A Home-made Ultrasonic Power Line Arc Detector

The device described in this article can help you track down power line noise sources to help utility crews more quickly resolve problems.

James T. Hanson, W1TRC

Even though BPL interference has captured the headlines for some time now, amateurs continue to be bothered by old-fashioned power line noise. In some areas, power line noise problems are actually getting worse due to utility company maintenance budget limitations.

A call to your local power company *should* be all that it takes to resolve power line noise problems. Radiation from leaky power equipment is a *nonintended emitter* in FCC speak and the power companies are required to address the issue. Unfortunately, in real life, an amateur is much more likely to achieve prompt resolution if he can point the power company towards the source of the noise. The relatively simple receiver described here can help you do exactly that.

Helping the Power Company will Help You

Due to the various potential sources of radio noise, it is advisable to do some investigation before contacting the utility company. For one thing, it is possible that the noise being picked up may not be power line noise at all, and it is also possible that the noise is coming from something in the amateur's own house or a close neighbor's house. Examples of possible noise sources include light dimmers, switching power supplies, electric fences, and even doorbells. Some utility companies have limited capability to pinpoint the source of noise, so anything the ham can do to locate the problem will only help to resolve the problem. It also happens that many noise sources are moisture dependent, so if you have a problem on rainy days and the investigative crews come out on clear days (that's when I'd want to climb a pole!), it can be a long time before the crew tracks down the problem.

There have been many excellent magazine articles and books published on how to determine the location of radio noise and one of the best sources of information is the ARRL Web site technical information service page titled "Track and Solve Electrical Interference."[1] The references on this site describe how to recognize and locate power line noise, and describe the best radio receiver devices and techniques to do this. In general, the articles point out that VHF or UHF AM receivers are the best for locating noise, because, at the higher frequencies, power line noise is generally weaker, so one must be fairly close to the source to pick it up. It is also possible to build or purchase some type of directional antenna for use at these frequencies. The antenna can be as simple as a dipole, with the nulls off the ends used as an indication of the direction of the interference.

Getting Closer is Even Better

Once the source of the radio noise has been narrowed to a particular utility pole or one of several poles, it is advantageous to verify the source of radio noise. One instrument that is capable of doing this is an ultrasonic detector. Arcing from a utility pole makes acoustic noise, as well as radiating RF. The sound is usually at ultrasonic frequencies around 40 kHz, and this requires special equipment to detect.[2] Commercial ultrasonic detectors have been available for a number of years but they have been very expensive. This article describes a homemade ultrasonic detector that can be built by the typical ham at reasonable cost.

[1]Notes appear on page 45.

Why Build an Ultrasonic Detector?

I have had and continue to have multiple sources of power line noise, all of which are intermittent. The strength of the noise varied from S7 to S9 +20 dB. Before contacting the utility company, I used a VHF MFJ-852 line noise meter to locate the general area of the noise sources and traced the noise to three different locations, all of which were within ¼ mile of my home. This was all done before I built an ultrasonic detector.

At this point, I sent a certified letter to the utility company, describing the noise problems I was having, and the steps I had taken to identify where I thought the problems were located. Within a few weeks, I received a telephone call from the utility radio lab informing me that they were sending out a person to investigate the noise problem. The person was coming out on a specific date to do the investigation. This bothered me a little bit since the noise was intermittent, and I wondered if the noise would cooperate with the scheduled investigation.

As it turned out, the noise did not cooperate, and on the day that the person came from the radio lab, all was quiet. The single tool that the investigator had to locate the noise was a commercial ultrasonic detector, but I could tell from my MFJ-852 line noise meter that everything was silent on this particular day. Fortunately, the person from the radio lab was sympathetic and scheduled another day to look for noise. On this second visit, two of the locations were generating noise at full blast, and the investigator found two sources of arcing at both locations. A work crew was scheduled to do the repairs.

Unfortunately, the work that was initially done by the repair crew did not solve the noise problem. Prior to the work, I had decided to build an ultrasonic detector for myself. This was an instrument that the utility company used and understood, and I could do my own independent investigation of exactly where the noise was coming from when the noise was present. After I continued to experience noise problems following the completion of the initial repair work, I was able to go to the locations on days that I was experiencing noise and was able to not only locate the pole but also the location on the pole that had the source of the arcing. After reporting this to the utility radio lab, they made additional trips to the site and were able to verify my measurements so additional repair work was done. The occurrence of noise has been substantially reduced, and the utility company has promised to clear up any remaining problems.

One of the features of an ultrasonic detector that makes it so valuable is its narrow beam-width. The 18 inch parabolic dish that I used has a directional beam width of about 1.5°. Because of this narrow beam width, it is possible to determine not only which pole has arcing, but also where on the pole the arcing is coming from. It is also surprising how loud the arcing can be. I have had the experience of being able to easily detect arcing from a pole while standing across the street from the pole that had an arcing insulator.

The Ultrasonic Detector Details

One of the first things I did when I decided to build an ultrasonic detector was an Internet search for construction details. I found that there is a large group of hobbyists who have built electronic detectors that could detect the ultrasonic sound of bats (the flying kind). The detectors fall into several general categories. One type of detector simply amplifies the high frequency bat signal and feeds the amplified output into a threshold comparator followed by a frequency divider to generate a lower frequency signal within the frequency range of the human ear. A second type of detector is classified as a frequency translator. These detectors operate like a direct conversion receiver and simply amplify and then mix the ultrasonic signal with a local oscillator to heterodyne the ultrasonic signal to audio frequencies, which can be heard with earphones. Because it preserves the amplitude and sound characteristics of the ultrasonic signal, this is the type of detector that I decided to build. A simplified block diagram of the detector is included in Figure 1.

The heart of the detector is a parabolic dish and a transducer capable of picking up ultrasonic sound. Several companies make low cost transducers that have a peak response at 40 kHz. This is fortunate, since this is also the frequency at which power line arcs are readily detected. The transducer I used was the Kobitone 255-400ER18, a stock item at Mouser Electronics. The output of the ultrasonic transducer is amplified in a low noise preamplifier and is then fed to a mixer in which the signal is heterodyned to audio frequencies by mixing with an oscillator that is offset from the 40 kHz ultrasonic signal. The resultant audio signal is filtered in a simple low pass filter and amplified to produce an audio output to a pair of earphones. The electronics operate from a single 9 V battery.

The parabolic dish assembly is a modification of a design that was built by Greg Kunkel.[3] In his original application, Greg used an audio microphone and a recorder to pick up and record bird songs. The beauty of Greg's design is that it uses an off-the-shelf Edmund Scientific parabolic dish and low cost, readily available PVC pipe fittings for the assembly. The modifications that I made to adapt the design for an ultrasonic detector included:

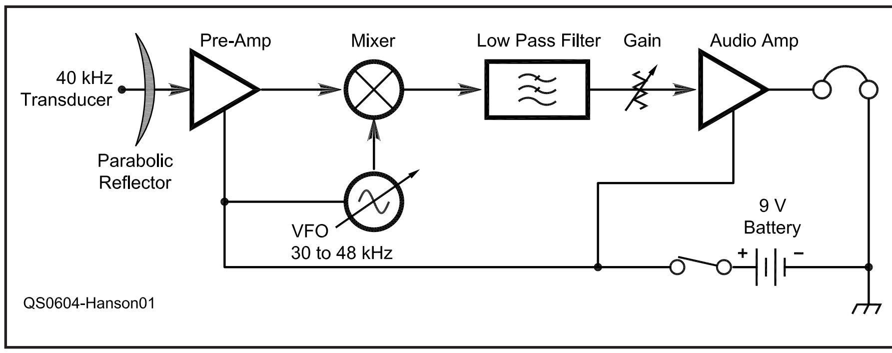

Figure 1 — Simplified block diagram of the ultrasonic detector.

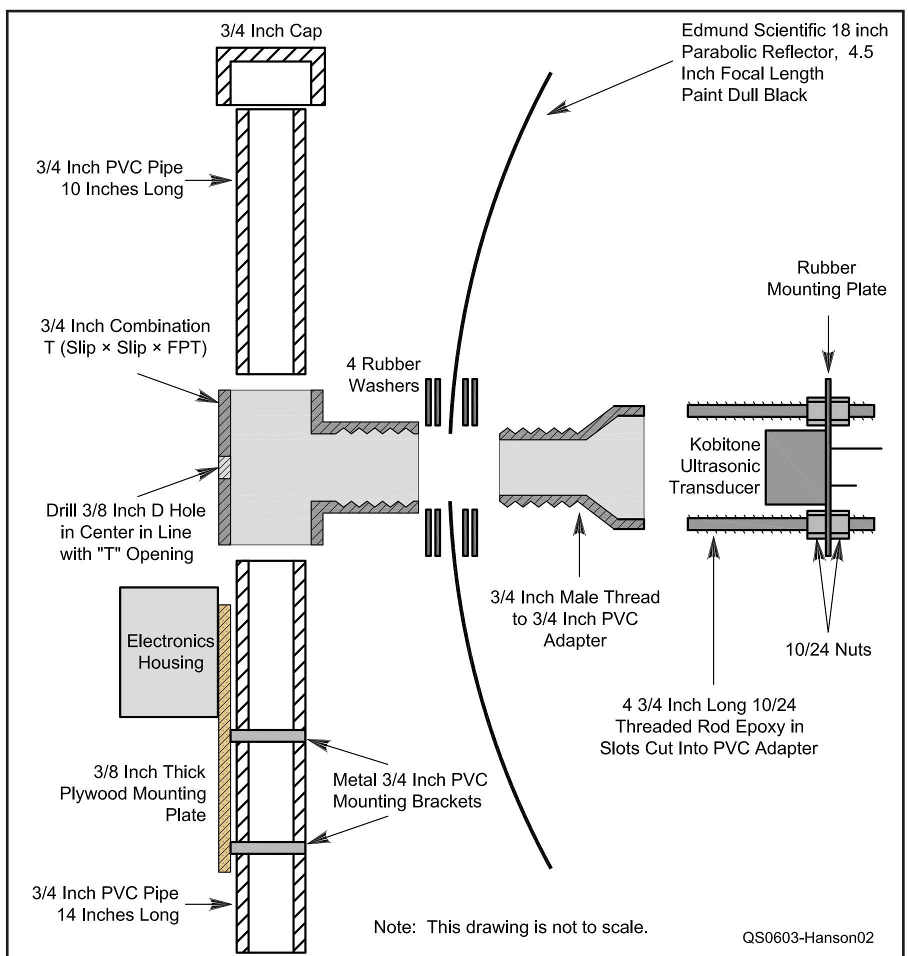

Figure 2 — Ultrasonic dish assembly.

- In the original design, the microphone was held in place with elastic bands. The reason for this was to isolate the microphone from the mechanical assembly. I wanted something that would be more rugged, so the design modification for ultrasonic use uses a piece of the same ⅛ inch rubber gasket material used for the PVC gaskets to support the ultrasonic sensor.
- I added a ⅜ inch hole in the back of the PVC T connector. This provides a shorter path for the shielded wire from the sensor to the electronics and also provides a sight so that you can see in the direction that the sensor is pointed.
- I increased the length of the top PVC pipe to provide a better place to hold the complete assembly.

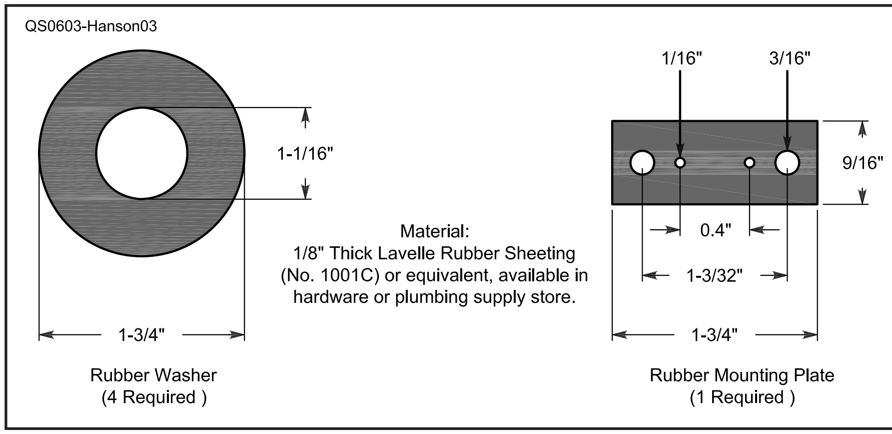

Figure 3 — Rubber washer and mounting plate details.

Putting it Together

All of the components of the mechanical assembly are shown in Figure 2. The Edmund Scientific parabolic dish is key to building a successful ultrasonic detector. This is an 18 inch aluminum dish with a 1.13 inch center hole and a 4.5 inch focal length. The center hole is a good fit for the PVC threaded pipe assemblies. Rubber gaskets cut from ⅛ inch gasket material provide a tight fit for the PVC threaded pipefitting. The drawing for the gaskets and the transducer holder are included in Figure 3. I purchased the gasket material at a local hardware store.

One thing that needs to be emphasized is the need to paint the parabolic dish. As the dish comes from Edmund Scientific, it is unpainted aluminum and it is quite an efficient reflector of light. One of the uses that Edmund Scientific advertises for the dish is a solar furnace. I tested this "feature" in February while the outside temperature was about 20°F. I poked a piece of wood through the dish hole and aimed the dish at the sun. In less than 30 seconds, the wood was smoking. It was scorched and would have burst into flame had I left it any longer. This convinced me to paint the dish, as I did not want to destroy the ultrasonic transducer if the dish were ever inadvertently aimed too close to the sun. I used a spray can of flat black paint to paint the dish. This greatly reduces the solar reflection but does not have any effect on the sound reflection characteristics of the dish.

The ultrasonic transducer wants to be positioned so that its smooth detector side (opposite from the leads) is at the focus of the dish and pointed at the dish. The 4.5 inch dish focal length turns out to be the actual depth of the dish. Because of this, the focal point can be found very easily by simply placing a straightedge across the dish edges and aligning the depth of the transducer so that it is aligned with the edge of the straightedge.

The electrical connection from the transducer is made with a length (about 12 inches) of small diameter (0.11 inch diameter) shielded wire. I had some wire in my junk box but you can also use RG-174 coax, which is about the same diameter. The shielded wire is soldered directly to the transducer and the soldered connections keep the transducer positioned and locked to the rubber plate. The only critical part of the connection is to connect the shield of the coax to the transducer terminal that is electrically connected to the case of the transducer. This can be checked with an ohmmeter. I found that this was the shorter of the two pins on my transducer. An RCA audio plug is used on the end that connects to the electronic converter box. The RCA plug will fit through the ⅜ inch hole that is drilled in the PVC T so the connection can be soldered before the wire is passed through the PVC pipe.

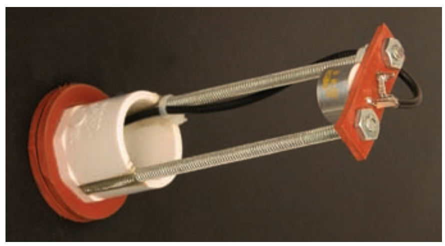

Figure 4 — Transducer mounting details.

The details of the final ultrasonic transducer assembly mounted to the parabolic dish are shown in Figure 4. The shielded cable is held to one of the 10-24 rods with small plastic tie wraps. The 10-24 nuts are used to adjust the position of the transducer so that it is properly positioned at the focus of the parabolic dish.

The schematic of the electronics is shown in Figure 5. The design is a modification of a downconverter that I found on one of the "Bat" Web sites.[4] The design shown in the schematic is based on one published in the December 1994 issue of *Popular Electronics*. I made several modifications to the original schematic, including the following:

- The original circuit used an LMC567 low power tone decoder for the oscillator. I replaced this with a TLC555 CMOS 555 timer chip operating in the multivibrator mode. The 555 is a very common chip and is readily available from multiple sources.
- I reduced the oscillator tuning range from the original 7.5 to 88 kHz to a range of 30 to 48 kHz. This covers the range required to detect 40 kHz arcing signals and makes setting of the oscillator much less critical.
- I changed both of the preamplifier transistors from 2N3904 to 2N4401, which have a lower audio noise figure, and have become a favorite with audio enthusiasts.
- I used a 6¼ × 3¾ × 2 inch plastic enclosure that I had to house the electronics. A cover plate was fabricated from a piece of scrap aluminum. RadioShack used to sell these housings with a cover plate, but it is no longer a RadioShack item. Keystone Electronics makes the same size box, and the box and an aluminum cover are available from Digi-Key. There is nothing critical about the box other than it needs to be able to hold the electronics and a 9 V battery.

