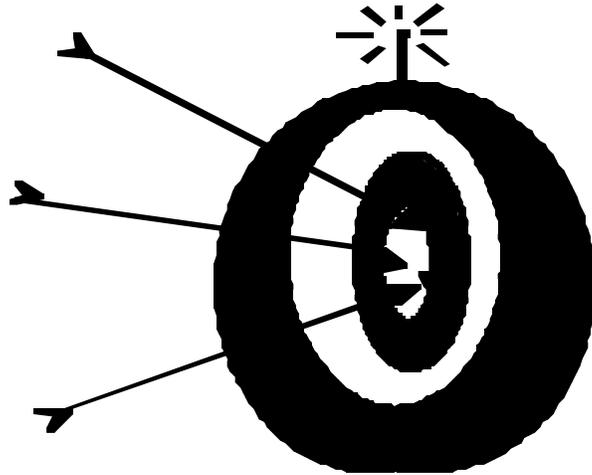


Amateur Radio Direction Finding



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What is RDF?

Radio Direction Finding, Bunny Hunts, Fox Hunts, T-Hunts, Hidden Transmitter Hunts. All mean essentially the same thing: Locating and identifying the source of a radio signal. Have you ever rotated an AM broadcast radio to improve reception? Congratulations! You've already mastered the basics of RDF!

RDF activity takes place across the radio spectrum. For amateur radio use, most organized activity is on the 80 and 2 meter bands. In the United States, 2 meter FM is by far the popular choice. Participation ranges from highly competitive, all day treks through wilderness areas and involving multiple transmitters, to casual searches through suburban neighborhoods for a single "bunny box."

Do I need special (and expensive) equipment?

No. As with almost any aspect of Ham Radio (or any other hobby, for that matter), you can certainly invest a considerable amount of money in the latest and greatest toys. Fortunately, basic direction finding antennas are easy and cheap to build, with all of the materials as close as your junk box, basement, local hardware store, or Radio Shack. For example, a 2 meter beam can be easily constructed from less than \$5.00 worth of PVC tubing, wire, and coax. With a little practice and patience, this can be an accurate and competitive RDF antenna. Any 2 meter radio or scanner with an S-Meter is fine as a receiver.

What About Books and Web Sites?

The "bible" is without a doubt *Transmitter Hunting - Radio Direction Finding Simplified* by Joe Moell, K0OV (K-Zero_O_V) and Tom Curlee, WB6UZZ. It is published by TAB Books, and available through the ARRL, the publisher, or via web sites selling books. Expect to pay about \$25.00. There is also a wealth of information on the Internet. Start your Web surfing at Joe Moell's home page:

<http://members.aol.com/homingin/>

There is plenty of great info and links to other RDF sites.

Or use any of the Internet search engines. Search for Amateur Radio Direction Finding.

The major Ham Radio Magazines run RDF articles regularly. Check that pile of back issues under the table in your shack!

The ARRL Handbook and the ARRL Antenna Book are also full of information and projects.

Isn't RDF mostly about finding jammers?

About as much as fishing is for putting dinner on the table. Bunny hunting is done mostly for enjoyment and/or competition. It is just one of the 25 or so different ways to enjoy amateur radio. But the skills learned by bunny hunting are also useful in finding jammers, so let's talk about them for a minute.

How do we deal with jammers?

There are 4 steps to dealing with jammers:

1. Ignore
2. Ignore
3. Ignore
4. When in doubt, refer to rules #1, #2, and #3.

The jammer feeds on attention. It wants to hide behind the anonymity of a microphone. It is a vandal, a graffiti artist on the air. By denying or ruining the pleasure that others derive from something, it makes up for the frustration and powerlessness that consume its everyday life. Above all, the jammer craves attention. **IGNORE IT! IGNORE IT! IGNORE IT!** The cruelest thing you can do to a jammer is to completely ignore its presence. Leave it scratching its head, wondering if its signal is really interfering. In many cases, you can continue your QSO. If not, end it normally, and resume it later.

