usually set the laptop speaker volume near maximum. If possible, it is best to have a passenger handle all interfacing with the laptop and radio.

RFIM can also be used at a fixed location to record noise readings over a long period of time (24 – 48 hours). A longer recording is useful when noise floor level changes may be tied to timed events such as



Figure 4 — GPS unit supported by RFIM.

sunrise/sunset, streetlights, or electrical systems turning on and off. The data can then be analyzed with Microsoft Excel or other tools. If the radio supports remote connection and remote computer-aided transceiver capabilities, RFIM can pull data from a radio that is not local. I have used RFIM to record data via a remote FlexRadio installed at an operator's home in the Northeast, and then I analyzed the data for long-term changes. This remote recording feature is useful for doing RFI assists when you can't be at the station.

Knowing Where to Look

For stations using wire antennas, I suggest reviewing all roads within half of a mile. Stations using HF beam antennas at 50 feet should probably review roads up to 1 mile, but a directional HF antenna will provide a quadrant (northeast, southeast, southwest, and northwest) to focus on. Stations with high-gain HF antenna arrays on tall towers may have to cover roads beyond 1 mile. My farthest finds were 1.7 and 3 miles away, but these distances were highly unusual. At a 20 mph average, you can cover about 10 road miles in half an hour, which covers a lot of territory. If you live in a large city, there is no need to overwhelm yourself by finding every noise source; start looking closest to your station and focus on the things that impact it. If the noise source is in front of your house, you don't need a WAN tool like RFIM. You can progress directly to using a local-area noise tool like the VHF Yagi/attenuator/handheld.

When driving on a route, I have found that maintaining a speed of around 20 – 30 mph works well. At 25 mph, a sample is collected every 36 feet, which usually provides enough resolution to narrow noise sources down to a pole or two. Even speeds of up to 50 mph seem to work well, but samples will be spaced 73 feet apart.

```
 The RFI File is:     C:\RFI_Data\RFI.csv
 The Back-Up File is: C:\RFI_Data\RFI_BKUP.csv

* Intializing Talker using: S-0

SAMPLE  TIME          LATITUDE       LONGITUDE      ELEVATION      SATS    S-METER

 1      12:16:29      34.26023500    -84.00418333   1342           08       7.7
 2      12:16:30      34.26023500    -84.00418167   1342           08       5.0
 3      12:16:31      34.26023333    -84.00418000   1342           08      10.3   **
 4      12:16:32      34.26023500    -84.00418000   1342           08       1.7
 5      12:16:33      34.26023500    -84.00418000   1342           08       9.0   *
 6      12:16:34      34.26023500    -84.00418000   1342           08      13.0   *****
 7      12:16:35      34.26023500    -84.00418167   1342           08       2.3
 8      12:16:36      34.26023500    -84.00418167   1342           08       5.7
 9      12:16:37      34.26023500    -84.00418167   1342           08       5.7
 10     12:16:38      34.26023333    -84.00418333   1342           08       3.0
 11     12:16:39      34.26023333    -84.00418333   1342           08      13.0   *****
 12     12:16:40      34.26023333    -84.00418333   1342           08      13.0   *****
 13     12:16:41      34.26023167    -84.00418333   1342           08       9.0   *
 14     12:16:42      34.26023167    -84.00418333   1342           08       5.7
 15     12:16:43      34.26023167    -84.00418333   1342           08       9.0   *
 16     12:16:44      34.26023167    -84.00418333   1342           08       4.3
 17     12:16:45      34.26023167    -84.00418333   1342           08       9.0   *
 18     12:16:46      34.26023167    -84.00418333   1342           08       5.7
 19     12:16:47      34.26023167    -84.00418333   1342           08       7.0
 20     12:16:48      34.26023167    -84.00418333   1342           08      11.0   ***
 21     12:16:49      34.26023000    -84.00418333   1342           08       8.3
 22     12:16:50      34.26023000    -84.00418333   1342           08       7.7
 23     12:16:51      34.26023000    -84.00418333   1342           08       6.3
 24     12:16:52      34.26023000    -84.00418333   1342           08      11.7   ***
```

Figure 5 — RFIM data collection screen.

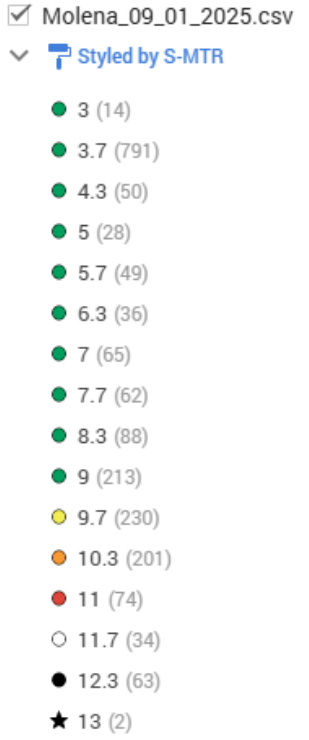


Figure 6 — S-meter scale used for mapping. For simplicity, readings above S9 have been converted to S units, with each S unit being an additional 6 dB. S10 is 6 dB over S9, and S11 is 12 dB over S9, etc. Anything over S10 usually warrants close review if it's near the receiving location. Numbers in parentheses are the number of samples at that signal level.