The circuit was built on a RadioShack $2\frac{13}{16}$ × 3¾ inch "universal component PC board" (part number 276-168). This board has 0.1 inch hole spacing, which will accept standard dip packages. It also has two separate buses, which are used for power and ground connections. Figure 6 is a photograph of the finished circuit. The layout is straightforward and follows the schematic.

The input preamplifier section is in the lower left-hand corner of the picture and connects to the RCA input jack. Just to the right and slightly above is the mixer, and the audio amplifier section is to the far right. The oscillator is at the top of the board. The circuit board and all of the connectors and controls are mounted to the housing aluminum cover plate. I made some small rubber washers out of the same ⅛ inch rubber gasket material and used two at each corner to space the circuit board off the cover plate.

I mounted the electronics enclosure to a

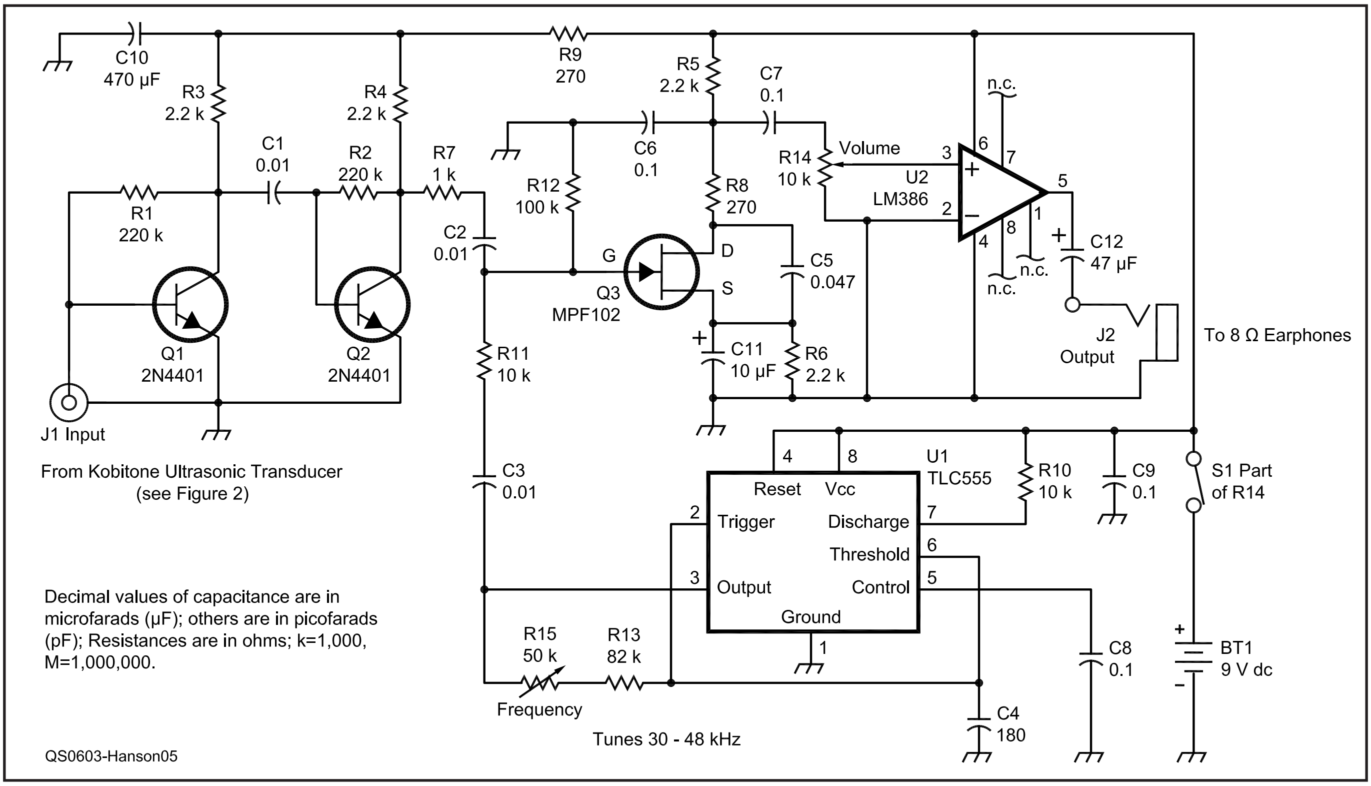

Figure 5 — Ultrasonic detector schematic and parts list. Most components are stocked by RadioShack, www.radioshack.com; Mouser, www.mouser.com, or Digi-Key, www.digikey.com.

BT1 — 9 V "transistor" battery.
C1-C3 — 0.01 µF, 100 V subminiature polyester capacitor (Mouser 140-PM2A103K).
C4 — 180 pF COG (NPO) multilayer ceramic (Mouser 80-C315C181J1G).
C5 — 0.047 µF, 100 V subminiature polyester capacitor (Mouser 140-PM2A473K).
C6-C9 — 0.1 µF, 100 V subminiature polyester capacitor (Mouser 140-PM2A104K).
C10 — 470 µF, 25 V capacitor (Mouser 140-XRL25V470).
C11 — 10 µF, 35 V capacitor (Mouser 140-XRL25V10).
C12 — 47 µF, 35 V capacitor (Mouser 140-XRL25V47).
J1 — Panel mount RCA jack (Mouser 161-1002).
J2 — ¼ inch panel mount phone jack (Mouser 161-1804).
P1 — Small RCA plug (Mouser 17PP050).
Q1, Q2 — 2N4401 (Mouser 610-4401).
Q3 — MPF102 (Mouser 512-MPF102).
R1, R2 — 220 kΩ, ¼ W (Mouser 660-CF1/4L 224J).
R3-R6 — 2.2 kΩ, ¼ W (Mouser 660-CF1/4L 222J).
R7 — 1 kΩ, ¼ W (Mouser 660-CF1/4L 102J).
R8, R9 — 270 Ω, ¼ W (Mouser 660-CF1/4L 271J).
R10, R11 — 10 kΩ, ¼ W (Mouser 660-CF1/4L 103J).
R12 — 100 kΩ, ¼ W (Mouser 660-CF1/4L 104J).
R13 — 82 kΩ, ¼ W (Mouser 660-CF1/4L 823J).
R14 — 10 kΩ, audio control with SPST switch (Mouser 31XP401).
R15 — 50 kΩ, linear taper potentiometer (Mouser 31VA405).
S1 — Part of R14.
U1 — TLC555 CMOS 555 timer (RadioShack 276-1718).
U2 — LM386 audio amplifier (RadioShack 276-1731).
Ultrasonic transducer, Kobitone 255-400ER18 (Mouser 255-400ER18).
Plastic enclosure — 6¼ × 3¾ × 2 inch, Keystone Electronics (Digi-Key 700K-ND).
Cover — Plastic Enclosure Aluminum Keystone Electronics (Digi-Key 2046K-ND).
Universal component PC Board 2¹³⁄₁₆ × 3¾ inch (RadioShack 276-168).
Parabolic reflector — 18 inch diameter (Edmund Scientific 3080254).

6¼ × 4 inch piece of ⅜ inch plywood and mounted the plywood to the PVC pipe with a pair of two hole galvanized tubing straps. The board was left over from a previous project. This arrangement allows the electronics box to be removed from the PVC pipe without opening the electronics box. The electronics box could be mounted directly to the PVC pipe without the plywood if desired. Figure 7 is a photo of the front panel. The rear view of the completed detector is shown in Figure 8.

Testing Out the Detector

Plug a pair of 8 Ω headphones into the ¼ inch jack and turn on the power. You should hear a white noise rushing sound, which will change slightly as you adjust the frequency control. The only adjustment that has to be made is setting the frequency of the 555 oscillator. Set the frequency to about 39 kHz, which will tune the downconverter for a 40 kHz input signal. There are several ways that the frequency can be set.

I had an ultrasonic transmit transducer, which I connected to a signal generator adjusted for 40 kHz at a very low output. It was then a simple matter to aim the dish at the transmit transducer and adjust the frequency control until I could hear the audio tone in the earphones. I marked this point on the front panel so that I could easily set the oscillator to the correct frequency.

You can also set the oscillator frequency with a frequency counter or an oscilloscope connected to the junction of R11 and C2.

The following procedure, which does not require any special test equipment, can also be used. You can generate an ultrasonic signal by gently rubbing your fingers together. If you do this in front of the dish, you should be able to hear the sound quite loudly. Turn down the volume until you can just hear the sound of your rubbing fingers and carefully adjust the frequency control for the loudest sound. You may want to reduce the volume further as you make the final frequency adjustment. Place a mark on the front panel where the frequency control is. That is all there is to it — you are now ready to go hunting for arcing insulators on power lines.

Using the Ultrasonic Detector

The Ultrasonic detector should not be

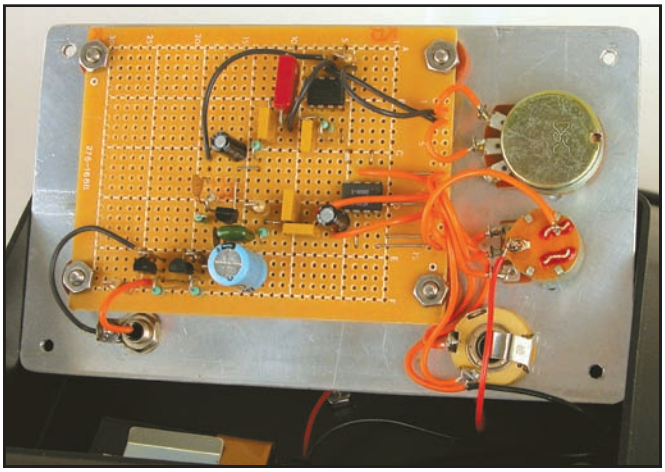

Figure 6 — Ultrasonic detector electronic assembly.

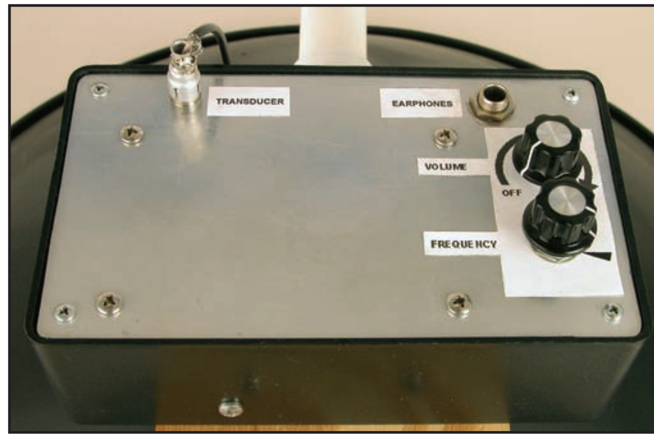

Figure 7 — Ultrasonic detector front panel.

used as the primary tool to hunt for power line noise. The techniques outlined in Notes 1 and 2 should be followed to find the general area of the noise. I have been able to get the heading of the noise by rotating my triband beam while monitoring the noise on 10, 15 or 20 meters with the receiver in the AM position. I have had some success finding the initial area by driving around with my car and listening to the AM radio tuned to the very high frequency end of the band. When I am in the vicinity of the noise, I have had very good luck using the MFJ-852 power line noise meter to narrow down the search. This VHF AM receiver has a signal strength meter with a 50 dB range and is very useful for tracking down the source. I have found that when I get close to the source of noise, the meter will be close to full scale.

Once you are in the vicinity of the problem pole, it is time to bring out the ultrasonic detector. To aim the parabolic dish, site through the ⅜ inch hole drilled into the PVC T and center the ultrasonic transducer in the hole. There is enough of a gap around the transducer to allow you to see the wires and insulators on the pole. If arcing is occurring, you should hear a deep growl when you are pointing at the arcing source. The exact sound can be different, depending on the exact nature of the arcing. Arcing can consist of single or multiple spikes at a 60 or 120 Hz rate, and each will make a unique sound.

If you read some of the reference material about ultrasonic detectors, they will mention that, if there is blockage between you and the arc, it will not be possible to hear the arc. My experience has been that, although the amplitude has varied, I have been able to hear the arc on all of the poles that I have investigated to date.

The ultrasonic detector is only one of several tools that can be used to track down radio noise. An ultrasonic detector can get you very close to determining the location of the problem on a pole. It is also a very good verification that a problem exists, but the final determination of what needs to be fixed and how to fix it should be left up to the utility company. Remember that they are the experts. The value of the ultrasonic detector is that it provides very good and convincing evidence that a problem exists on a given pole. It is very difficult for the utility company to ignore the fact that you are hearing actual arcing. It is also possible to record the detector output and to convert the sound to an audio file if further proof is required.

Good hunting!

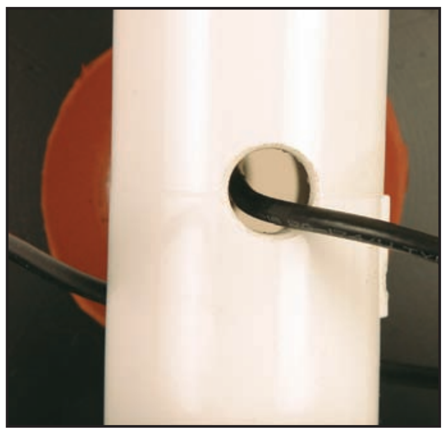

Figure 8 — Rear view of completed ultrasonic detector.

Notes

[1]"Track and Solve Electrical Interference," **www.arrl.org/tis/info/rfi-elec.html**.

[2]M. Loftness, KB7KK, *AC Power Interference Handbook*. Available from your ARRL dealer or the ARRL Bookstore, ARRL order no. 9055, telephone 860-594-0355, or toll-free in the US 888-277-5289; **www.arrl.org/shop/**; **pubsales@arrl.org**.

[3]G. Kunkel, "Parabolic Microphone Design," **web.archive.org/web/20041023131641/ourworld.compuserve.com/homepages/G_Kunkel/microphone.htm**.

[4]"Bat Detector," *Popular Electronics*, Dec 1994, **www.njsas.org/projects/bat_detector/heterodyne.html**.

Jim Hanson, W1TRC, has been an ARRL member for over 50 years. He received his General class license in 1951, his Advanced class license in 1952 and his Amateur Extra class license in 1984. His primary ham radio interest has been working DX and he is at the top of the phone and mixed DXCC honor roll. Jim has a BS degree in electrical engineering and has been retired from Raytheon Company Inc since 2004 where he worked on radar receiver and low noise exciter designs. He holds several patents relating to radar design. You can reach the author at 8 Ethelyn Circle, Maynard, MA 01754 or **w1trc@arrl.net**.

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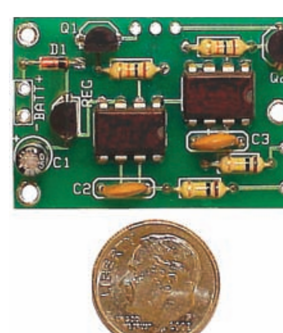

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QST Issue: Mar 2001
Title: A Simple TRF Receiver for Tracking RFI
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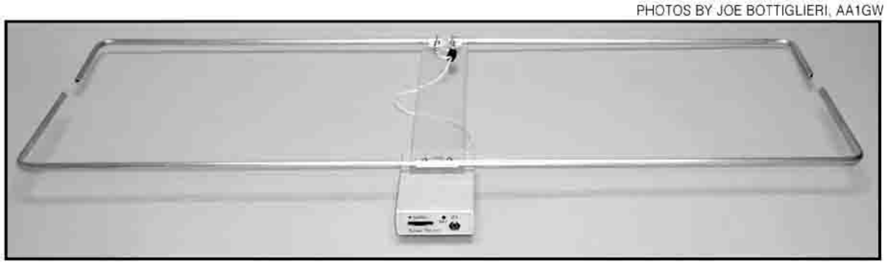
By Rick Littlefield, K1BQT

A Simple TRF Receiver for Tracking RFI

If the notion of a quiet band seems like a dream from the distant past, don't despair! This project can help you track down RFI and restore serenity to your shack.

PHOTOS BY JOE BOTTIGLIERI, AA1GW



The hum, buzz and whine we call *line noise* may come from electrical faults associated with local utility lines, or it may originate from customer-owned electrical and electronic equipment that has turned power lines and other wiring into antennas. Regardless of the source, RFI can be difficult to track at HF because it tends to travel long distances along wiring and evade localization. At VHF, however, noise-propagation distance is dramatically shorter and pinpointing trouble spots becomes correspondingly easier.

If unwanted noise is spoiling your operating fun, it's quite likely that a quick search with a VHF tracking receiver could easily pick up the offending racket within a few blocks of your home. From there, you may be able to locate a specific utility pole number, building, or equipment site and report it to the responsible party. Of course, local noise sometimes originates a little closer to home—in your utility room, office, workshop, VCR, dimmer switch or ham shack! No matter where the problem lurks, this receiver will help you sniff out noise and track it to the source.