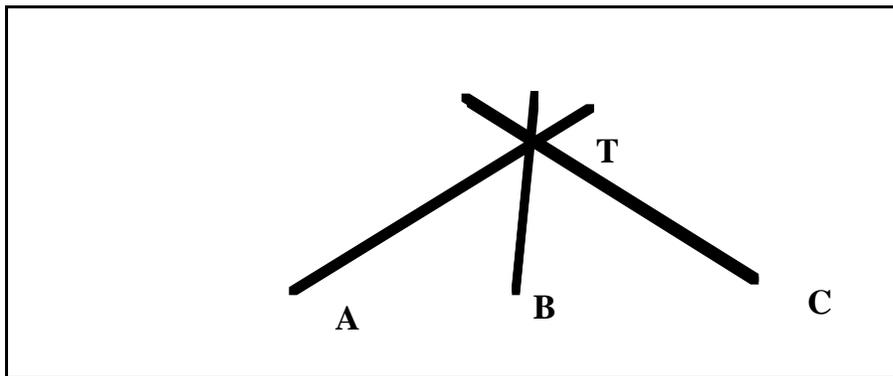
Don't acknowledge in any way, shape, or form, the jammer. Don't say "the idiots are out tonight". Don't say "Am I making it over the noise?" Don't say "DFQ in Meriden". Don't explain what you'd like to do to it. Don't try to threaten it or reason with it. Again, **IGNORE IT! IGNORE IT! IGNORE IT!** Like any other untamed animal, the jammer will go where food and water (in this case, attention) are plentiful. Please don't feed the jammers!

In many cases, simply identifying a jammer publicly is enough to deter its actions. The FCC has finally begun to levy significant fines and penalties against stations found to be the source of malicious interference. (See recent issues of the ARRL letter, QST, etc.). When a jammer realizes that there is a very good chance of (a) being publicly identified, and (b) coughing up big bucks to the FCC, it will most likely move on to greener pastures.

In any event, identifying and building a case against jammers is not what we're here to talk about. Most clubs and repeater groups have established policies and procedures to deal with malicious interference. These efforts are, by necessity, carried on out of the spotlight and are not discussed over the air, for obvious reasons. Contact your club officials for further information.

OK, Back to the fun stuff!

Below is a diagram of simple triangulation. All you need to do is get directional bearings on the bunny (at point "T") from points "A", "B", and "C". Drive up to point "T", look for the guy with the microphone, and you win! Simple, no? Well, in theory, anyway! The bunny is usually an automated transmitter, coming on anywhere from 5 to 30 seconds out of every minute. And it usually does not sport a large sign with a bullseye and a "Bunny Here" logo. In fact, Bunny boxes can be extremely small, and easy to hide. Yet with modest equipment, they are also (relatively) easy to find.



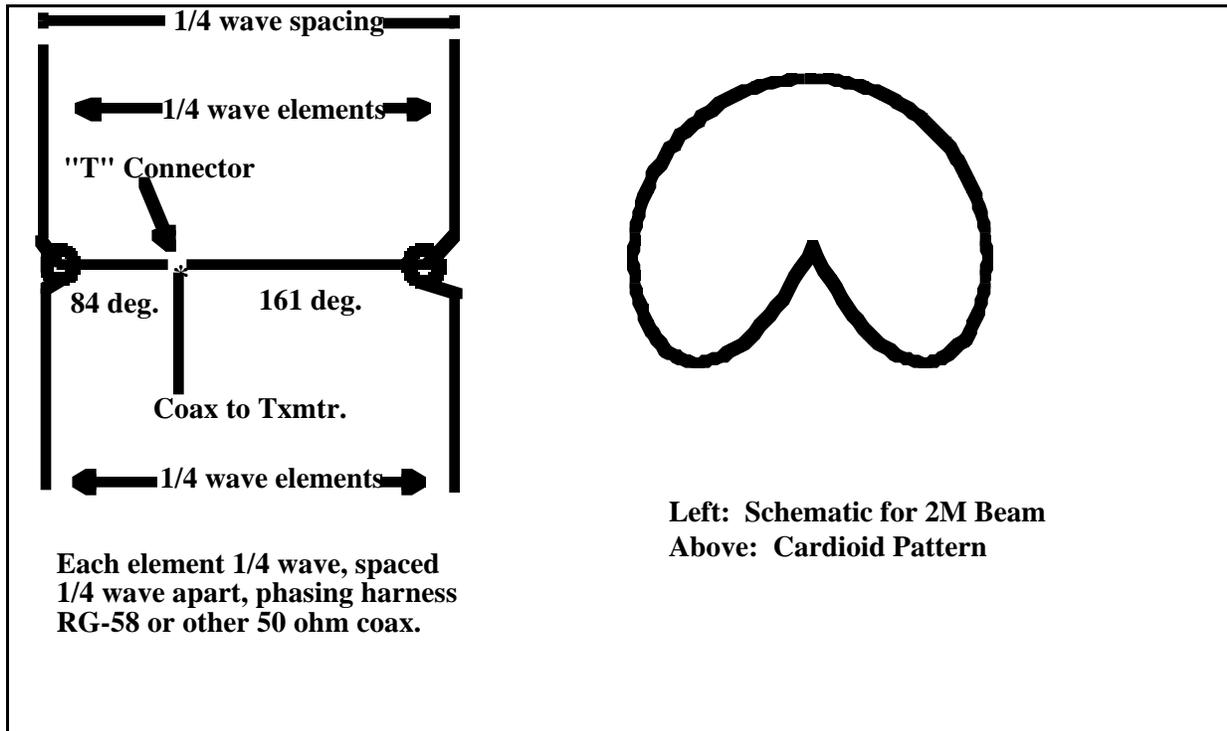
Well, how do I get a directional bearing?