Mapping

Google My Maps is a great application that allows you to map a dataset by importing a file with latitude and longitude. It also allows you to select several different types of map backgrounds (roads, satellite view, elevation, etc.) as a layer. All can be useful when determining the source of your noise. Satellite view is the one that you will use most often. When mapping, I find that the simple circle icons work much better than the default pushpin icons. After you add a marker, you can find the circle icons by selecting **STYLE** and then **OTHER ICONS**. Additional information can be found in the RFIM User Guide provided at **www.github.com/w4dd**.

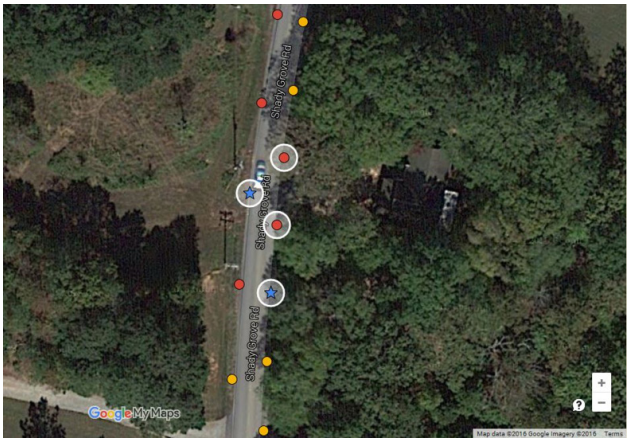


Figure 7 — Sample detailed noise map. In this image, the blue stars are S12 (S9 plus 18 dB). The pole between the blue stars was highly suspect, and it turned out to be the problem (a defective pole top insulator).

Once you have produced a noise map, review it and pay special attention to noise magnitude versus distance from your location. You can click on any dot on the map to display the parameters (see Figures 6 and 7). If you click on a noise level in the legend, all readings at that level will be highlighted. You will then want to visit the suspect location(s) and confirm the source pole using a directional antenna. For this step, I use a simple 137 MHz three-element homebrew Yagi, a 45 dB attenuator, and a Yaesu VX-5R handheld that covers the aircraft band. Be sure to make an audio recording at the pole and compare it to what you hear at your home station to confirm that it's the correct source. Noise characteristics like sputtering, occurring only at certain times of the day, being affected by weather, or having low- or high-pitch buzz can help you confirm the right source. Always consider what's closest to your station first.

Communicating with the Power Company

You can use the Windows Snipping Tool to cut and attach parts of the map into an email to send to your power company contact. When I communicate with a power company, I usually provide an overview map and drill-down maps of the most significant problem areas, and I circle the suspect pole. I have found the drill-down maps to be effective for locating the exact pole — or close to it. The VHF Yagi/attenuator/handheld combination should help you confirm the pole. If you have access to an ultrasonic dish, you may be able to provide the power company with the exact part causing the issue, but some companies already carry commercial ultrasonic dishes. Taking a picture of the pole with your cell phone and circling the suspect part can be very helpful to them. When narrowing down the noise source, remember to never touch power pole hardware.

Once the power company makes repairs, you can drive the route again to confirm that the repairs were effective. You should also see a major reduction in noise at your home station.

With this automated data collection system, you can locate many more poles that generate RF noise than the power company needs to repair. Don't overwhelm your power company engineer and line crew. You can map all of the issues, but prioritize the ones that impact your receiving ability and station performance. If you identify the correct issues, you will build credibility with your power company personnel.

Where to Find the Software

1. Make a directory on your PC labeled C:\RFIM.
2. Download the program, user guide, release notes, and .cfg file from **www.github.com/w4dd**.
3. Select **CODE**, and then **DOWNLOAD ZIP** to download all four files in a zip format to your directory.
4. Extract the zipped files.
5. Move the extracted files to the C:\RFIM directory.
6. Place a shortcut on the desktop by right-clicking/holding on the RFIM.exe file, and drag it to the desktop where you can save it as a shortcut.

Spectrum pollution is an ever-increasing issue. If we are to continue to enjoy our hobby, we will be challenged to find and resolve RFI being generated from not only power lines, but many new sources of noise. RFIM has enabled me to easily evaluate and solve many issues of this kind. I hope you will also find RFIM to be a useful addition for helping you to efficiently find RF noise sources, even if they're scattered over a large geographical area.

All photos provided by the author.

Jeff Stuparits, W4DD, became interested in RF interference about 20 years ago when RFI affected his ability to enjoy ham radio for contesting, weak-signal work, and making contacts. In addition to his 20-year career in wireless communications, he had earlier roles in telephone operations and air-defense communications. Jeff has a degree in electrical engineering and an MBA, and he is a licensed professional engineer. Additional information about Jeff can be found at **www.qrz.com/db/w4dd** or in the August 2022 "Member Spotlight" column. He can be reached at **w4dd@arrl.net**.

For updates to this article, see the *QST* Feedback page at www.arrl.org/feedback.

VOTE
If you enjoyed this article, cast your vote at www.arrl.org/cover-plaque-poll