General Description

The project is a simple tuned-radio-frequency (TRF) receiver operating at about 136 MHz, in the upper portion of the aircraft band. I say "about" because TRF receivers have no local oscillator to establish a specific central operating frequency and no IF selectivity to provide narrow channel separation between individual stations. Instead, a TRF receiver covers a *frequency span*, which is determined solely by multiple sections of preselective filtering ahead of the detector (a form of direct conversion). If this approach sounds unsophisticated, remember that the real purpose of a noise receiver is to sample everything occurring in a broad range of frequencies rather than select individual signals. In fact, for noise investigation, the TRF is a better tool than its more complex counterpart, the superhet.

The package consists of a handheld receiver/antenna combination: You simply point the antenna in the direction of suspected noise sources. A Moxon Rectangle antenna attached to the receiver case delivers directivity. This miniature Yagi, originally described by Les Moxon and profiled extensively by L.B. Cebik, has a well-defined cardioid pattern.[1] The broad front lobe is useful for identifying the general direction of a noise source, and the pronounced backfield null can provide directivity rivaling that of a 5- or 6-element Yagi when you get in close. To use the null, simply turn the unit around in your hand and rotate it for minimum rather than maximum signal. To preserve the symmetry of the cardioid pattern, a current choke decouples the outer surface of the coax feed line from the antenna feedpoint.

Circuit Description

The receiver schematic is shown in Figure 1. The selective elements that define the receiver's operating span include its resonant antenna, a two-pole Butterworth filter (L1, L2, C1 and C5) on the input side of RF preamp Q1 and a high-Q tuned-input circuit (L3) at the gate of the AM pulse detector Q2. Together, these selective circuits establish a −10-dB bandwidth of approximately 2 MHz and provide relatively deep passband skirts to keep out unwanted interference from strong TV and FM broadcast stations.

Q1 is a low-noise UHF bipolar device that delivers a gain of roughly 20 dB. Q2 is a high-transconductance FET configured as an infinite-impedance AM detector. Detected audio is recovered at the drain of Q2 and amplified to headphone level by dual op amp U1. The first audio stage, U1A, is set for near-maximum gain by feedback resistor R5. Output from this stage is coupled to U1B through attenuator R7, the **GAIN** control. U1B is set for a gain level consistent with stable operation by R11, with HF roll off provided by C14. U1B develops sufficient output to drive a pair of Walkman-type stereo headphones at modest volume. RFC1 and RFC2 isolate J1 from the receiver PC board, preventing headphone leads from acting as an antenna and interfering with the Moxon Rectangle. The unit's power switch is part of the attenuator pot R7, and an LED (DS1) serves as both a pilot

[1]Notes appear on page 36.

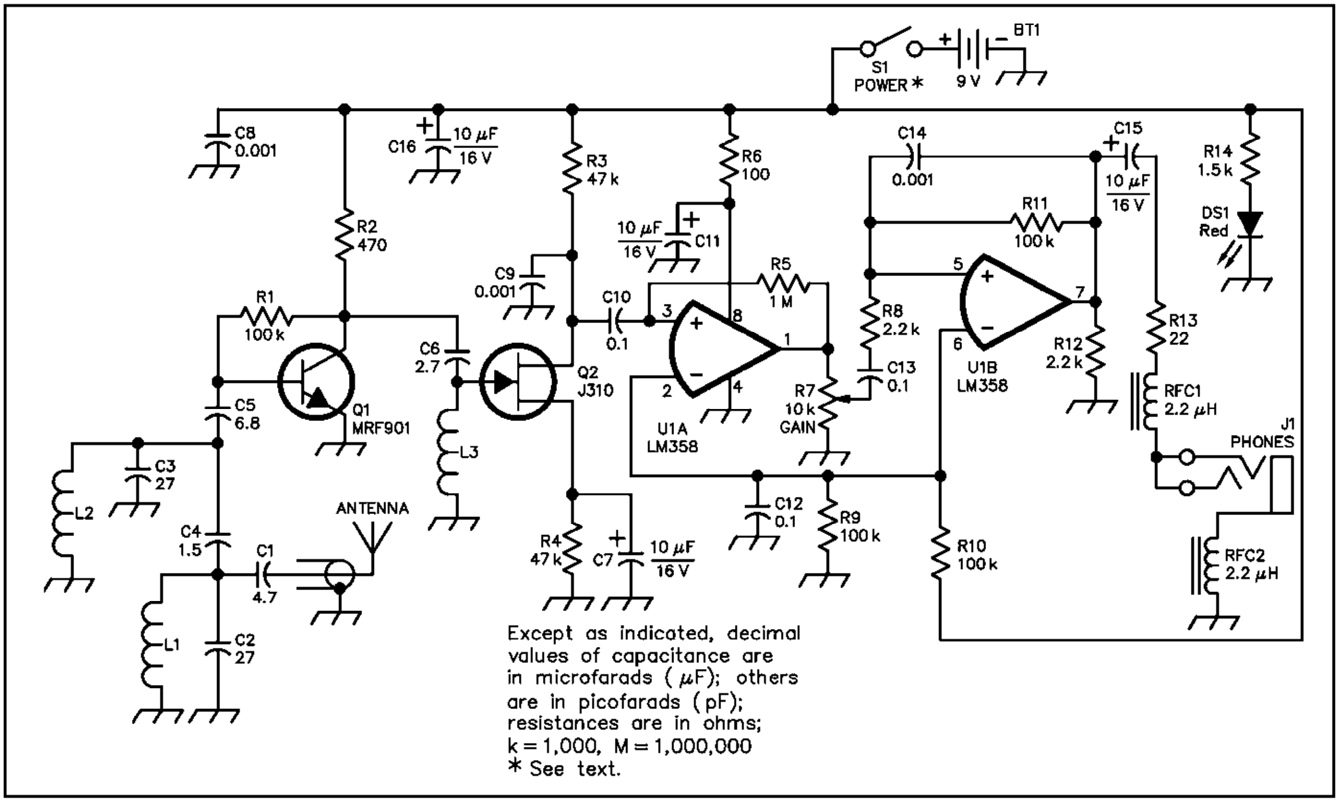


Figure 1—Schematic of the TRF RFI receiver. Unless otherwise specified, resistors are 1/4-W, 5%-tolerance carbon-composition or metal-film units. Part numbers in parentheses are CS (Circuit Specialists, Inc, PO Box 3047, Scottsdale, AZ 85271-3047; tel 800-811-5208, 602-464-2485, fax 602-464-5824; www.cir.com); DS (Dan's Small Parts and Kits, Box 3634, Missoula, MT 59806-3634; tel and fax 406-258-2782; www.fix.net/dans.html); RS and RSU (RadioShack.com, PO Box 1981, Fort Worth, TX 76101-1981; tel 800-843-7422, fax 800-813-0087; www.radioshack.com); ME (Mouser Electronics, 958 N Main St, Mansfield, TX 76063-4827; tel 800-346-6873, 817-483-4422, fax 817-483-0931; sales@mouser.com; www.mouser.com). Equivalent parts can be substituted; n.c. indicates no connection.

BT1—9-V battery
C1—4.7 pF disc ceramic (DS)
C2, C3—27 pF multilayer (ME 581-UEC270J1)
C4—1.5 pF disc ceramic (DS); a 2-pF capacitor may be used if a 1.5-pF unit is unavailable.
C5—6.8 pF disc ceramic (DS)
C6—2.7 pF disc ceramic (DS)
C7, C11, C15, C16—10 µF, 16 V electrolytic (RSU 11296852)
C8, C9, C14—0.001 µF (RS 272-126)
C10, C12, C13—0.1 µF (RS 272-135)
DS1—Red T1 3-mm LED (RS 276-026)
J1—3.5-mm three-circuit (stereo) mini jack (RS 274-246)
L1, L2—Air-wound inductor made of 5 turns #24 tinned wire formed on the threads of a #6-32 screw
L3—Air-wound inductor made of 11 turns #24 tinned wire formed on the threads of a #8-32 screw
Q1—MRF-901 (CS MRF901)
Q2—J310 N-channel FET (CS J310)
R1, R9-R11—100 kΩ (RS 271-1347)
R2—470 Ω (RS 271-1317)
R3, R4—47 kΩ (RS 271-1342)
R5—1 MΩ (RS 271-1356)
R6—100 Ω (RS 271-1311)
R7—10 kΩ PC-mount pot with switch (ME 31XT401)
R8, R12—2.2 kΩ (RS 271-1325)
R13—22 Ω (RSU 11344579)
R14—1.5 kΩ (RSU 11344892)
RFC1, RFC2—2.2 µH molded choke (ME 434-22-2R2)
S1—SPST toggle (part of R7)
U1—LM358 dual op amp (CS LM358)

light and battery condition indicator. Circuit current drain is approximately 12 mA, permitting several hours of operation from a single 9-V battery.

The notion of using a TRF design at VHF for noise detection was inspired by a simple UHF AM wideband-data receiver circuit described in *RF Design Magazine.*[2] However, for this particular application, I used commonly available experimenter parts and added an RF preamp to increase sensitivity. I also routed the output of Q2 to the lower-impedance inverting input of U1A to provide heavier detector loading. This change reduces a tendency toward AF instability, yielding a 10-dBm improvement in overall receiver performance.

Given its simplicity, the receiver is quite sensitive. On the bench, the detection threshold for a weak narrowband AM signal at the passband center measured −100 dBm. This level of receiver sensitivity, combined with the antenna's gain, enhances weak-signal reception. The receiver has no signal-strength metering system, nor does it need one. Relative signal strength is measured audibly—by listening to differences in loudness in the headphones. Gain is controllable over a wide signal range by the manual attenuator, R7, so even small amplitude changes are easy to detect. The lack of AGC in a receiver of this type could prove problematic, except that U1B has limited output capability. If an extremely strong signal suddenly appears at a high gain setting, U1B saturates at a sufficiently low level to protect your eardrums.

Antenna Construction

Figure 2 shows the Moxon Rectangle antenna is constructed from four lengths of 1/4-inch OD aluminum tubing. The short sections of the driven and reflector elements are four and six inches long, respectively. The most difficult task is shaping the 90° element bends without crimping and breaking the tubing. Gently heating the tubing prior to bending will help. Use a small tubing bender (available at most Home Depot stores and other such outlets), or use the partially open jaws of a vise as a fulcrum to form the bend progressively in four or five increments. Complete each bend and check it with a square *before* cutting the element section to length. Once formed, clamp the element sections to a 1/4×2×12-inch Plexiglas or plastic mounting plate.

Form the element-retainer clips from 0.032-inch aluminum hobby stock. To radius the clips, shape them over the shank of a 7/32-inch drill bit, then with the help of a vise, trim and bend each one to shape. The radius should be slightly undersized to exert clamping pressure on the 1/4-inch OD element. To prepare for mounting, drill aligning holes (#4-40 clearance) through each clip, element section and the antenna-mounting plate, as shown. Prepare short pigtails on the antenna end of the coaxial feed line and install spade lugs for attachment to the driven-element hardware. Loop the feed line through four FT37-43 beads to form the feed-line choke. Finally, pass the feed line through its guide hole to the underside of the plate entry into the receiver box. The antenna plate mounts on top of the receiver case using the two reflector-element-mounting screws. Use #6 flat washers or better yet, a small aluminum plate inside the plastic case to increase retention area and add strength to the antenna mount.

After mounting the elements, adjust the element tips for an air-gap of approximately 1 1/2 inch. Although some authors suggest installing insulators between the element tips to add rigidity, I don't recommend it. Range tests carried out at 150 MHz using a variety of nonconductive materials resulted in resonance shifts and degraded back-null performance. *NEC* plots representing the antenna pattern assume air gaps and fail to show this effect.

If you have access to a VHF antenna analyzer, test your antenna before mount-

A close-up view of the receiver's front panel.

Table 1
Antenna Parts List

Quantity	*Item*
2	Reflector-element sections 1/4-inch OD 15 1/2 × 6-inch aluminum tubing; see text and Figure 2.
2	Driven-element sections 1/4-inch OD 15 1/2 × 4-inch aluminum tubing; see text and Figure 2.
1	Right-hand driven-element mounting clip; see text.
1	Left-hand driven-element mounting clip; see text.
6	#4-40 × 3/4-inch screws
8	#4-40 nuts with integral lock washers, or use separate items.
2	#4-40 flat washers
2	#6 spade lugs
1	18-inch length of miniature 50-Ω coax (RG-174)
4	FT37-43 ferrite cores

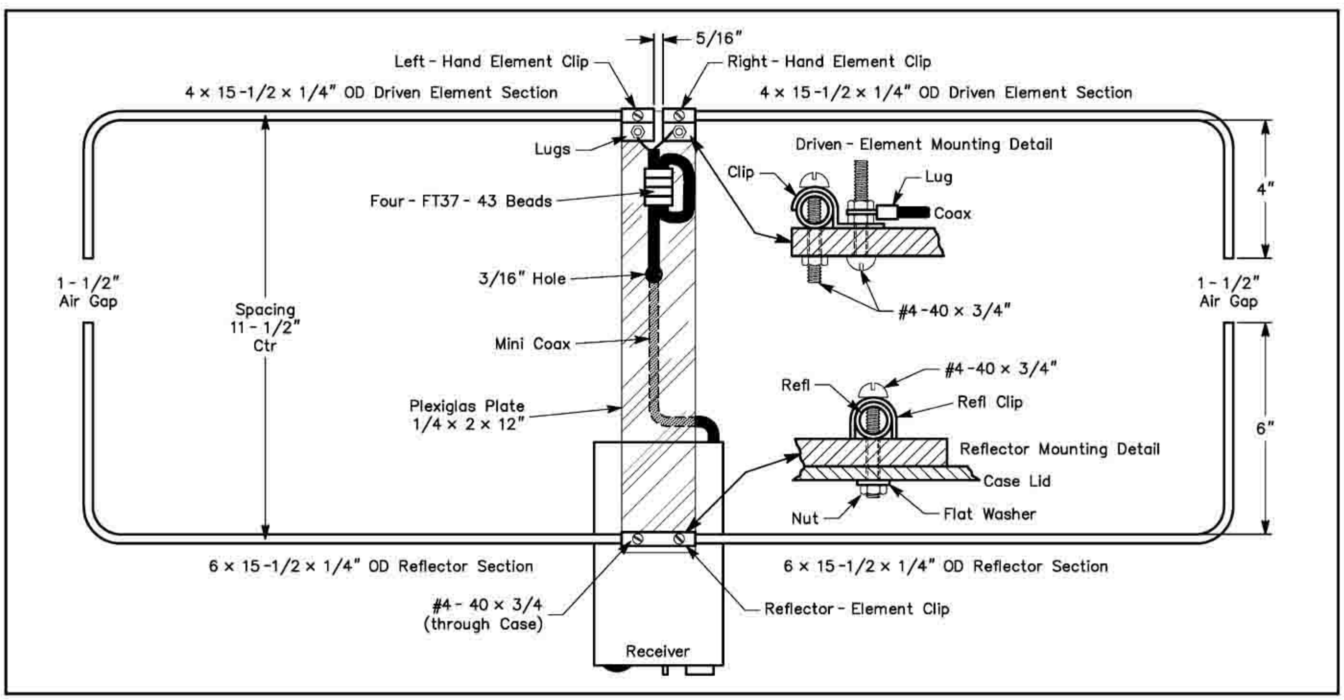
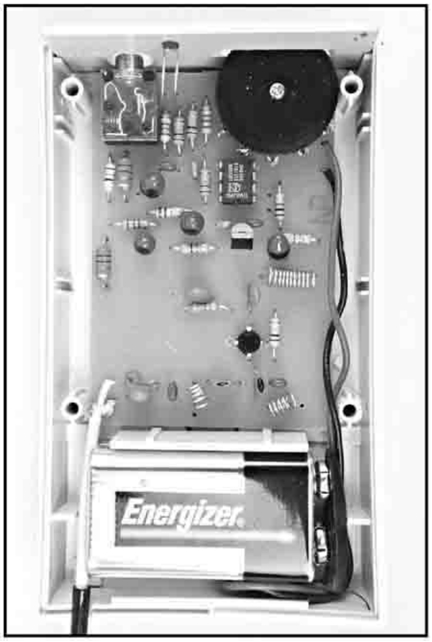


Figure 2—Antenna assembly details. See Table 1 for a list of parts needed. The driven- and reflector-element clamps are made of 0.032-inch hobby aluminum stock.