The simplest method is by "body fade." Hold your HT close to your chest, and turn slowly. When you see a dip in your S-Meter, or hear a lower signal, the bunny is directly behind you. If the bunny is pinning your meter, try removing your antenna, and/or tuning 5 or 10 KHz away. This will usually attenuate the signal enough to give you usable information. The more in the clear, away from obstructions and sources of reflections (cars, metal fences, etc.) you are, the more consistent and reliable your bearings will be.

As with many aspects of ham radio, a directional antenna offers a significant advantage. At two meters, a 1/4 wavelength is approximately 20 inches. Beam antennas based on dipoles are therefore about 40 inches wide. A classic, easy to build RDF antenna is two half-wave dipoles, spaced a quarter wave apart and fed 90 degrees out of phase. This arrangement results in a so-called cardioid pattern. See the figure below. The sharp, deep null produced (similar to the body fade method above) is ideal for bunny hunting.

The feed method below is taken from the ARRL antenna book, 17th edition. It takes into account the effects of the antenna elements on each other. This book is another excellent reference source, as is the ARRL Handbook. Along with Moell's Transmitter Hunting Book, all three deserve a place in your library.

Details of a simple to build and inexpensive 2 Meter RDF Antenna:



The length (in feet) of an electrical line is determined by the formula:

$$L = \frac{984 \times VF \times n^{\circ}}{F(\text{Mhz}) \times 360^{\circ}}$$

Where n = the number of electrical degrees.

Assuming that the design frequency is 146.565 MHz (generally used for bunny hunts), the 84⁰ section above is

$$\frac{984 \times .66 \text{ (the Velocity Factor, or VF of RG-58)} \times 84^{\circ}}{146.565 \times 360^{\circ}} = 12.4 \text{ inches.}$$

See the Antenna Book for a discussion of velocity factors of various types of wires.

Elements can be made of any type of wire. Use what you have. Most common insulated wire has a velocity factor of .95. Air has a velocity factor of 1 (so the physical spacing between the elements is 20.1 inches.) RG-58 with BNC connectors at the "T" is a good choice. I used Schedule 40 PVC pipe and connectors to support the elements and phasing harness. The connectors are a **very** tight fit! If you file down the ends of the pipe, where they go into the connectors, just enough, you will be able to achieve your spacing while not making the fit so loose that the antenna falls apart. By not gluing the supports together, you can disassemble the antenna for easy transport and storage. Careful attention to the dimensions will give you a great antenna. As you move from the design frequency, the null broadens and flattens. Use and practice will tell you how to interpret the readings you're getting. The peak will be in the direction of the lagging element (the one with the 161⁰ line, in this case). If you are going to hold the

antenna in front of your body, orient it so that the null points back towards you, adding body fade to the null.

So How Does A Bunny Hunt Work?

The variations are limited only by imagination and the forbearance of the hunters. A typical hunt is as follows. One ham agrees to be the bunny. He or she sets boundaries for the hunt (within 3 miles of point "X", or 4 boundary roads, for example.) The Huntmaster takes check-ins, and at the designated start time the bunny turns on an automated "bunny box". The box transmits a message ("This is the N1GNV hidden transmitter. Come and find me, etc.") for 30 seconds, and is silent for 30 seconds. The first hunter to find the hidden transmitter wins.

One popular variation on this is a mileage hunt. All hunters start at the same spot. The hunter with the lowest elapsed mileage, within an allowed time period, wins. Some groups use a "transmit by request" system. The bunny is silent until one of the hunters requests a transmission. The requesting station is then penalized a predetermined amount of minutes or miles. Yet another approach is to divide the hunters into teams. Team members work together, relaying bearings to each other via a simplex frequency (not, of course, the hunt frequency.) If the other teams happen to listen in on that frequency, they can gain obvious advantages.

Some hunts involve multiple transmitters, most often 5. They each transmit for one minute out of 5, in rotation. Along with a legal Callsign ID, they identify in Morse Code with MOE, MOI, MOS, etc. The number of dits indicates which one is on the air. (Good news for those of us whose CW is, well, a little rusty!)

Are there more sophisticated systems?

Of course. The most popular are generally called Doppler systems, although purists will debate whether they are truly dopplers. In essence, a set of 2, 4, 8, or more 1/4 wave whips are arranged in a circle and mounted to the roof of a car. This array connects to a display of 4, 8, 16, or more LEDs, through a little black box of magic electronic stuff. The electronics sense which antenna received the signal first, and light up the corresponding LEDs, indicating the direction of the signal.

