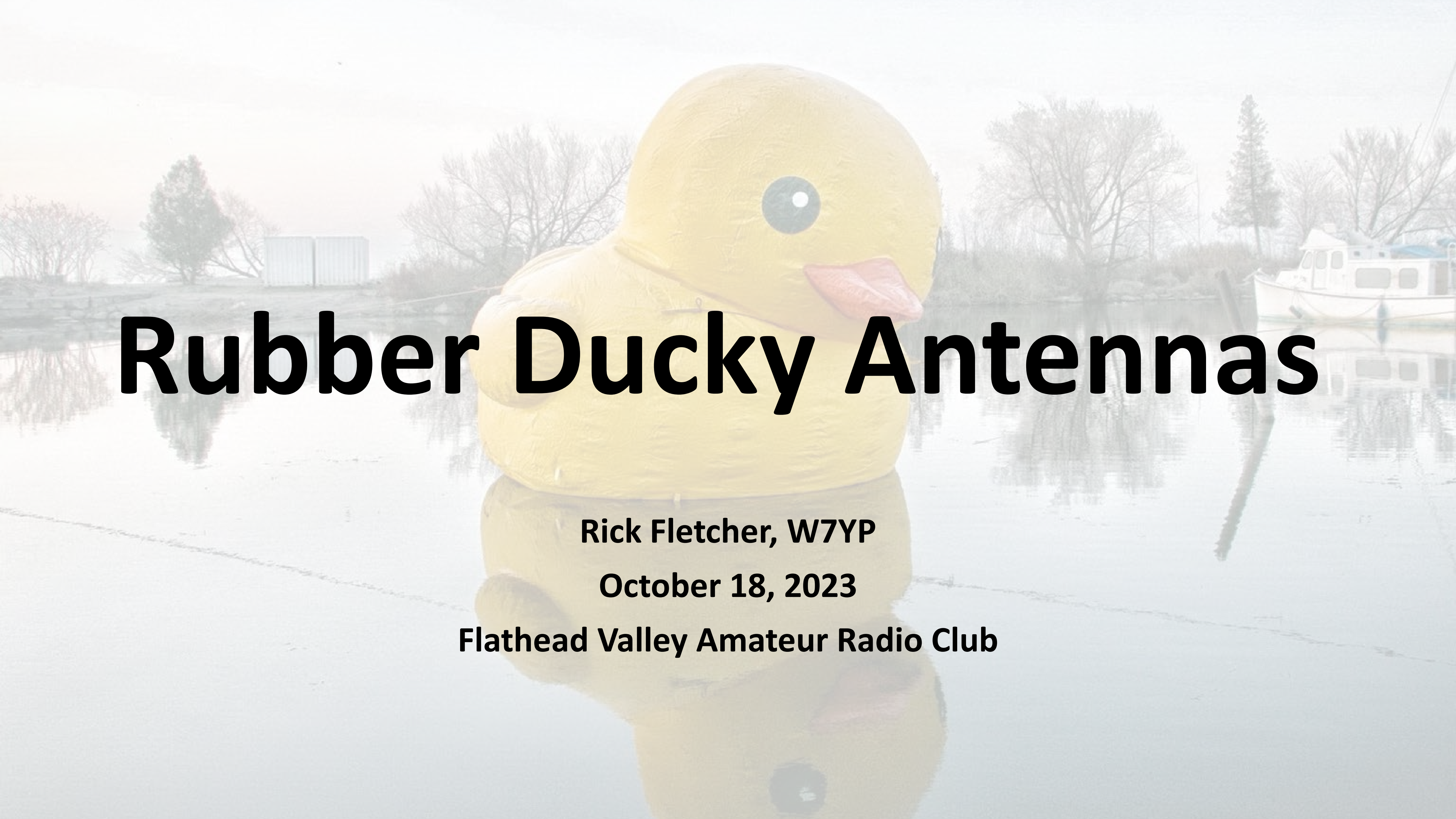

Rubber Ducky Antennas

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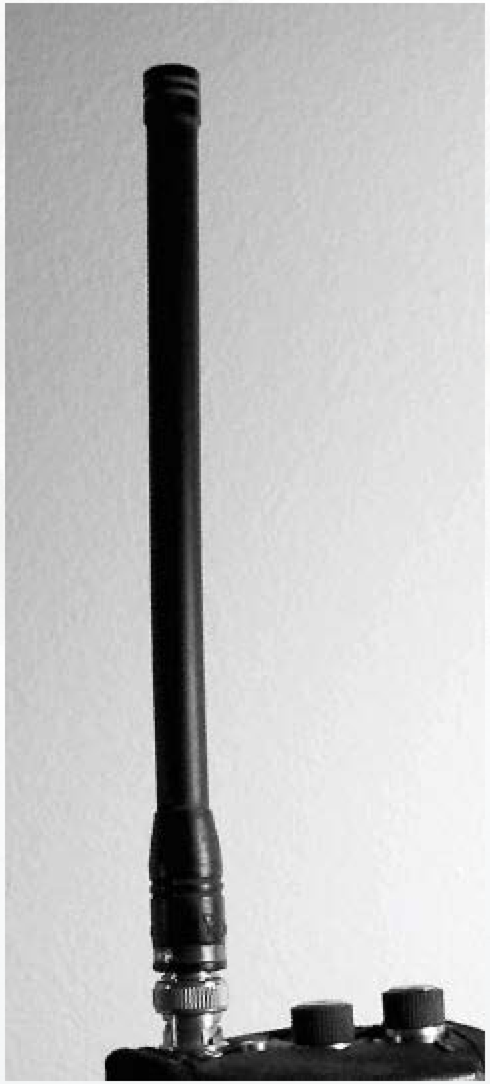
Flathead Valley Amateur Radio Club

What is a Rubber Ducky Antenna?