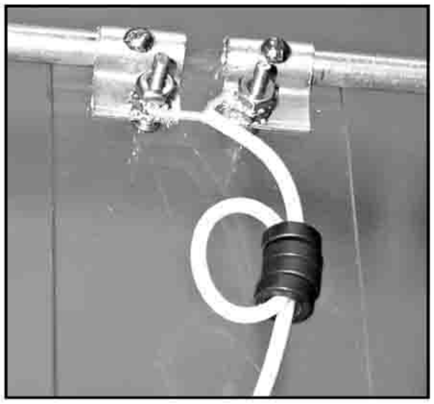


An inside view of the neatly assembled TRF RFI receiver prototype.

ing it on the receiver case; the SWR should be 1.2:1 or better at resonance. According to an HP8735E, my test antenna indicated a virtually flat response at 136.6 MHz. If the antenna resonance falls a little below or above the 136-MHz target frequency, there's no need to readjust the antenna. Simply note where minimum SWR occurs and peak your receiver for that particular frequency.

Receiver Construction

The receiver is built on a single-sided PC board with a generous ground plane and construction is straightforward.[3] Because this is a VHF project, be sure to keep all capacitor leads in the RF section as short as possible. L1, L2 and L3 are air-wound coils. Wind L1 and L2 on a #6-32 screw; form L3 using a #8-32 screw. When installing the MRF-901 preamp, note that the collector is the longest of the four leads. To mount pot R7, first remove its thumbwheel, then lay the control lugs flat on the top of the PC board. Secure each lug in place at its mounting hole using a short piece of wire (a discarded component-lead end will do). When mounting DS1, leave the leads nearly full length so the LED lens can protrude through its mounting hole near the top of the front panel (the shorter LED lead goes to the foil-side mounting hole).



Loop the feed line through four FT37-43 beads to form the feed-line choke to decouple the outer surface of the feed line from the antenna feedpoint.

For the receiver case, I used a Pan-Tec $1\times2^3/_4\times4^5/_8$-inch (HWD) project box (RadioShack 910-5006). To prepare the case, begin by clamping both halves together and drilling a $^1/_8$-inch hole in the rear panel to pass the feed line. Center this hole on the case split and not more than $^3/_{16}$ inch from the right-hand corner. The feed line, passing through this hole, is clamped in place when the box is assembled. Next, drill two #4-40 clearance holes in the top of the case approximately $1^7/_8$ inch forward of the back panel. These holes are used to mount the antenna assembly (use the antenna plate as a drilling template). Finally, prepare the removable front panel.[4] To cut the thumbwheel slot for R7, drill a line of small holes to rough out the opening, then carefully finish the hole with an X-acto knife and a small file. Panel lettering may be added using dry transfers, or using your PC and a program (such as MS *Draw*) to make a full-sized panel decal.

Receiver Testing and Tune-Up

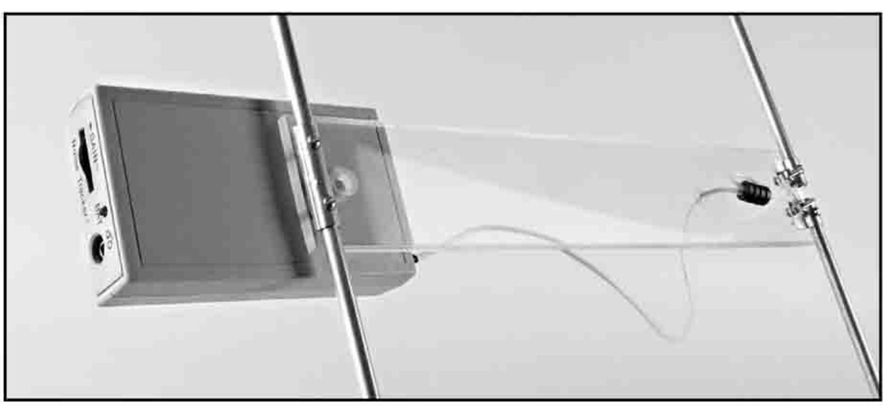
Testing and alignment is done with the receiver PC board out of the case. Install a fresh battery, plug in a pair of stereo headphones and turn the **GAIN** control to maximum. You should hear a background hiss that increases in both volume and high-frequency response with higher gain settings.

Alignment consists of tuning L1 through L3 for maximum sensitivity at the antenna's resonant frequency. If you have access to a modest calibrated signal generator (HP-8640B, Wave-Tek 3000, etc), tune-up will be a snap. Connect the receiver to the generator by a short length of temporary feed line. Set the generator for the desired frequency with 1-kHz AM modulation adjusted to 80-90% and output set at approximately −60 dBm (reduce the generator output as needed while tuning). Tune L1 through L3 by gently stretching or compressing windings using the tip of a plastic insulated tool. For a more precise tuning indication, attach a 'scope or sensitive ac voltmeter to R13. Repeat the tuning sequence until there's no further improvement. With L1-L3 fully peaked, a −90-dBm signal should be comfortably audible and you may detect audio down to −100 dBm or beyond.

If you don't have access to a calibrated generator, use a VHF antenna analyzer to produce a test signal. *Don't connect the antenna analyzer directly to the receiver*; you may damage the preamp and detector. Instead, terminate the receiver's antenna terminals temporarily with a 47-Ω resistor. Tune the analyzer to the antenna's resonant frequency and position it a suitable distance away to yield a noisy but usable signal level. Most analyzers have audible AM superimposed on the signal by internal processor or counter transients. *Don't attempt to optimize the receiver for maximum background noise without using a generator or calibrated signal source.* The TRF design must be peaked for maximum sensitivity *at the resonant frequency of the Moxon antenna* in order to take advantage of the antenna's characteristic cardioid pattern.

Final Assembly

Once tuned, avoid moving L1-L3 while connecting the miniature feed line and installing the PC board in its case. To assemble the case, slip its end panel over the **GAIN** control and make sure the LED, DS1, protrudes through its open-



A topside view of the tracking receiver and antenna. The receiver is attached to the antenna and Plexiglas strip by two screws.

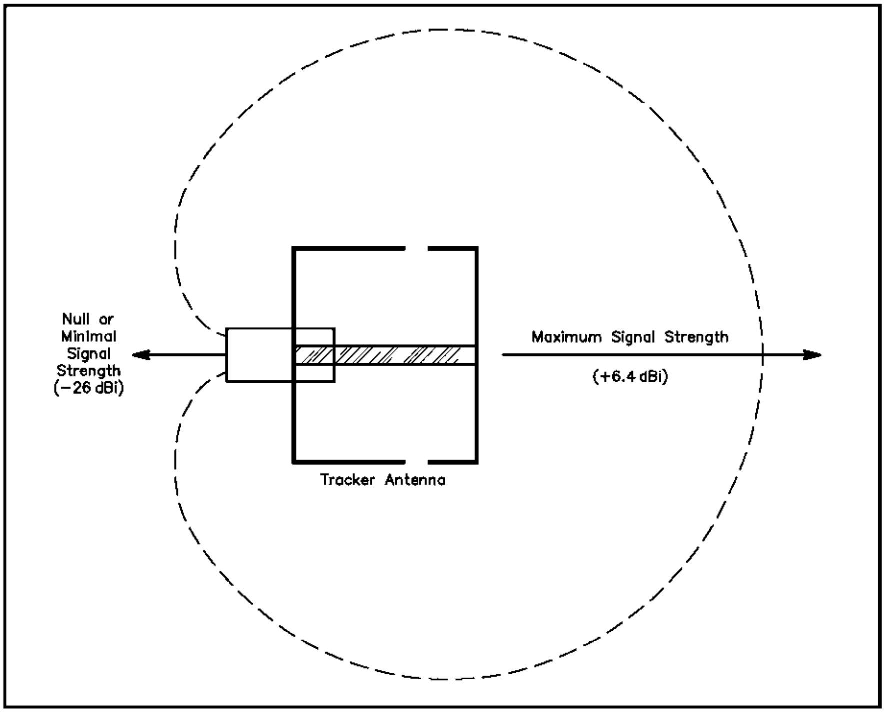


Figure 3—A Moxon Rectangle antenna pattern. Note that the pattern null points toward the user.

ing. Guide the end panel and PC board into the bottom half of the case and route the miniature coax over its exit groove. Route the battery clip out through the open battery compartment door. Attach the antenna assembly to the top half of the case by means of the antenna's reflector-mounting screws and secure it in place. Finally, sandwich the case together and install the assembly screws.

Operation

To operate your receiver, simply turn it on and direct the antenna toward suspected noise sources. As a rule, the Moxon's broad forward lobe is best for identifying general locations and the sharper back null is best for pinpointing specific nearby sources (Figure 3). A word of caution: In the real world, multipath, polarity differences and many other anomalies may appear to muddy the antenna's ideal cardioid response pattern. Fortunately, you can shift polarity with a twist of the wrist, and shift location in terms of antenna wavelengths by moving only a few feet.

RFI comes from many sources, including ac power-line sparking, electric-fence arcing, motors and control circuitry, noisy lighting equipment, defective switching supplies, leaking computer networks and much more. Also, 136 MHz coincides with cable channel 16, so a strong buzzing sound may be the result of sync-pulse noise from TV-cable leakage rather than ac-line noise (the two sounds can be very difficult to distinguish). A quick check with an AM broadcast radio will usually resolve this question, since TV sync won't appear in the AM band while a strong ac line noise will.

There are many tricks and techniques for isolating RFI sources and for identifying the exact type of fault they represent—far too many to cover here. For the amateur noise hunter, two excellent resources are available. I strongly recommend *The ARRL RFI Book* prepared by ARRL Lab Supervisor, Ed Hare, W1RFI, his choice of call being no coincidence.[5] I also suggest obtaining the *Interference Handbook* by William R. Nelson, WA6FQG, which is also available from the ARRL and most ham-radio bookstores.[6] Both books are packed with useful information. Finally, see the ARRL's Technical Information Services RFI pages at **www.arrl.org/tis/info/rfigen.html**.

In many parts of the country, the frequencies about 136 MHz may be populated with air-band activity, so it's inevitable you'll pick up transmissions as you hunt for noise. For instance, here in the busy Northeast corridor, I regularly hear air-to-ground conversations, bursts of aircraft automated-reporting-system packet, and even an occasional weather satellite passing overhead. However, aircraft-band transmissions are normally very short and won't disrupt your search. Moreover, intermittent chatter provides reassurance that the receiver is working properly.

Summary

RFI levels are increasing in most communities. The same interference that plagues Amateur Radio affects other services as well. For example, many municipal police and fire departments struggle with decreased handheld-portable coverage because of rising noise floors. Also, regional FM broadcasters now routinely install low-power translators to overcome degraded reception in noisy downtown areas. Excessive RFI is not just a ham problem; it's a community problem affecting everyone with an interest in communicating by radio!

FCC policy dictates that our licensed radio services need not tolerate excessive RFI levels. (See **www.arrl.org/tis/info/part15.html** for a comprehensive description of the applicable FCC rules.) However, Federal enforcement is stretched to the limit and local electrical inspectors usually lack the equipment and training to intervene. Thus, neighborhood RFI detection and reporting often falls to utility companies and radio amateurs like you and me. If you're tired of local noise invading our bands, why not join the cleanup and perform a public service at the same time? This simple hand-held project—plus a little legwork—may be all it takes to restore a cleaner spectrum for you and your neighbors!

Notes

1. L. B. Cebik, W4RNL, "Modeling and Understanding Small Beams, Part 2, VK2ABQ Squares and Moxon Rectangles," *Communications Quarterly*, Spring 1995, pp 55-70.
2. Robert Friday and John Neder, "A Low-Cost UHF AM Receiver," *RF Design*, Nov 1991, pp 31-36.
3. A parts kit including the PC board (but excluding case and antenna) is available from Rick Littlefield, K1BQT, PO Box 465, Barrington, NH 03825. Price: $29.95 plus $4 shipping and handling.
4. A front-panel template/labeling guide and a PC-board part-placement pictorial are available from the ARRL ftp site at **www.arrl.org/files/qst-binaries/** in TRFRFI.ZIP.
5. See **www.arrl.org/shop/**, order number 6834. Ed Hare, W1RFI, *The ARRL RFI Book* (Newington: ARRL, 1999, 1st ed).
6. See **www.arrl.org/shop/**, order number 6015. W. R. Nelson, WA6FQG, *Interference Handbook* (Lakewood, NJ: Radio Amateur Callbook, 1993).

Rick Littlefield, K1BQT, is an Extra Class ham, first licensed at age 13 in 1957. An avid equipment designer and prolific writer, he has over 100 technical articles published in various journals worldwide and is a member of the ARCI QRP Hall of Fame. Rick's ham-radio resume includes work for familiar manufacturers such as MFJ Enterprises and Ten-Tec. He holds a master's degree from the University of New Hampshire and is currently employed in the engineering department of Cushcraft Corporation in Manchester, New Hampshire. You can contact Rick at 109A McDaniel Shore Dr, Barrington, NH 03825; **k1bqt@aol.com.**

AN ACTIVE ATTENUATOR FOR VHF-FM

During a VHF transmitter hunt, the strength of the received signal can vary from roughly a microvolt at the starting point to nearly a volt when you are within an inch of the transmitter, a 120-dB range. If you use a beam or other directional array, your receiver must provide accurate signal-strength readings throughout the hunt. Zero to full scale range of S-meters on most hand-held transceivers is only 20 to 30 dB, which is fine for normal operating, but totally inadequate for transmitter hunting. Inserting a passive attenuator between the antenna and the receiver reduces the receiver input signal. However, the usefulness of an external attenuator is limited by how well the receiver can be shielded.

Anjo Eenhoorn, PAØZR, has designed a simple add-on unit that achieves continuously variable attenuation by mixing the received signal with a signal from a 500-kHz oscillator. This process creates mixing products above and below the input frequency. The spacing of the closest products from the input frequency is equal to the local oscillator (LO) frequency. For example, if the input signal is at 146.52 MHz, the closest mixing products will appear at 147.02 and 146.02 MHz.

The strength of the mixing products varies with increasing or decreasing LO signal level. By DFing on the mixing product frequencies, you can obtain accurate headings even in the presence of a very strong received signal. As a result, any hand-held transceiver, regardless of how poor it's shielding may be, is usable for transmitter hunting, up to the point where complete blocking of the receiver front end occurs. At the mixing product frequencies, the attenuator's range is greater than 100 dB.

Varying the level of the oscillator signal provides the extra advantage of controlling the strength of the input signal as it passes through the mixer. So as you close in on the target, you have the choice of monitoring and controlling the level of the input signal or the product signals, whichever provides the best results.

The LO circuit (**Fig 13.50**) uses the easy-to-find 2N2222A transistor. Trimmer capacitor C1 adjusts the oscillator's frequency. Frequency stability is only a minor concern; a few kilohertz of drift is tolerable. Q1's output feeds an emitter-follower buffer using a 2N3904 transistor, Q2. A linear-taper potentiometer (R6) controls the oscillator signal level present at the cathode of the mixing diode, D1. The diode and coupling capacitor C7 are in series with the signal path from antenna

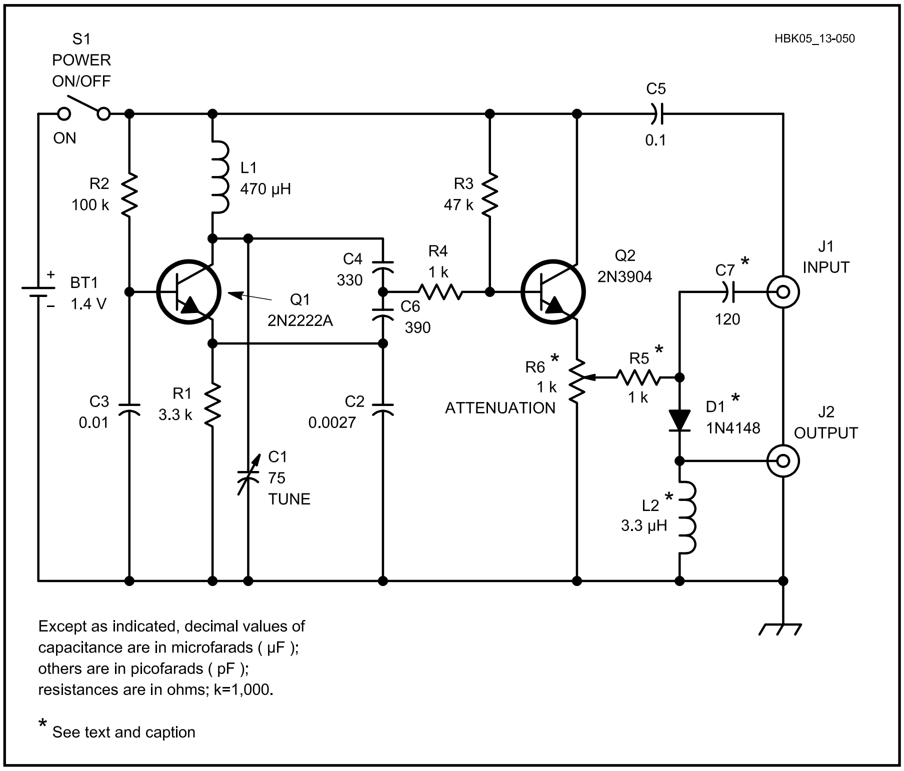


Fig 13.50 — Schematic of the active attenuator. Resistors are 1/4-W, 5%-tolerance carbon composition or film.