For the more technically inclined: The electronics switch the antennas, sequentially, at a rapid rate. This produces an audible tone. By means of the phase shift in the received signal, the proper LEDs are lit, and the strength and quality of the tone denote the accuracy of the bearing.

Follow the links from Joe Moell's home page, and you will find a wealth of information on commercially made systems. Most are fairly pricey... \$200 - \$400. Used equipment, though not abundant, can also be found.

In between the commercial units and the low-budget beam above are any number of projects you can build. Remember that as with most of amateur radio, antenna improvements give you the most bang for the buck. (And antennas are, in my opinion, the most fun and least expensive way to experiment.) Once you have a good antenna, look for plans for amplified field strength meters, active attenuators, external S-Meters, and the like.

Tips and Tricks

Once you are close to the bunny, the signal will often be full scale on your S-Meter. Many hunters use a step attenuator to knock down the signal and bring it back into S-Meter range. A step attenuator is easy to build, and plans are in the ARRL Handbook. When you are very close, the attenuator will not help, since the signal will get into your HT directly. At this range, you can hunt on the third harmonic of the bunny's frequency. (Multiply the frequency by 3.) This falls in the 70cm ham band, in most cases. With today's wide range receiving HTs, you can even hunt on the 5th harmonic. (My Yaesu FT-50, for example, will receive at those frequencies.) Or try tuning 5 or 10 KHz away from the bunny. The 3rd harmonic will attenuate the signal by 40-60 dB, the 5th much more so. Even cross-polarization (using a horizontally polarized antenna on a vertically polarized signal) will give you 10-20 dB of attenuation.

Be aware that the cardioid antenna pattern above will not be duplicated (using the same antenna) at the higher frequencies, although the antenna will still show peaks and nulls to a lesser degree. A 70cm antenna, **scaled to the same design**, should produce the same pattern, although I have not built one for the 3rd (or the 5th) harmonic. As you go higher in frequency, small variations from design dimensions result in greater pattern distortion.

Shareware and freeware programs are available for building beams. They take a little practice to use, but are well worth a look. Most will optimize an antenna for several factors. For RDF work, go for maximum front-to-back ratio. In most cases, it is better to hunt a sharp null in the signal, rather than to hunt a peak that is most likely going to be fairly broad. In the case of a very weak signal, start by hunting the peak until your S-Meter reads at least half scale, then switch to hunting the null.

If the boundaries of the hunt are disclosed in advance, take a few minutes to study a map of the area. Bunnies are likely to hide in out of the way places, requiring long drives around railroad tracks, or at the end of dark dead end streets. Bring the map (and a flashlight!) with you on the hunt.

Directional antennas like beams and quads can be mounted on your car. See Moell's book for ideas and details. Doing this will make hunting much easier, since you won't need to get out of your car to get bearings. Please remember to observe all traffic laws and use common sense.

Before using an antenna for a hunt, test it. Find an active repeater, and try to DF it. You will find that signal reflections can give erroneous readings. Learn how to distinguish those from the true bearing to the bunny. A crafty fox will no doubt try to maximize the effect of reflections on his or her signal.

Even a little bit of height can make a big difference in your ability to get a bearing. Find a hill, the top of a parking garage, etc. to start your hunt. The more in the clear and free from obstructions you are, the better the bearing you will get from your equipment.

If you have an extra HT, leave it on the floor of the car with no antenna. When the bunny breaks the squelch, you know you are close. Keep turning up the squelch. Since your car will act as a shield from all but strong signals, when you can't squelch out the signal you are very close to the bunny. Body fade should get you the rest of the way in.

Maximize Your Investment!

You paid good money for that 2-meter rig. Ragchewing on the repeaters is fun, but there's a lot more you can do with that HT or Mobile. And the skills you will learn while hunting are useful in a wide range of Amateur Radio activities. Instead of spending a C-Note on a 2-Meter amplifier, you'll know how to build a beam antenna for 5 bucks and get the same result. Since there is no

transmitting necessary on the part of the hunters, you don't even need a license to participate. This might be a great way to introduce a friend to Ham Radio.

Children often enjoy Bunny Hunting as well. Explain that it's kind of like hide and seek for grownups. Let them help you to get bearings. They'll love it.

More Questions?

E-Mail n1gnv@arrl.org, that's the best way to get me. My phone number is (203) 440-4468.

By the way, clubs and repeater groups with active RDF interest are generally much less troubled by jammers and other interference, for some reason. If anyone wants to start a regular MARC hunt group, let me know. I'll give you whatever help I can, including plans for a low-cost and very effective bunny-box.

73,
John, N1GNV