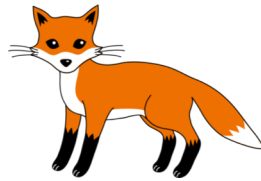


Radio Direction Finding (AKA Fox Hunting)

West Island Amateur Radio Club

Monday March 20, 2023

By Mark Morin VA2MM



Objectives:

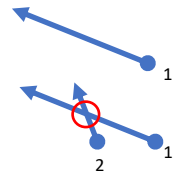
- To use direction-finding equipment, skills and/or luck to find a hidden 2m FM beacon transmitter.
- To accurately copy the Fox Message for your team (written on the outside of the beacon enclosure) and report that message verbatim to the hunt judge
- To hone your direction-finding skills and equipment
- To have fun!

Set-up:

- A 2m beacon transmitter is hidden somewhere within a specified search area
 - The search area may be several km in diameter, so a vehicle per team will be required
 - The fox beacon may be camouflaged so it will be necessary to approach it closely on foot to find it
 - The beacon transmits a 30-second message periodically (typically every 1 or 2 minutes)
 - A label on the beacon enclosure includes a unique secret message for each team. This message must be reported verbatim to the judge

Phase 1 - the Far Game:

- The beacon signal may be weak at the starting point
 - Use an efficient antenna and receiver, in an uncluttered location
 - If necessary, move to a better location to make your first bearing measurement. Have a contingency plan of where to go in case you don't pick up the beacon from the starting point.
- Use a directional antenna or other RDF device (e.g. Doppler array) to estimate the signal direction
 - Use compass & map to estimate bearing to the fox and *home* into it in that direction, then repeat
 - Or move slightly off from the estimated bearing to take an intersecting bearing and *triangulate*
- Beware of possible false bearings from reflected signals. Avoid nearby buildings.
- Signal strength may be highly variable due to fading. In this case it's often best to average multiple measurements

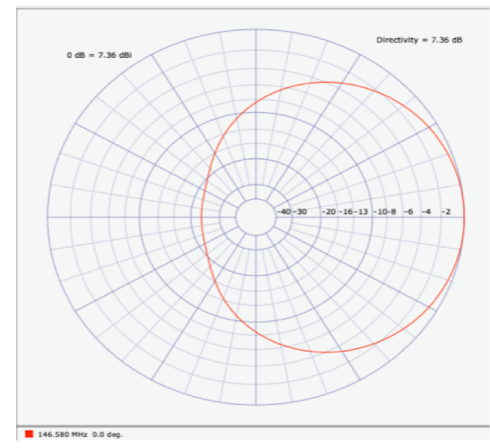
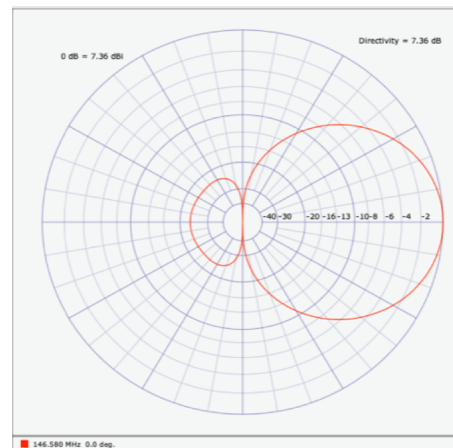
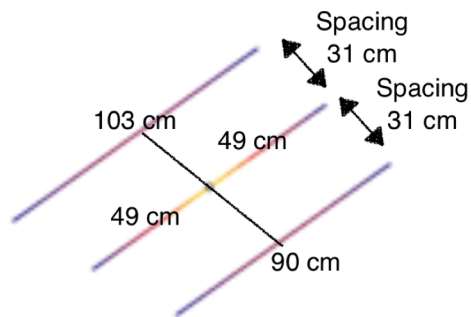
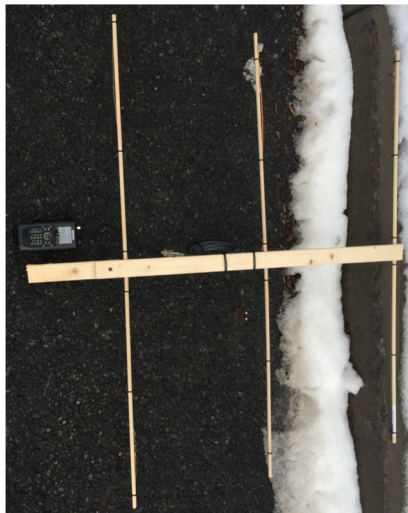


Phase 2 - the Near Game:

- As you approach the fox location, the signal will become overwhelmingly strong
 - Attenuate the signal to avoid S9++ readings in every direction
 - Passive hardware attenuators are of limited use because strong signals bypass them and enter directly into the receiver circuit
 - Offset (frequency-shifting) attenuators are much preferable. These simple devices shift the attenuated receive frequency by several MHz, so that they don't overwhelm the receiver. Variable offset attenuations of 100 dB are achievable.
 - Determine direction using antenna pattern nulls rather than the main lobe
 - It may be necessary to remove the antenna completely, open the squelch and home in to maximum quieting
 - Doppler arrays, work well even with very strong signals, although they are not very portable
- Use your eyes, your wits and grunt work
 - Look for visual clues (foot prints, obvious hiding places)
 - Walk the area systematically in a grid to avoid missing it

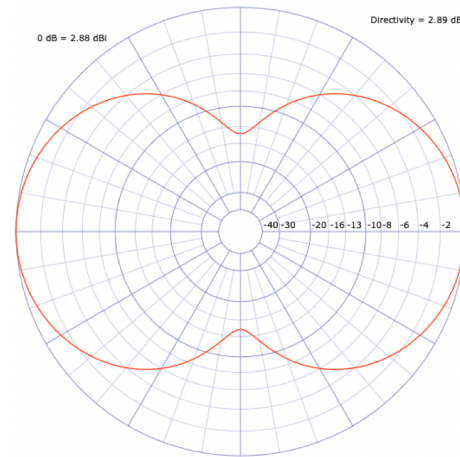
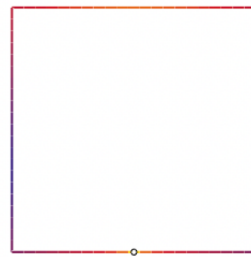
Equipment for the Far Game:

- Simple Yagi Antenna (or similar directional antenna like a cubical quad)
 - I built this one with a piece of 1x2 wooden boom and dowels to support the wire elements. Conductors are 14 AWG wires. Also see Tape Measure Yagis on Internet
 - Gain approx. 7 dBi
 - Narrower beam-width with horiz. polarization. 6 dB beam-width: 90 deg. H vs. 175 deg. V
 - Note the nice deep nulls at 90 degrees for H pol. These are more accurate than the main lobe
 - Recommended technique: Find rough direction with peak of main lobe, then turn antenna 90 degrees away and look for sharp **dip** in signal (end-fire along the driven element). Measure bearing with compass and plot on a map



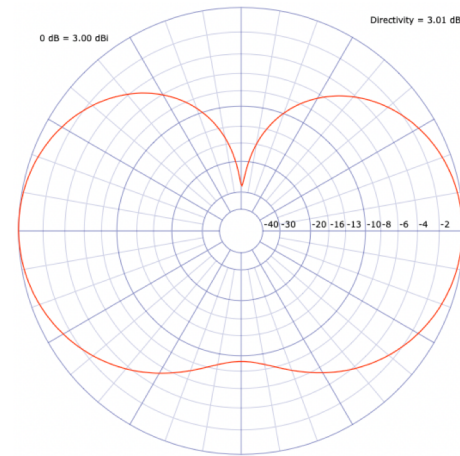
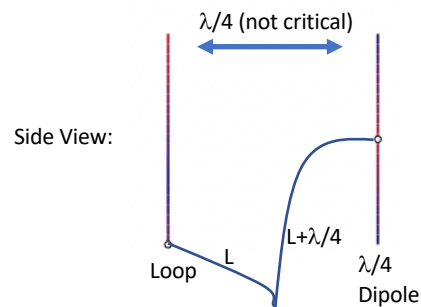
Alternative Antenna for the Far Game:

- 1λ Vertical Loop (H pol.)



Note the bidirectional pattern

- Loop plus shortened dipole behind and fed 90° out of phase



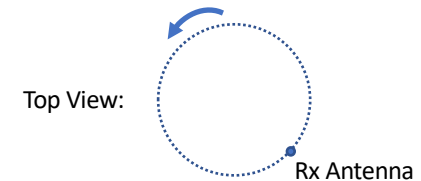
Adding a sense element behind the loop fills one of the nulls

Alternative Equipment for the Far Game:



- Doppler RDF

- Imagine an antenna rotating in a horizontal circle
- Frequency of rotation is in the audio band, say 1 kHz
- Due to the Doppler effect, the received frequency increases as the antenna rotates towards, and decreases as the antenna rotates away from the transmitter. This frequency-modulates the received signal with a 1 kHz tone



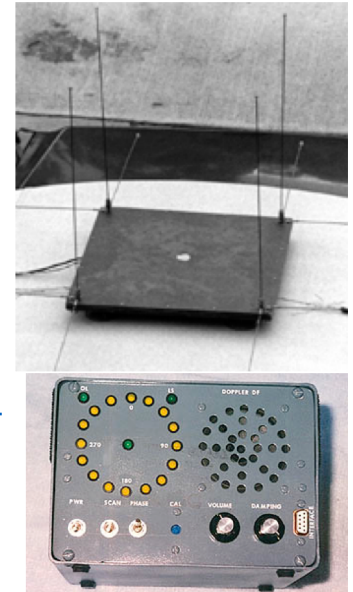
- Pseudo-Doppler RDF

- Instead of physically rotating the antenna, a fixed array of antennas can be electronically rotated through phasing or switching
 - Switching between antenna A and B will FM the signal but switching between antenna B and C will have no effect
 - Commercial mobile Doppler RDF systems are available
- Since this technique does not rely on amplitude, it works well even when the signal strength is too strong for other techniques.