BT1 — Alkaline hearing-aid battery, Duracell SP675 or equivalent.
C1 — 75-pF miniature foil trimmer.
J1, J2 — BNC female connectors.
L1 — 470-µH RF choke.
L2 — 3.3-µH RF choke.
R6 — 1-kΩ, 1-W linear taper (slide or rotary).
S1 — SPST toggle.

input to attenuator output.

This frequency converter design is unorthodox; it does not use the conventional configuration of a doubly balanced mixer, matching pads, filters and so on. Such sophistication is unnecessary here. This approach gives an easy to build circuit that consumes very little power. PAØZR uses a tiny 1.4-V hearing-aid battery with a homemade battery clip. If your enclosure permits, you can substitute a standard AAA-size battery and holder.

CONSTRUCTION AND TUNING

For a template for this project, including the PC board layout and parts overlay, see the **Templates** section of the *Handbook* CD-ROM. A circuit board is available from FAR Circuits. The prototype (**Fig 13.51**) uses a plated enclosure with female BNC connectors for RF input and output. C7, D1, L2 and R5 are installed with point-to-point wiring between the BNC connectors and the potentiometer. S1 mounts on the rear wall of the enclosure.

Most hams will find the 500-kHz frequency offset convenient, but the oscillator can be tuned to other frequencies. If VHF/UHF activity is high in your area, choose an oscillator frequency that creates mixing products in clear portions of the band. The attenuator was designed for 144-MHz RDF, but will work elsewhere in the VHF/UHF range.

You can tune the oscillator with a frequency counter or with a strong signal of known frequency. It helps to enlist the aid of a friend with a hand-held transceiver a short distance away for initial tests. Connect a short piece of wire to J1, and cable your hand-held transceiver to J2. Select a simplex receive frequency and have your assistant key the test transmitter at its lowest power setting. (Better yet, attach the transmitter to a dummy antenna.)

With attenuator power on, adjust R6 for mid-scale S-meter reading. Now retune the hand-held to receive one of the mixing products. Carefully tune C1 and R6 until you hear the mixing product. Watch the S-meter and tune C1 for maximum reading.

If your receiver features memory channels, enter the hidden transmitter frequency along with both mixing product frequencies before the hunt starts. This allows you to jump from one to the other at the press of a button.

When the hunt begins, listen to the fox's frequency with the attenuator switched on. Adjust R6 until you get a peak reading. If the signal is too weak, connect your quad or other RDF antenna directly to your transceiver and hunt without the attenuator until the signal becomes stronger.

As you get closer to the fox, the attenuator will not be able to reduce the on-frequency signal enough to get good bearings. At this point, switch to one of the mixing product frequencies, set R6 for on-scale reading and continue. As you make your final approach, stop frequently to adjust R6 and take new bearings. At very close range, remove the RDF antenna altogether and replace it with a short piece of wire. It's a good idea to make up a short length of wire attached to a BNC fitting in advance, so you do not damage J1 by sticking random pieces of wire into the center contact.

While it is most convenient to use this system with receivers having S-meters,

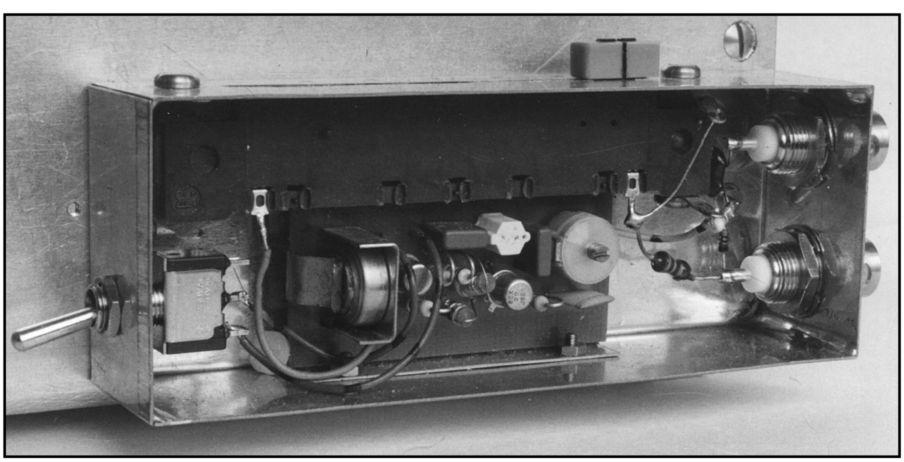


Fig 13.51 — Interior view of the active attenuator. Note that C7, D1 and L2 are mounted between the BNC connectors. R5 (not visible in this photograph) is connected to the wiper of slide pot R6.

the meter is not indispensable. The active attenuator will reduce signal level to a point where receiver noise becomes audible. You can then obtain accurate fixes with null-seeking antennas or the "body fade" technique by simply listening for maximum noise at the null.

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The "Searcher" (SDF-1) Direction Finder, Rainbow Kits.

ARRL Handbook CD

Template File

Title:	Eenhoorn Active Attenuator
Chapter:	27
Topic:	An Active Attenuator for VHF-FM

Template contains:

Note on PC board availability.

PC board etching pattern and parts placement diagram.

EENHORN ACTIVE ATTENUATOR PC BOARD TEMPLATE PACKAGE

Here is the PC-board template (Fig 1) and part-placement overlay (Fig 2) for the active attenuator described in Anjo Eenhoorn's "An Active Attenuator for Transmitter Hunting," <u>QST</u>, October 1992.

Figure 1 shows the etching pattern full-size, from the foil side of the board. Black areas represent unetched copper foil.

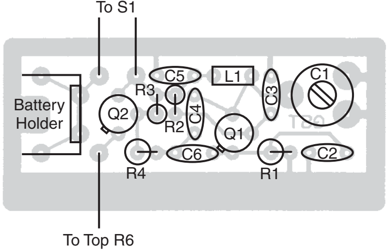
Figure 2 shows part placement from the nonfoil side of the board. The shaded area represents an X-ray view of the copper pattern.

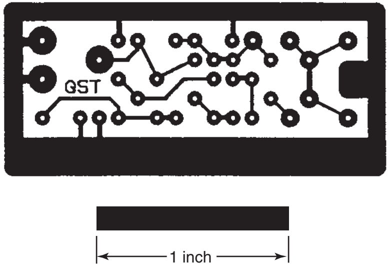
PC boards made from this pattern are available from FAR Circuits, 18N640 Field Court, Dundee, IL 60118; price, $3.50 per board plus $1.50 shipping and handling per order. Check or money order only; credit cards not accepted.

73, Steve Ford, WB8IMY

Assistant Technical Editor

edition 8/13/92





Active Attenuator for VHF-FM

PCB0004

THE SIMPLE SEEKER

The Simple Seeker for 144 MHz is the latest in a series of dual-antenna TDOA projects by Dave Geiser, W5IXM. Fig 13.36 and accompanying text shows its principle of operation. It is simple to perform rapid antenna switching with diodes, driven by a free-running multivibrator. For best RDF performance, the switching pulses should be square waves, so antennas are alternately connected for equal times. The Simple Seeker uses a CMOS version of the popular 555 timer, which demands very little supply current. A 9-V alkaline battery will give long life. See **Fig 13.46** for the schematic diagram.

PIN diodes are best for this application because they have low capacitance and handle a moderate amount of transmit power. Philips ECG553, NTE-555, Motorola MPN3401 and similar types are suitable. Ordinary 1N4148 switching diodes are acceptable for receive-only use.

Off the null, the polarity of the switching pulses in the receiver output changes (with respect to the switching waveform), depending on which antenna is nearer the source. Thus, comparing the receiver output phase to that of the switching waveform determines which end of the null line points toward the transmitter. The common name for a circuit to make this comparison is a *phase detector*, achieved in this unit with a simple bridge circuit. A phase detector balance control is included, although it may not be needed. Serious imbalance indicates incorrect receiver tuning, an off-frequency target signal, or misalignment in the receiver IF stages.

Almost any audio transformer with approximately 10:1 voltage step-up to a center-tapped secondary meets the requirements of this phase detector. The output is a positive or negative indication, applied to meter M1 to indicate left or right.

ANTENNA CHOICES

Dipole antennas are best for long-distance RDF. They ensure maximum signal pickup and provide the best load for transmitting. **Fig 13.47** shows plans for a pair of dipoles mounted on an H frame of $^1/_2$-inch PVC tubing. Connect the 39-inch elements to the switcher with coaxial cables of *exactly* equal length. Spacing between dipoles is about 20 inches for 2 m, but is not critical. To prevent external currents flowing on the coax shield from disrupting RDF operation, wrap three turns (about 2 inch diameter) of the incoming coax to form a choke balun.

For receive-only work, dipoles are effective over much more than their useful transmit bandwidth. A pair of appropriately spaced 144-MHz dipoles works from 130 to 165 MHz. You will get greater tone amplitude with greater dipole spacing, making it easier to detect the null in the presence of modulation on the signal. But do not make the spacing greater than one-half free-space wavelength on any frequency to be used.

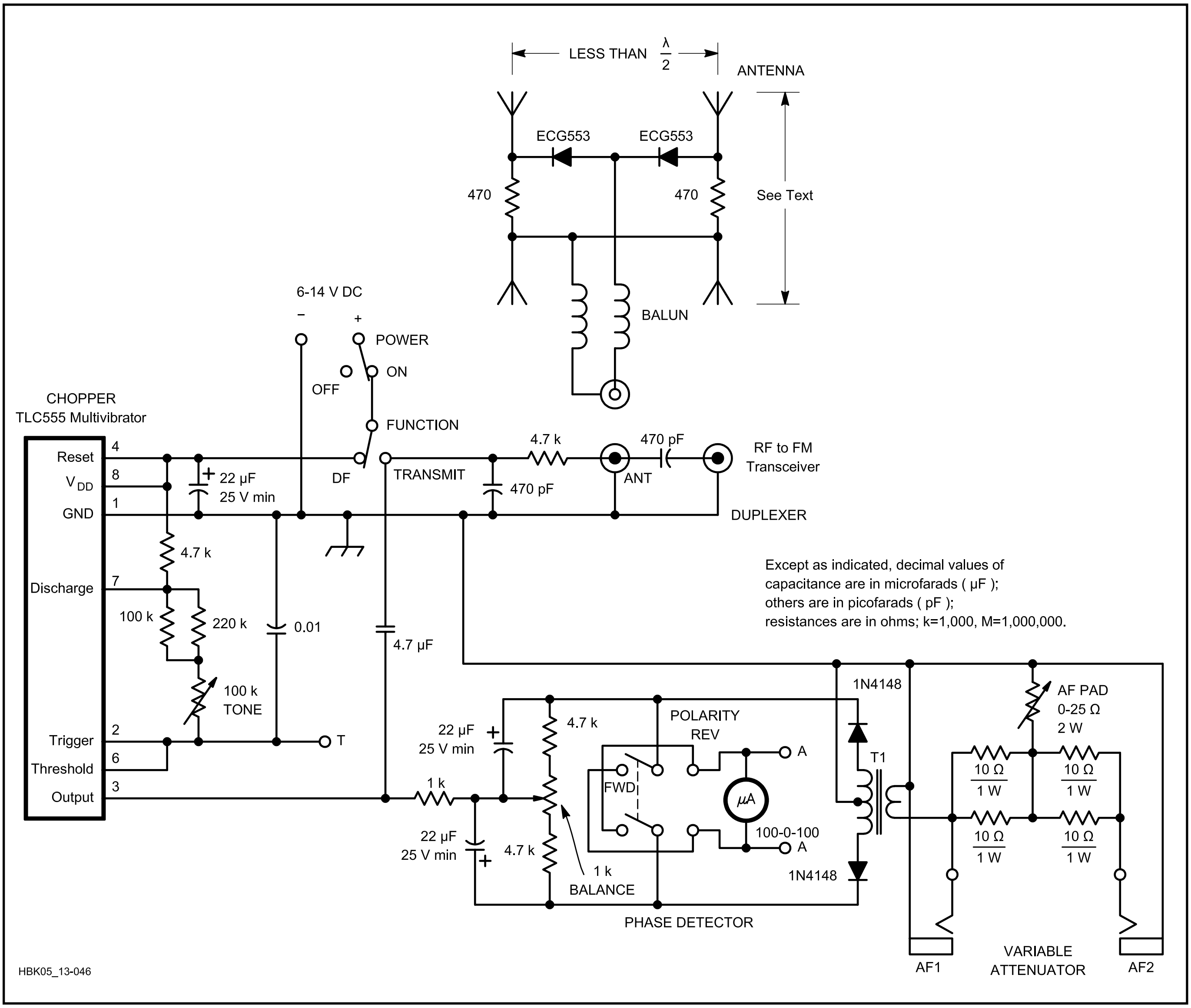


Fig 13.46 — Schematic of the Simple Seeker. A capacitor from point T to ground will lower the tone frequency, if desired. A single SPDT center-off toggle switch can replace separate power and function switches.

Best bearing accuracy demands that signals reach the receiver only from the switched antenna system. They should not arrive on the receiver wiring directly (through an unshielded case) or enter on wiring other than the antenna coax. The phase detecting system is less amplitude sensitive than systems such as quads and Yagis, but if you use small-aperture antennas such as "rubber duckies," a small signal leak may have a big effect. A wrap of aluminum foil around the receiver case helps block unwanted signal pickup, but tighter shielding may be needed.

Fig 13.48 shows a "sniffer" version of the unit with helix antennas. The added RDF circuits fit in a shielded box, with the switching pulses fed through a low-pass filter (the series 4.7-kΩ resistor and shunt 470-pF capacitor) to the receiver. The electronic switch is on a 20-pin DIP pad, with the phase detector on another pad (see **Fig 13.49**).

Because the phase detector may behave differently on weak and strong signals, the Simple Seeker incorporates an audio attenuator to allow either a full-strength audio or a lesser, adjustable received signal to feed the phase detector. You can plug headphones into jack AF2 and connect receiver audio to jack AF1 for no attenuation into the phase detector, or reverse the external connections, using the pad to control level to both the phones and the phase detector.

Convention is that the meter or other indicator deflects left when the signal is to the left. Others prefer that a left meter indication indicates that the antenna is rotated too far to the left. Whichever your choice, you can select it with the DPDT polarity switch. Polarity of audio output varies between receivers, so test the unit and receiver on a known signal source and mark the proper switch position on the unit before going into the field.

PIN diodes, when forward biased, exhibit low RF resistance and can pass up to approximately 1 W of VHF power without damage. The transmit position on the function switch applies steady dc bias to one of the PIN diodes, allowing communications from a hand-held RDF transceiver.