- An electrically short antenna which functions somewhat like a base-loaded whip or monopole antenna
  - Used because a one-quarter wavelength antenna (3’ long for VHF) over a ground plane is too long for easy portable operation
  - Repeater-based operation makes performance less critical
- Very flexible and resistant to damage, unlike the telescoping antennas which were previously used
- Two rumors link its name to the John F. Kennedy family:
  - One claims very young Caroline Kennedy pointed at a Secret Service agent’s HT antenna and said, “Rubber Ducky”.
  - The other rumor claims a NASA scientist named it after listening to one of Vaughn Meader’s comedies about the Kennedys
- A popular alternative name is “stubby antenna”

Origin of the Rubber Ducky Design

- Originally designed for the 6m amateur band by Richard B. Johnson while a student at a reform school, the Lyman School for Boys
  - Johnson was well-acquainted with the harsh realities of the juvenile detention system in the late ‘50s and early ‘60s
    - His propensity for being a bit of a firebug got him in trouble
- His design was less than one-third meter long
  - Substituted for a vertical antenna which would have been 1.5m long
    - Wouldn’t fit into his locker
  - Used a screen door spring with its length adjusted for resonance
  - Covered with a synthetic rubber hose
- At the time, portable radios used telescoping antennas which were clumsy in use and frequently broken

Anatomy of a Rubber Ducky Antenna

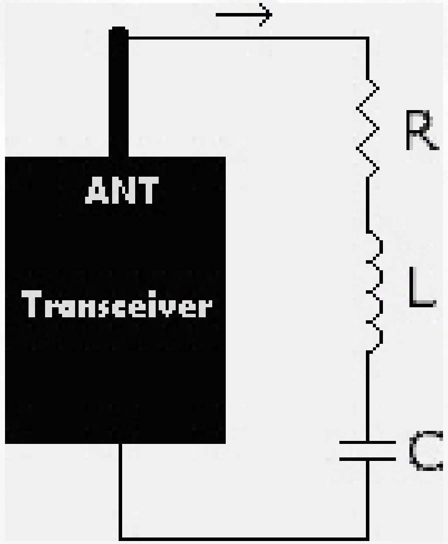
- Electrically short antennas have considerable capacitive reactance
  - An inductor (loading coil) is added in series to make them resonant
    - Antennas with these inductors built into their base are called base-loaded antennas or whips
    - In a Rubber Ducky, the coil is part of the antenna itself
      - The antenna is made of a narrow helix of wire, much like a spring
      - The helix is covered with rubber to protect it
      - Technically, it is a “normal-mode” helix which has broadside radiation which is omnidirectional
      - Maximum radiation is at right angles to the axis of the helix
      - For the typical monofilar design, the radiation is linearly polarized parallel to the axis of the helix
      - Rubber Duckies are typically 4% to 15% of a wavelength long
      - Has much less gain than a quarter-wave whip over a ground plane

Performance and Design Considerations

- Has somewhat better performance than an equal length base-loaded antenna
  - With the inductance distributed throughout the antenna, there is somewhat greater current flow in the antenna
  - Difficult to fully characterize electrically because the current distribution is not sinusoidal as it is with a thin linear antenna
- Has a high "Q", thus a narrow bandwidth
- Can be designed to cover a wide frequency range (e.g., 100-500 MHz)
  - If the coils have a large diameter relative to the length of the helix, the antenna will have narrow bandwidth
    - If resonant, the impedance will be well below 50 Ω
  - Narrow diameters will increase bandwidth
    - Performance declines significantly with wider bandwidth
    - If resonant, the impedance will increase towards 70 Ω
  - Tapered helix design can improve bandwidth while providing a better impedance match at the feedpoint
  - A good design can achieve an effective aperture comparable to a larger antenna
    - Aperture is the measure of the antenna's ability to 'capture' power radiated towards it
- In general, single band Rubber Duckies work better than multiband

Performance and Design Considerations (cont.)