Alternative Equipment for the Far Game:

- Doppler RDF systems are available as plans, kits or ready-built form from various sources:
 - Roanoke System <http://www.homingin.com/newdopant.html>
 - N0GSG Portable RDF from June 2020 CQ [https://archive.org/details/N0GSG Portable Radio Direction Finder/mode/2up](https://archive.org/details/N0GSG%20Portable%20Radio%20Direction%20Finder/mode/2up)
 - Montreal Doppler 3V2 by VE2EMM <https://www.qsl.net/ve2emm/pic-projects/doppler3/doppler3-e.html>
 - See Direction Finding category on eHam.net



Bill Briles WØOQC

More Equipment for the Far Game:

- Compass
- Paper map (to draw lines on)
- Clip board
- Ruler
- Pencil

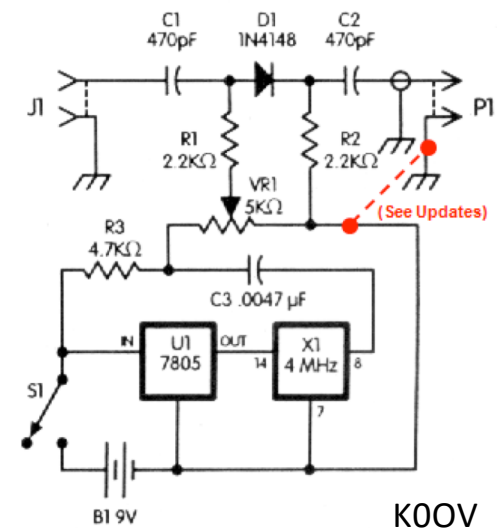


Equipment for - the Near Game:

- Too much of a good thing!
 - Free space loss = $10 \log(4\pi D/\lambda)$ where D is the distance in meters
 - So even at 100m away from a 1W (30 dBm) 2m transmitter, your receiver may see up to 0 dBm of signal. The IARU defines S9 as -93 dBm for VHF so that's more than 90 dB above S9!
 - The S meter is useless unless we can attenuate the signal by about 100 dB
 - Use your rig's attenuator function but it won't be sufficient, nor is an external passive attenuator. That much signal can overwhelm the receiver circuit, even without an antenna connected

Equipment for - the Near Game:

- The best solution: Offset (Frequency-shifting) Attenuator
 - Using a simple oscillator/mixer circuit, we can shift the received signal to a different frequency (e.g. +/- 4 MHz) at a much lower level (depending on the oscillator injection level)
 - An offset attenuator can be home-brewed from scratch, built from a kit, or purchased ready-built
 - <https://www.arrowantennas.com/main/4ofha.html>
 - <http://www.homingin.com/joek0ov/offatten.html>



WIARC Foxhunt Rules:

- Stay safe while driving, or on foot. Follow all traffic and parking laws.
- A minimum of 2 hunters per team (vehicle) with one dedicated (non-distracted) driver.
- Keep off private residential property (i.e. any lot with a house).
- The 1st, 2nd and 3rd place winners will be determined by the order in which they report their Fox Message correctly to the judge. After 3 teams have reported their Fox message to the judge, the beacon may be deactivated.
- Never transmit on the Fox Beacon frequency
- Do not attempt to move the fox beacon, and do not remove or tamper with the label on the beacon enclosure
- Once you find the Fox Beacon, do not disclose its location.

Beacon Details:

- FM transmitter on 146.58 MHz at power of a few Watts, as required for coverage.
- The beacon antenna will be vertically polarized.
- It is enclosed in a locked, waterproof hard case with a white label on the outside, all covered by camouflage material. The Fox messages are printed on this label (lift the camouflage cover to see it).
- Beacon transmissions last about 30 seconds. Each transmission starts with a “fanfare” sound, followed by VE2CWI in Morse-code (18 wpm) and a short silent periods punctuated by dits.
- Between beacon transmissions, there will be no signal transmitted.
 - During the first hour of the hunt, the inter-transmission pause will be set initially to 90 seconds (i.e. one 30 second transmission each 2 minutes).
 - After one hour, the fox will reduce the pause between transmissions to 30 seconds (i.e. one 30-second transmission each minute).
- Demonstration

Suggestions made by others at the meeting:

- For the near game:
 - Use a field-strength meter instead of a sensitive receiver
 - Tune to third harmonic with a UHF radio (429.74 MHz)