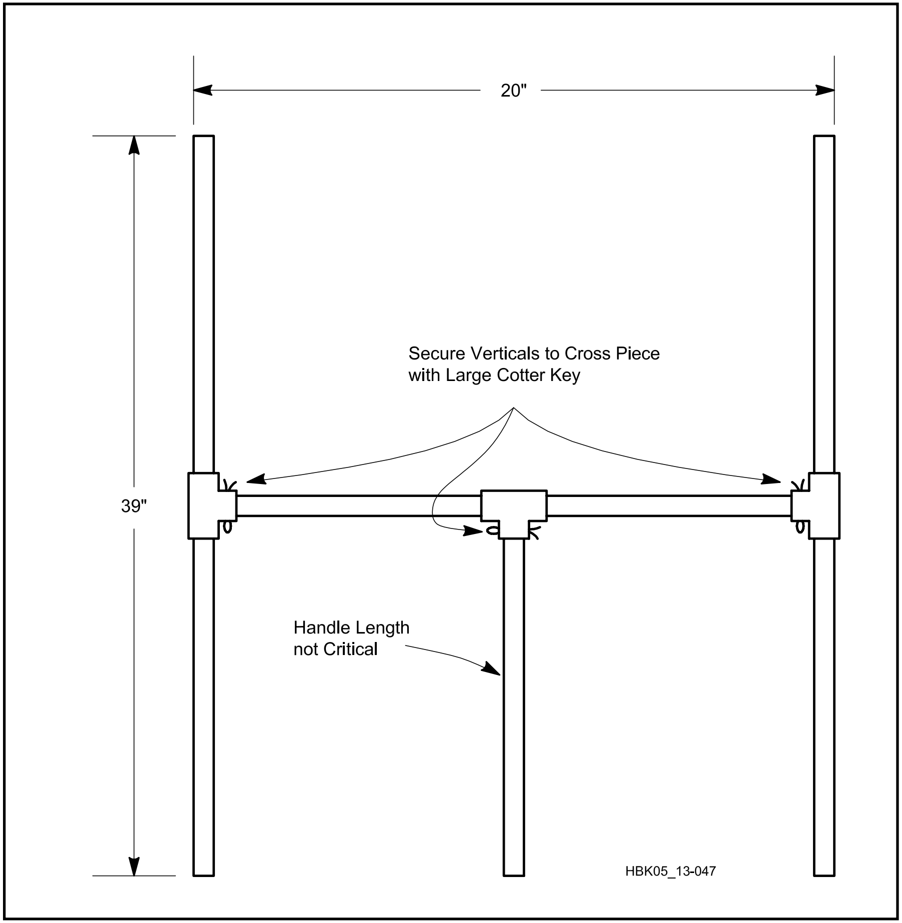


Fig 13.47 — "H" frame for the dual dipole Simple Seeker antenna set, made from ½-in. PVC tubing and tees. Glue the vertical dipole supports to the tees. Connect vertical tees and handle to the cross piece by drilling both parts and inserting large cotter pins. Tape the dipole elements to the tubes.

Fig 13.48 — Field version of the Simple Seeker with helix antennas.

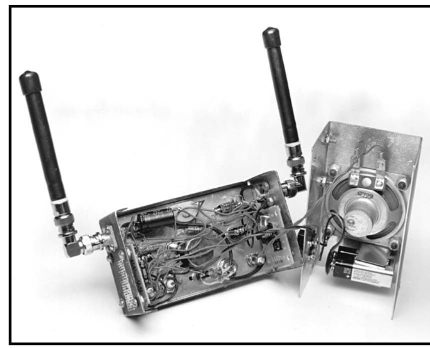


Fig 13.49 — Interior view of the Simple Seeker. The multivibrator and phase detector circuits are mounted at the box ends. This version has a convenient built-in speaker.

Adapting a Three Element Tape Measure Beam for Power Line Noise Hunting

Find that noise source to point your power utility in the right direction.

James T. Hanson, W1TRC

I have been using an MFJ-852 power line noise meter in conjunction with my homemade ultrasonic power line arc detector to track down power line noise.[1] The MFJ-852 meter uses a simple, built-in dipole antenna for reception. In the process of hunting down power line noise, I came across a situation in which I just could not pinpoint the noisy pole with my MFJ-852 power line noise meter. I decided that there must be more than one noise source in the vicinity. ARRL Lab RFI Engineer Mike Gruber, W1MG, pointed out the difficulty of using the MFJ-852 power line noise meter in a complex noise environment in his November 2006 *QST* review of the meter.[2] Because of the problem I was having at this location, I decided to replace the simple dipole used in the MFJ-852 with a directional three element Yagi.

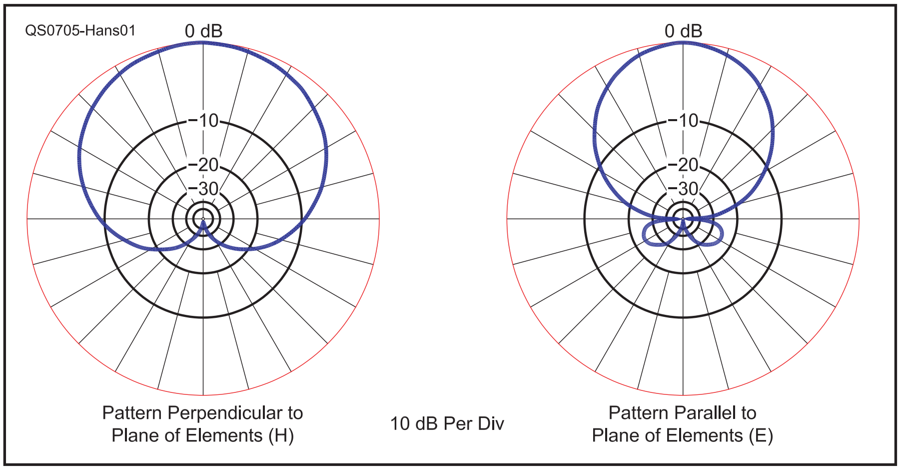


Figure 1 — *YAGI-CAD* predicted tape measure beam patterns.

An Easy to Make Yagi for the '852

While doing some searches on the Internet, I came across the Web site of Joe Leggio, WB2HOL, titled "Tape Measure Beam Optimized For Radio Direction Finding."[3] Joe developed a three element tape measure beam that he optimized for 2 meter fox hunting. The characteristics that have made his design such a success for fox hunting include all of the desirable features of an antenna optimized for power line noise hunting. These features include a very high front-to-back ratio, low cost, easy construction with simple hand tools and lightweight portability.

The antenna evolved during a search for a beam with a really great front-to-back ratio to use in hidden 2 meter transmitter hunts. The design exhibits a very clean pattern and is perfect for radio direction-finder (RDF) use. It trades a bit of forward gain in exchange for a very deep notch in the pattern toward the rear. These features, along with ease of construction and low cost, convinced me that this would be an ideal antenna to use for power line noise hunting.

One characteristic that is common to both RDF and noise hunting beam antennas is ease of getting it in and out of a car. This feature is accomplished by the use of steel tape measure elements. The elements can easily be folded when fitting the antenna into a car and yet, because of the short lengths at VHF/UHF frequencies, they are self-supporting.

Another desirable design goal was to use materials that were easy to obtain. The beam uses schedule 40 PVC pipe and fittings available at any hardware store for the boom and element supports. This keeps the cost for the antenna very low. The element supports consist of PVC crosses and Ts. The elements are cut from a steel tape measure.

Antenna Design Details

A shareware computer aided Yagi design program called *YAGI-CAD* written by Paul McMahon, VK3DIP, was used to design and evaluate the antenna.[4] A summary of the theoretical beam characteristics achieved is contained in Table 1. A plot of the E (electric field) and H (magnetic field) plane beam patterns predicted by *YAGI-CAD* is included in Figure 1. Notice that the beam has a theoretical front-to-back ratio of 50 dB. I have found the front-to-back ratio to be very impressive in actual use.

Table 1
Three Element Tape Measure Beam Performance Predicted by *YAGI-CAD*

Gain	7.3 dBd
Front-to-back ratio	>50 dB
Beamwidth, 3 dB E-plane	67.5°
Beamwidth, 3 dB H-plane	111°

The Yagi Elements

The beam consists of a boom constructed out of ½ inch PVC schedule 40 pipe and fittings and elements cut from 1 inch wide steel tape measure. I found a 25 foot, 1 inch wide tape measure at the bargain table of a local hardware store for under $5. This provided more than enough tape to build a three element beam at 135 MHz, the operating frequency of the MFJ-852 power line noise meter. I have since discovered that Home Depot also stocks a 25 foot, 1 inch wide tape measure for under $5. Inductive hairpin matching is used to match the antenna to 50 Ω coax.

Coax Termination

In the original RDF application, RG-58,

[1]Notes appear on page 31.

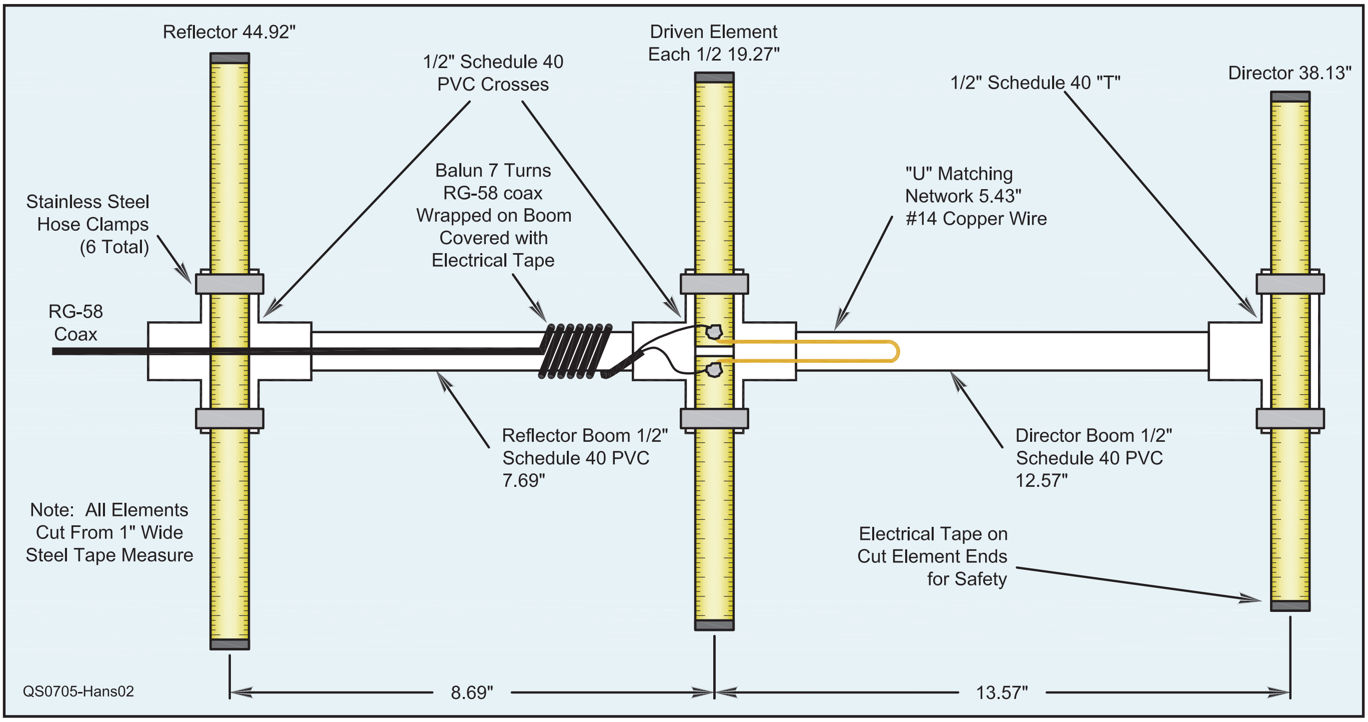


Figure 2 — 135 MHz tape measure beam assembly.

Table 2
Three Element Tape Measure Beam Dimensions (Inches)*

Frequency (MHz)	*146.565*	*135*	*224*	*432*
Reflector length	41.38	44.92	27.07	14.04
Driven element length	35.50	38.54	23.23	12.04
½ driven element length	17.75	19.27	11.61	6.02
Director length	35.13	38.13	22.98	11.92
Reflector to driven element center to center spacing	8.00	8.69	5.23	2.71
Reflector PVC length (see Note 1)	7.00	7.69	4.23	1.71
Director to driven element center to center spacing	12.50	13.57	8.18	4.24
Director PVC length (see Note 1)	11.50	12.57	7.18	3.24
U matching total length	5.00	5.43	3.27	1.70

*The length of PVC can vary somewhat depending on the PVC fitting exact dimensions. The critical antenna dimensions are the center to center element spacings.

50 Ω coax is connected directly to the driven element and matching network. I decided to create a balun by wrapping several turns of the coax around the boom right after the connection. This has also been done on a number of antennas that have been built for RDF use. The balun makes the transition from the balanced antenna feed point to the unbalanced coax. It should help generate a symmetrical antenna pattern. There is a measured antenna pattern plot on the Web site referenced in Note 4 that shows that the pattern is somewhat distorted. The pattern was taken without a balun, and it has not been redone with a balun.

Adapting to Other Frequencies

The original tape measure beam was designed for a 2 meter fox hunt frequency of 146.565 MHz. Since the MFJ-852 power line noise meter operates at a frequency of 135 MHz, the dimensions must be changed for this frequency. This is readily accomplished using Equations 1 and 2 that scale the dimensions of the 146.565 MHz design by the inverse of the new frequency. Equation 1 is used to scale the element lengths, element spacing and hairpin match length. Equation 2 is used to scale the reflector to the driven element and the director to the driven element boom lengths, which are shortened to take into account the length added by the PVC cross and T. Equation 2 is based on a distance of 1.25 inches from the edge of the PVC cross or T to the center of the corresponding beam element, and a penetration of the boom sections of 0.75 inch into the corresponding cross and T. This difference is 0.5 inch, which is multiplied by 2 to account for each end. This is where the 1 comes from in Equation 2. If you find the dimensions of your PVC parts differ from this, an adjustment to the factor "1" in Equation 2 should be made, so that the resultant element spacing is correct.

$$L_N = L_{146.565}*(146.565/F_N) \quad \text{[Eq 1]}$$
$$L_B = L_E - 1 \quad \text{[Eq 2]}$$

where:

L_N is the element length, element spacing or hairpin match length in inches at the new frequency.

$L_{146.565}$ is the corresponding 146.565 MHz antenna element length, element spacing or hairpin match length in inches.

F_N is the new frequency in MHz.

L_B is the boom length in inches at the new frequency.

L_E is the element to element spacing in inches at the new frequency.

The final dimensions for several different frequencies are included in Table 2. I found that the design scaled from 146.565 MHz to 135 MHz very well, and Joe Leggio, WB2HOL, has informed me that it scales up to 440 MHz just as well. It is recommended that if a 440 MHz version is built, that a ½ inch wide tape measure be used in place of 1 inch tape measure used in this model. Remember that as frequency increases, the tolerance of the dimensions gets tighter so at the higher frequencies, accuracy becomes more important. The antenna does not scale well if small diameter element material such as welding rod is substituted for the tape measure elements.

Putting it All Together

A drawing that shows all of the 135 MHz antenna construction details is included in Figure 2. The PVC components are not glued together. There is enough friction in the PVC pipe to hold the beam together and this allows it to be taken apart easily for transportation.

The tape measure can be cut with a pair of tin snips or a heavy pair of scissors. No matter how you cut the elements, be very careful. The edges are very sharp and will inflict a nasty cut if you are careless. Use some emery cloth to remove the really sharp edges and burrs resulting from cutting the elements to size. It is also a good idea to chamfer the edges by cutting about ⅛ inch off each corner. Put some vinyl electrical tape on the ends of the elements to protect from getting cut. Wear safety glasses while cutting the elements. Those bits of tape measure can be hazardous.

When I cut the tape, I used the tape measure itself to measure the length of the elements. I started out by cutting the end of the tape off at the 2 inch point and added 2 inches to the length of the first cut element to determine where the second cut should be made. I then trimmed the remaining tape to the next whole inch mark on the tape, and with simple arithmetic determined where the next cut should be made. I continued this process until all of the elements were cut to size.

Keeping Track of What's What

Notice that the driven element and reflector both use PVC crosses while the director element uses a PVC T. This was done purposely to make it easy to recognize the director and reflector elements when assembling the beam.

The wire size and type of wire used for the hairpin match is not critical. Hams have used anything from 22 to 14 gauge stranded or solid wire. I used 14 gauge solid copper house wire. It appears to be a good choice from a mechanical survivability point of view.

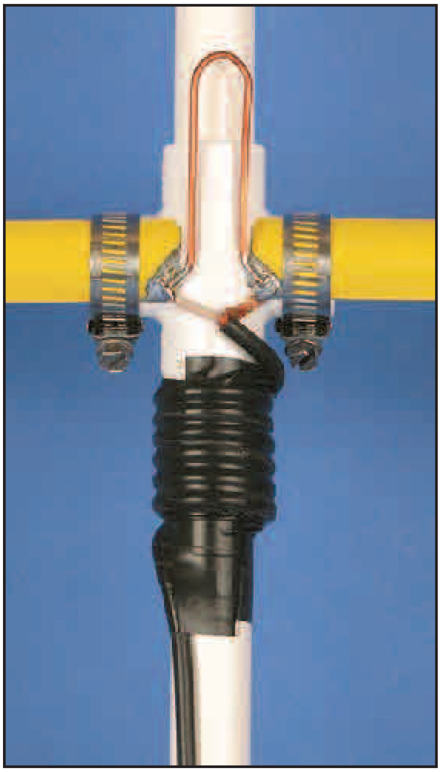


Figure 3 — Hairpin match and balun details.

Holding it Together

The elements are attached to the PVC fittings with stainless steel hose clamps. The only tricky part of assembling the beam is soldering the coax and hairpin match to the driven element, since the PVC will melt if you apply too much heat. One solution to this potential problem is to do the soldering before assembling the driven element to the PVC fittings.

Hooking it Up

Remove the paint from the corner of the driven element tape with some emery cloth and tin the steel tape. Temporarily tape the driven elements to a piece of scrap wooden board using electrical tape so the element ends are ¾ inch apart. Pre-form the hairpin match into a U shape so the spacing is ½ inch. Flare the last ¼ inch of the hairpin match out about 45°. Now solder the hairpin match and the coax to the elements. Carefully remove the electrical tape and position the assembly over the PVC cross. Slip the stainless steel clamps over the ends of the elements and tighten the clamps. The final assembly should look like the detail in Figure 3. After winding and wrapping the balun with electrical tape, the RG-58 coax was cut about 2 feet beyond the end of the reflector PVC cross and a BNC male connector installed on the coax. Figure 4 is a photograph of the assembled beam. Fine-tuning of the final match can be accomplished by increasing or decreasing the gap between the driven element halves. I checked the match with an MFJ-259B SWR analyzer and found that it was very close to 1.1:1.

Taking it Apart

When it is not in use, and when transporting the beam, disassemble the elements and director portion of the boom. The boom section that goes to the reflector is kept attached to the driven element since it has the coax balun attached. Each of the elements can be folded back on itself and slipped into the corresponding PVC cross or T to minimize its size. The disassembled components are shown in Figure 5. I carry the beam pieces in a plastic shopping bag.

Interfacing the Beam to the MFJ-852 Power Line Noise Meter

The final part of the project is to interface the beam with the MFJ-852 power line noise meter. The MFJ-852 has a metal front

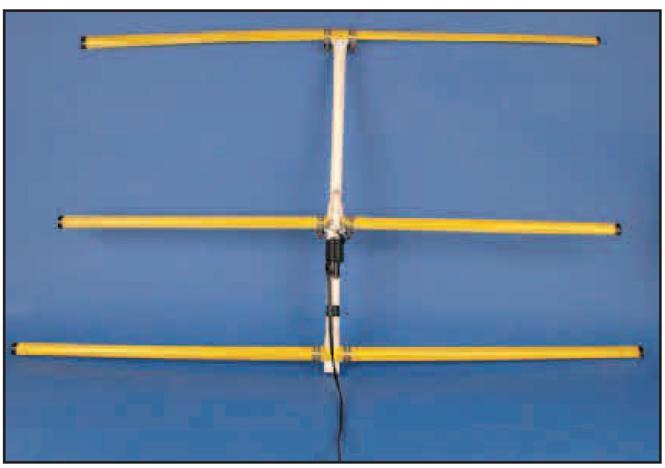


Figure 4 — Assembled 135 MHz tape measure beam.

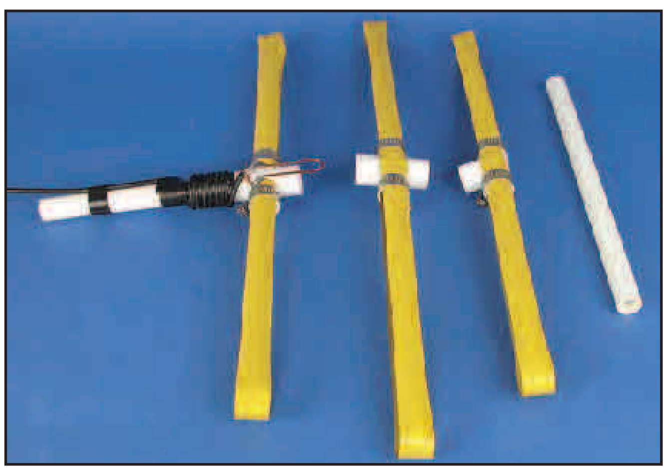


Figure 5 — Disassembled beam ready for transport.

panel but it is in a plastic box. I wanted to shield the electronics from any stray pickup to preserve the deep notch off the back of the beam, so I removed the plastic box and unsoldered the antenna coax connection from the PC card. The plastic box, telescoping antenna sections and coax balun are not used. I then mounted the MFJ-852 power line noise meter front panel and electronics to a cutout in a 3 × 5 × 4 inch aluminum BUD box (BUD part number AU-1028). I mounted a BNC female connector to the box and used a short length of small diameter 50 Ω coax (RG-174 or equivalent) to connect the coax connector to the MFJ-852 printed circuit card. The holes in the MFJ-852 printed circuit card have a very small diameter, so I found it necessary to use a piece of 22 gauge bus wire to make the connection to the coax shield.

Figure 6 — Shielded MFJ-852 mounted in metal Bud box.

Noise Hunting With the Three Element Beam

The beam makes a big difference when tracking down noise if there are two or more noise sources in relatively close proximity. I have found that the null off of the back of the beam is a very good indicator of the direction of the noise. I have found that it works best if I can get some distance (100 yards or more) away from multiple noise sources. In the complex environment I was investigating, I found that I could get more than one null off of the back of the beam, and each null pointed me to a noisy pole. Once I found the area where poles were generating noise, I was able to hear the arcing on the offending poles using my ultrasonic detector, and I was able to pinpoint the exact noise sources.[5]

The MFJ-852 signal strength meter has a dynamic range of about 50 dB. To extend the range, I carry a small, homemade, 20 dB, 50 Ω π-section attenuator in a shielded enclosure with BNC connectors. The attenuator can be connected between the antenna and the MFJ-852 to extend the dynamic range. I have found the attenuator to be helpful if the signal strength gets too strong.

Using Receivers Other Than the MFJ-852 Power Line Noise Meter

Any VHF or UHF receiver capable of receiving AM can be used with a tape measure beam to hunt for power line noise. There are several homemade and modified commercial receivers documented on the ARRL Technical Information Service (TIS) Web page.[6]

One example of a simple receiver is a tuned radio frequency (TRF) design by Rick Littlefield, K1BQT, published in the March 2001 issue of *QST*.[7] Rick let me try out one of his receivers that he had mounted in a shielded box for me with an SMA connector for the antenna. I purposely went hunting for some power line noise (it is never very far away) and was able to successfully hear and locate a noise source with this receiver using the tape measure beam.

There are also a growing number of small handheld receivers and transceivers that include general coverage receivers operating up to 1 GHz. Any that include an AM detector are suitable. Some of these receivers include a signal strength indicator or a switchable attenuator between the antenna and receiver can also be used to determine relative signal strength when pinpointing the noise source. A suitable switchable attenuator with 42 dB total range is described in the *QST* article titled "A Line Noise Sniffer That Works."[8] This article can be found on the ARRL TIS Web page. The article also describes how to use an attenuator when tracking down a noise source.

As Mike Gruber pointed out in his review of the MFJ-852, one of the unique requirements of a noise locating receiver is wide bandwidth, since noise is a wide band signal and the receiver sensitivity improves with bandwidth. The MFJ-852 has an IF bandwidth of 100 kHz. While most general coverage receivers will have bandwidths much narrower than this, the reduced sensitivity will be partially compensated for by the gain of the tape measure beam.

Notes

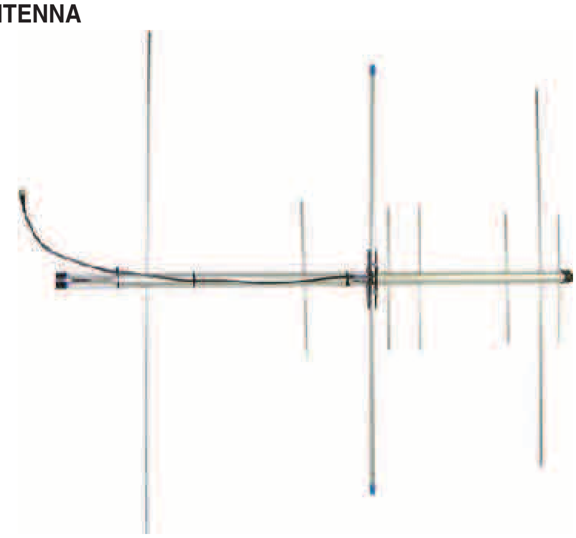
1 J. Hanson, W1TRC, "A Home-made Ultrasonic Power Line Arc Detector," *QST,* Apr 2006, pp 41-45.
2 M. Gruber, W1MG, "Product Review — MFJ-852 Power Line Noise Meter," *QST,* Nov 2006, pp 75-76.
3 **home.att.net/~jleggio/projects/rdf/rdf.htm**.
4 **www.teara.org**.
5 See Note 1.
6 **www.arrl.org/tis/tismenu.html**.
7 R. Littlefield, K1BQT, "A Simple TRF Receiver for Tracking RFI," *QST*, Mar 2001, pp 32-36.
8 W. Leavitt, W3AZ, "A Line Noise 'Sniffer' That Works," *QST,* Sep 1992, pp 52-55.

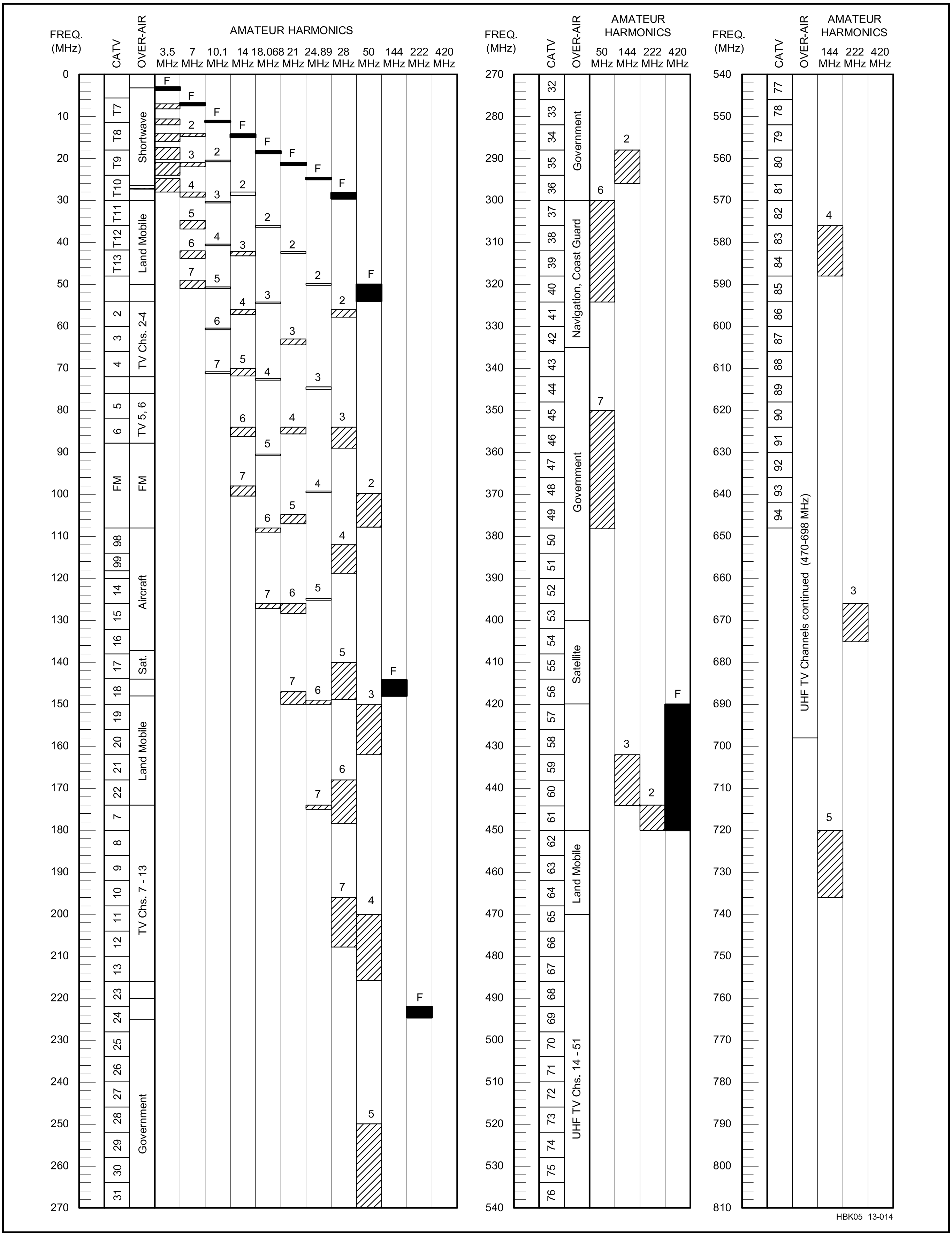
Jim Hanson, W1TRC, has been an ARRL member for over 50 years. He received his General class license in 1951, his Advanced class license in 1952 and his Amateur Extra class license in 1984. His primary ham radio interest has been working DX and he is at the top of the phone and mixed DXCC Honor Roll. Jim has a BS degree in electrical engineering and retired in 2004 from Raytheon Company Inc, where he worked on radar receiver and low noise exciter designs. He holds several patents relating to radar design. You can reach the author at 8 Ethelyn Cir, Maynard, MA 01754 or **w1trc@arrl.net**.

New Products

MFJ 144/440 MHz YAGI ANTENNA

◊The MFJ-1760 Yagi antenna uses 3 elements on 144 MHz and 5 elements on 440 MHz and requires only one feed line. Power rating is 500 W, the longest element is 40.5 inches, the boom length is 45 inches and the antenna weighs 2 pounds. The MFJ-1760 works with masts up to 1.5 inches diameter. A similar product, the DB-2345, is available from MFJ's Hy-Gain product line. Price: MFJ-1760, $79.95; Hy-Gain DB-2345, $89.95. To order or for your nearest dealer, call 800-647-1800 or see **www.mfjenterprises.com**.





This chart shows CATV and broadcast channels used in the United States and their relationship to the harmonics of MF, HF, VHF and UHF amateur bands. Over-the-air UHF TV channels 52-69 (698-890 MHz) have been reallocated to other services. (F denotes a fundamental frequency for amateur signals.)

ARRL Periodicals Archive – Search Results

A membership benefit of ARRL and the ARRL Technical Information Service

QST Issue: Jun 2006
Title: Ultrasonic Arc Detector Update
Author: Jim Hanson, W1TRC

Summer Meteor Scatter Contest — FSK441, sponsored by Radio Club "Golubinci" YT7GOL from 2000Z Jun 16-2000Z Jun 18. Frequencies: 144 MHz. Categories: SO and MO. Exchange: Call sign, report, final acknowledgment ("Roger"). QSO points: 1 pt/QSO. Score: QST pts × DXCC entities. For more information and changes for US station rules: **solair.eunet.yu/~s.ilic/summer_msc.htm**. Logs due Jul 10 to **golmscont@ptt.yu**.

Spanish Islands Contest — CW/SSB/RTTY, sponsored by the Diploma Islas Españolas (DIE), from 0600Z-1200Z Jun 18. Frequencies: 80-10 meters. Exchange: RST + DIE number or serial number. QSO points: Island stations 2 pts/QSO, otherwise 5 pts/QSO. For more information: **www.ea5ol.net/die**. Logs due 60 days after the contest to **ea5aen@ea5ol.net** or EA5AEN, PO Box 11055, Valencia, Spain.

June 24-25

ARRL Field Day — 1800Z Jun 24 to 2100Z Jun 25 (see May *QST*, p 105, or **www.arrl.org/contests**).

His Majesty King of Spain Contest—SSB, 1200Z Jun 24-1200Z Jun 25 (see May *QST*, p 100).

Here's a neat, low-power spin on the traditional Field Day activity.

QRP ARCI Milliwatt Field Day — 1800Z Jun 25-2100Z Jun 26. Follows ARRL Field Day rules; see **www.qrparci.org/contest.htm** for more information.

www.arrl.org/contests ◆ www.ncjweb.com ◆

Interested in finding out more about contesting and "how they do it"?

Try the free, biweekly e-mail newsletter *Contester's Rate Sheet* (**www.arrl.org/contests**) or the bimonthly magazine *National Contest Journal* (**www.ncjweb.com**). Both are packed with the practical information you need for contesting success.

Strays

ULTRASONIC ARC DETECTOR UPDATE

◊Jim Hanson, W1TRC, author of "A Home-made Ultrasonic Arc Detector" [Apr 2006, pp 41-46], reports that PC boards for the project are available. FAR Circuits, **www.farcircuits.net**, is producing the 2 × 3 inch boards based on artwork developed by Tom Hammond, NØSS, and John Brosnahan, WØUN.

Jim reports that there has been quite a bit of interest in the detector. He notes that at least one ham, Roger Monroe, K7NTW, already has his detector working. He has been able to use it to pinpoint his first noise source on a pole about ¼ mile from his home that has been giving him problems on 15 meters.

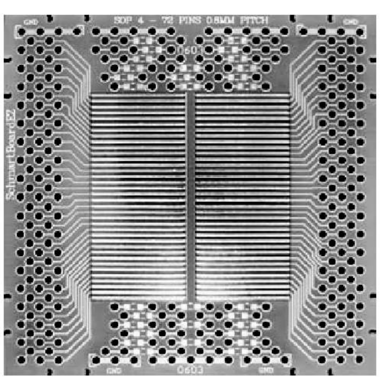
I would like to get in touch with...

◊anyone who has run power directly from the battery into the passenger compartment of a 2003 Toyota Sienna minivan. — *Terry Simonds*, **wb4fxd@mchsi.com** or 252-482-4335.

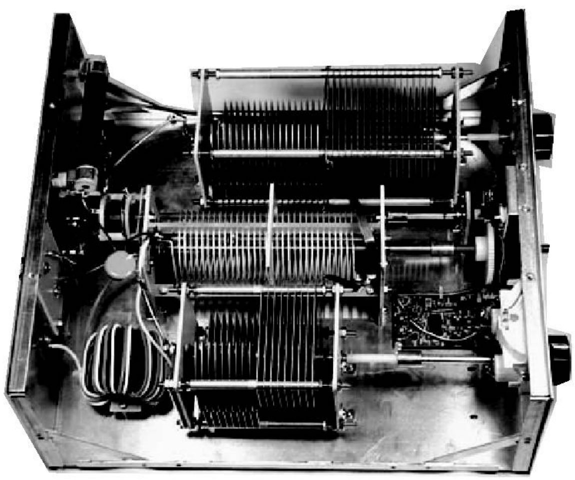
New Products

SCHMARTBOARD-EZ PROTOTYPING BOARD EASES SMD SOLDERING

◊SchmartBoardEZ prototyping boards are specifically designed to make it easy to build projects that require hand soldering of surface mount components. The solder mask is higher than the pads, not lower, to create grooves for the legs of ICs or other components. This is said to allow for easy component placement. The bottom of each groove already contains solder, so no additional solder is needed. To solder the component in place, touch a fine tip soldering iron to the outside end of a groove and push the melted solder until it touches the chip's leg. The solder stays in the groove to avoid short circuits. A variety of available boards can accommodate different SMD component and case styles. Prices are in the $5 to $10 range, depending on board size and type. Visit **www.schmartboard.com** for more information and a list of distributors, or to place an order.



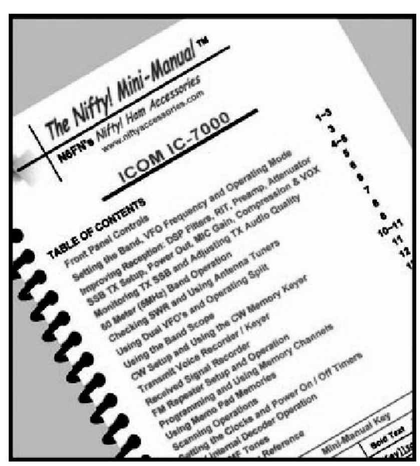
MFJ-9982 HIGH POWER ANTENNA TUNER



◊MFJ's 9982 antenna tuner is rated to handle 2500 W continuous carrier output on all modes and on all HF bands, and to work with coax-fed antennas or balanced lines. The tuner is said to employ an edge-wound roller inductor, high current 1000 and 500 pF variable capacitors, and a balun made from four 2.5 inch cores and wound with 12 gauge Teflon wire. Other features include 6:1 reduction drives, a cross-needle SWR/power meter and a ceramic antenna switch for two coaxial cables, a balanced line and a dummy load. Price: $699.95. To order or for your nearest dealer, call 800-647-1800 or see **www.mfjenterprises.com**.

IC-7000 MINI-MANUAL FROM NIFTY HAM ACCESSORIES

◊The IC-7000 Mini-Manual from Nifty Ham Accessories is a quick reference guide that covers control functions, programming and operating instructions for ICOM's IC-7000 transceiver. The Mini-Manual is 20 pages, and measures 4.5 × 8 inches. Pages are laminated and bound with a spiral wire binding so it lays flat. Price: $20.85. For more information or to order, visit **www.niftyaccessories.com**.



What To Do if You Have an Electronic Interference Problem

This is a self-help guide for the consumer published jointly by the American Radio Relay League (ARRL), an organization representing Amateur Radio operators, and the Consumer Electronics Association (CEA).

Introduction

As our lives become filled with more technology, the likelihood of unwanted electronic interference increases. Every lamp dimmer, hair dryer, garage-door opener, radio transmitter, microprocessor-controlled appliance or remote-controlled new technical "toy" contributes to the electrical noise around us. Many of these devices also "listen" to that growing noise and may react unpredictably to their electronic neighbors.

Interference: What Is It?

Complex electronic circuitry is found in many devices used in the home. This creates a vast interference potential that didn't exist in earlier, simpler decades. Your own consumer electronics equipment can be a source of interference, or can be susceptible to interference from a nearby noise source. Interference can also result from the operation of nearby amateur, citizens band, police, broadcast or television transmitters.

The term "interference" should be defined without emotion. To some people, it implies action and intent. The statement, "You are interfering with my television" sounds like an outright accusation. It is better to define interference as any unwanted interaction between electronic systems -period! No fault. No blame. It's just a condition.

Personalities

You can't overestimate the importance of personal diplomacy when you're trying to solve a problem that involves two or more people! The way you react and behave when you first discuss the problem with other individuals, such as a neighbor, utility or cable company, or manufacturer, can set the tone for everything that follows. Everyone who is involved in an interference problem should remember that the best solutions are built on cooperation and trust. This is a view shared by electronic equipment manufacturers, the Federal Communications Commission (FCC) and the American Radio Relay League (ARRL).

Responsibilities

No amount of wishful thinking (or demands for the "other guy" to solve the problem) will result in a cure for interference. Each individual has a unique perspective on the situation -- and a different degree of understanding of the technical and personal issues involved. On the other hand, each person may have certain responsibilities toward the other and should be prepared to address those responsibilities fairly.

Any individual who operates a radio transmitter, either commercial or private, is responsible for the proper operation of the radio station. All radio transmitters or sources are regulated by the FCC. The station should be properly designed and installed. It should have a good ground and use a low-pass filter, if needed. If consumer electronics equipment at the station is not suffering the effects of interference, you can be almost certain that the problem does not involve the radio station or its operation. However, if the interference is caused by a problem at the station, the operator must eliminate the problem there.

Manufacturers of consumer electronics equipment are competing in a difficult marketplace. To stay competitive, most of them place a high priority on service and customer satisfaction. For example, many manufacturers have service information that can be sent to a qualified service dealer. Most manufacturers are willing to assist you in resolving interference problems that involve their products. Over recent years, manufacturers have built up a good track record designing equipment that functions well in most electrically noisy environments.

The FCC will do what it can to help consumers and radio operators resolve their interference problems. They expect everyone involved to cooperate fully. Experience has taught them that solutions imposed from the outside are not usually the best solutions to local problems. Instead, they provide regulatory supervision of radio operators and manufacturers. To help consumers, basic information concerning interference solutions is now available on the Internet through the FCC Consumer & Governmental Affairs Bureau Home Page. This basic information includes the CIB Interference Handbook and the FCC Consumer Facts Interference Bulletin. Specific information includesthe CGB Telephone Interference Bulletin,What Can I Do About Interference to My Radio page and the What Can I Do About Interference to My Television page. The CIB Interference Handbook includes a list of equipment manufacturers who provide specific assistance with interference problems. The list also is available through the Commission's Fax on Demand at (202) 418-2830. Callers should request document number 6904.

Finally, the consumer has responsibilities, too. You must cooperate with the manufacturer, the radio operator, and, if necessary, the FCC as they try to determine the cause of the problem. They need your help to find a solution.

What Causes Interference?

Interference occurs when undesired radio signals or electromagnetic "noise" sources are picked up by consumer electronics products -most often telephones, audio equipment, VCRs or TVs. It usually results in noise, unwanted voices or distorted TV pictures. In most cases, the source is nearby.

There are three common types of interference:

(1.) Noise: Interference can be caused by an electromagnetic noise source. Defective neon signs, bug zappers, thermostats, electrical appliances, switches or computer systems are just a few of the possible sources of this type of interference. Both you and your neighbors may be suffering from its effects. In some cases, the noise may be the result of a dangerous arc in electrical wiring or equipment and may provide warning of an unsafe condition that should be immediately located and corrected.

(2.) Overload: Even if a nearby radio signal is being transmitted on its assigned frequency, if it is strong your equipment may be unable to reject it. Your telephone, radio, stereo or TV should be able to separate the desired signal or sound from a large number of radio signals and electrical noises. This is shown in Figure 1.

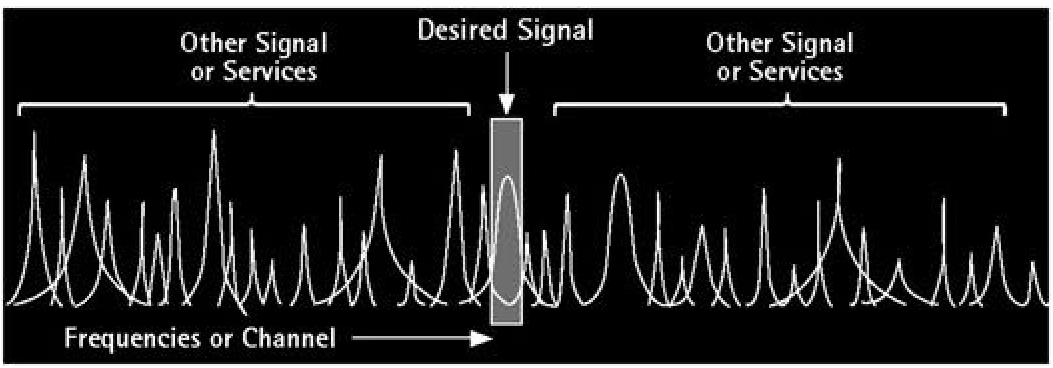


Figure 1.

Consumer electronics equipment manufacturers have worked in cooperation with government regulators to set and meet voluntary standards of interference immunity. Modern equipment usually includes enough filtering and shielding to ensure proper performance under average conditions. Older equipment may not meet these standards, however, and even modern equipment can be affected if the interfering signal is particularly strong. In these cases, your equipment is working as designed, but it may need some additional filtering or shielding to function properly.

(3.) Spurious emissions: A nearby radio transmitter could be inadvertently transmitting weak signals on a frequency not assigned to that transmitter. These signals are called "spurious emissions." FCC regulations concerning spurious emissions are very clear. If interference is caused by spurious emissions, the operator of the transmitter must take whatever steps are necessary to reduce the spurious emissions as required by FCC regulations. Fortunately, modern transmitting equipment is manufactured to meet stringent regulations, and many radio operators are examined and licensed by the government. These federally licensed operators often have the technical skill to resolve interference problems that originate from their radio stations.

With all of these possibilities, it is difficult to guess which type of problem is causing your interference. Usually, only a technical investigation can pinpoint the cause and suggest a solution. This is where a spirit of cooperation and trust will pay off! If you believe your equipment is picking up signals from a nearby radio transmitter, the operator may be able to help you both find a solution to a mutual problem.

How to Find Help

Most consumers do not have the technical knowledge to resolve an interference problem. Even so, it's a comfort to know that help is available. Gather information about interference. The FCC and ARRL have self-help information packages or books. If the problem involves an electrical-power, telephone or cable-television system, contact the appropriate utility company. They usually have trained personnel who can help you and your neighbor pinpoint the cause of the problem.

Most consumer electronics manufacturers are willing to help you. Your owner's manual, or a label on your equipment, may give you information about interference immunity or tell you who to call about interference problems. If not, the Consumer Electronics Manufacturers Association will be able to give you the address of your equipment manufacturer's general customer service personnel. The manufacturers know their equipment better than anyone else and will usually be able to help you.

Operators of licensed amateur or commercial transmitters usually have some technical ability. These operators are the nearest source of help. Remember, the station operator may also be a neighbor! Use a polite approach to ensure that the relationship stays "neighborly." Licensed Amateur Radio operators have access to volunteers (Technical Coordinators and local interference committees) who are skilled at finding solutions for most interference problems.

Testing One, Two, Three . . .

If you think a neighbor's radio transmitter might be involved, you and your neighbor should arrange a test. It's important to determine whether the interference is (or is not) present when the radio station is "on the air." Your neighbor may want to ask another operator friend to participate in the test at your home. By the same token, you may want to invite a friend to attend the test at the radio operator's station. Having impartial witnesses will make you and your neighbor more comfortable with the outcome -whatever it may be. Be sure to choose your witness carefully. Select someone who is diplomatic and tactful.

The tests must be thorough. The transmitter operator must try all normally used frequencies, antenna directions and power levels. All results must be carefully written down. More than one set of tests may be needed. Once you and your neighbor have determined which frequencies and power levels cause the problem, you'll be one step closer to finding a solution.

Try the Easy Things First

Sometimes, the easiest solutions are the best. Many cases of interference can be resolved without the need for technical investigations or knowledge. As first steps, you might check your wiring for damage, for open outer wire shields, or for loose terminal connections. Try removing any added devices, such as video games, or even relocating the equipment or re-orienting the device's antenna and power cord.

If you suspect that the problem is caused by electrical noise, check for overloaded circuits, frayed wires, loose sockets, etc. These types of problems should be fixed no matter what! Have your electrician shut off one breaker at a time, noting if this has any effect on the interference. If so, determine which devices are connected to that particular line, then remove the suspect devices one at a time. When the interference goes away, you've found the "culprit." Your electric utility company service department will offer assistance if the interference is coming from defective equipment on the power lines or distribution equipment.

Interference filters for your consumer electronics equipment can be purchased locally or by mail order. These filters usually eliminate unwanted interference if they are used properly on the equipment that is in need of additional filtering.

According to the FCC's Interference Handbook, telephones and other audio devices that pick up radio signals are improperly acting as radio receivers. The interference can usually be cured, but the necessary filtering must be applied to the affected device.

Several companies sell modular telephone interference filters that are very effective. Your telephone company service department also may be able to help.

A high-pass filter may reduce interference to an antenna-connected television or VCR. A common-mode filter should be tried first on TVs or VCRs connected to a cable system. An AC-line interference filter may help with electrical or radio interference. These items can be purchased locally or by mail order.

Some interference cures must be applied to the internal circuitry of the affected equipment. This should always be done by authorized service personnel.

The ARRL has an information package called "RFI/EMI Radio Frequency Interference". They also sell a book, Radio Frequency Interference - How to Find It and Fix It, that provides additional guidance and technical information. Although it was written for Amateur Radio operators, the book may be helpful to you, too. Contact ARRL for information about their products and membership services.

Self-Help Cures

In some cases, when all else fails, you may need to resolve the problem yourself, or with the help of your electronic service person. It's impossible to use the remaining space to outline all of the possible cures for interference problems (the subject is quite complex). However, a few simple cures using commonly available parts can eliminate most problems. The self-help packages supplied by the ARRL and the FCC explain these cures in more detail.

Interference Can Be Cured!

Remember, most cases of interference can be cured! It takes cooperation between the consumer, the manufacturer and the radio operator. With a little bit of work, you and your neighbor can both enjoy your favorite activities in peace.

For More Information...

The ARRL and the FCC have self-help packages available to help you resolve interference problems.

American Radio Relay League, Inc.
RFI Desk
225 Main Street
Newington, CT 06111
Tel 860 594 0214
Internet Web Site: http://www.arrl.org/
E-mail: rfi@arrl.org

Federal Communications Commission
Compliance & Information Bureau
1919 M Street, N.W.
Washington DC 20554
Tel 202 418 0200
Internet Web Site: http://www.fcc.gov/

Consumer Electronics Association
2500 Wilson Boulevard
Arlington, VA 22201-3834
Tel 703 907 7600
Internet Web Site: http://www.ce.org/

For copies of U.S. Government publications, contact:

U.S. Government Printing Office
North Capitol & H Streets, N.W.
Washington, DC 20401
tel (202) 512-1800
Internet Web Site: http://www.access.gpo.gov/

Sources of interference filter products:

High-pass filters:

Industrial Communication Engineers
RadioShack catalog #15-579, 15-577 (FM Trap)
TCE Labs

Common-mode filters:

Industrial Communication Engineers
TCE Labs

Telephone-interference filters:

Industrial Communication Engineers
K-Com
RadioShack 43-150
TCE Labs

Contact:

Industrial Communication
Engineers
P.O. Box 18495
Indianapolis, IN 46218-0495
tel (800) 423-2666

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