- Like most monopoles, a ground-plane or counterpoise is required
  - With HTs, the ground-plane is often only the metal chassis in the body of the HT
    - Modern HT construction typically uses nonconductive plastic/polymer for the case, reducing the effectiveness of the antenna by eliminating a conductive path to the user
  - Johnson mounted his design to a metal paint can to which there were four radials soldered to the can
  - Depicted here is the equivalent electrical circuit:
  - Lack of a good counterpoise seriously affects performance
    - A wire counterpoise can sometimes be added by the user
      - Make a loop of exposed wire around the HT's antenna connector
      - Screw the Rubber Ducky down good to hold it in place
      - With some quality HTs with OEM antennas, a counterpoise isn't helpful

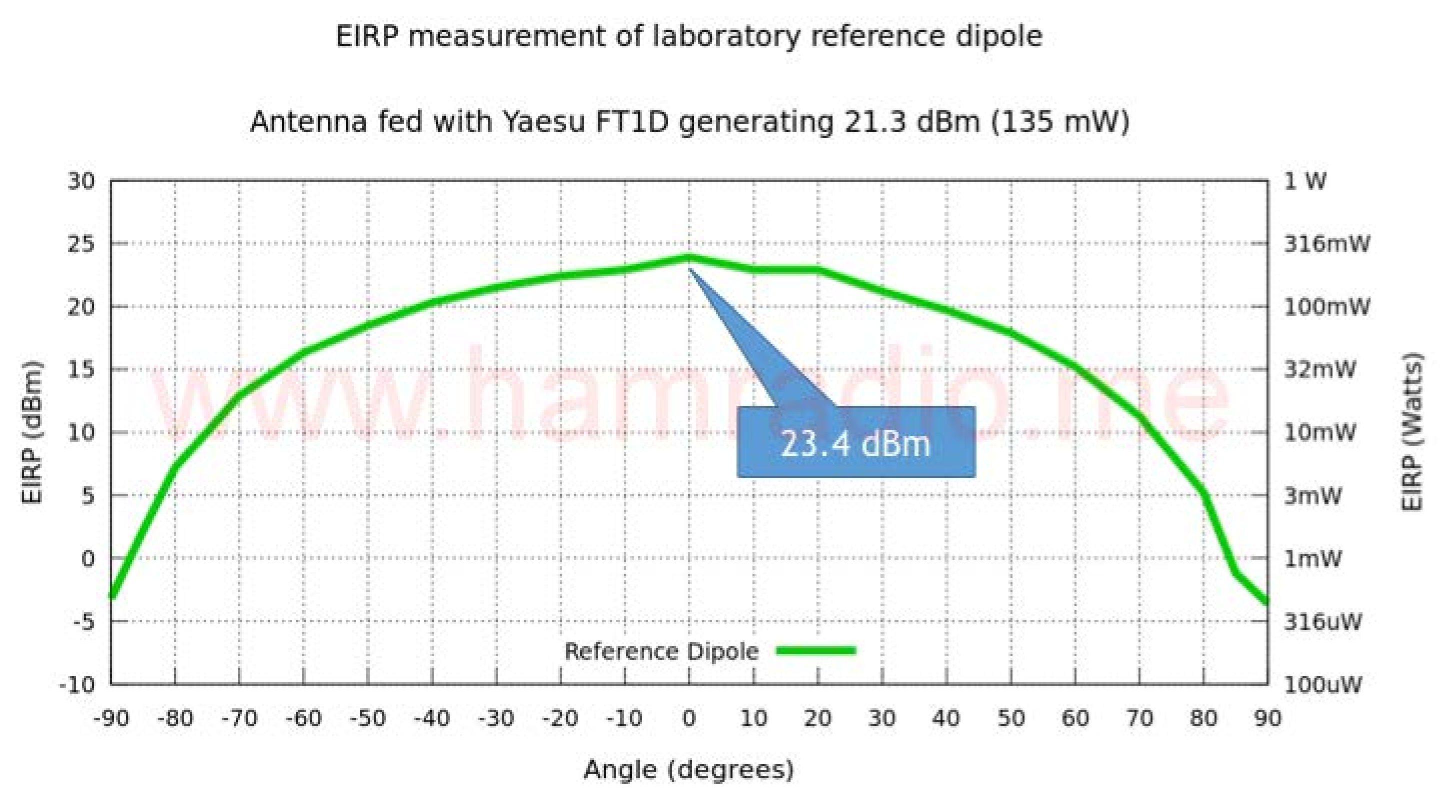


Real World Amateur HT Rubber Duckies

- Choosing an HT antenna often comes down to what sucks the least
- Measuring Effective Isotropic Radiated Power to compare antennas
  - EIRP is essentially equal to the power input to the transmitter's antenna multiplied by a theoretical isotropic antenna's gain which is '1' (0 dB)
  - Measure of the radiated power in the direction of the real antenna's "main lobe" when compared to the theoretical isotropic antenna which radiates equally and omnidirectionally
  - Measurements were taken by KX4O (John Huggins) in an antenna chamber with RF absorptive insulation using a laboratory reference dipole tuned to 146 MHz
    - A half-wave dipole has a gain of 1.64 (2.15 dB) compared to an isotropic radiator
  - As we'll see, Rubber Duckies all have negative gain compared to our reference antenna
  - KX4O tested the following antennas using the FT1D as the transmitter:
    - Laboratory reference dipole
    - Stock Yaesu FT1D antenna
    - Diamond SRH7&CA ¼ wave whip
    - MFJ-1714 ½ wave antenna
  - Tests were done using the FT1D packet beaconing mode on 2m
    - 135 mW (21.3 dBm)

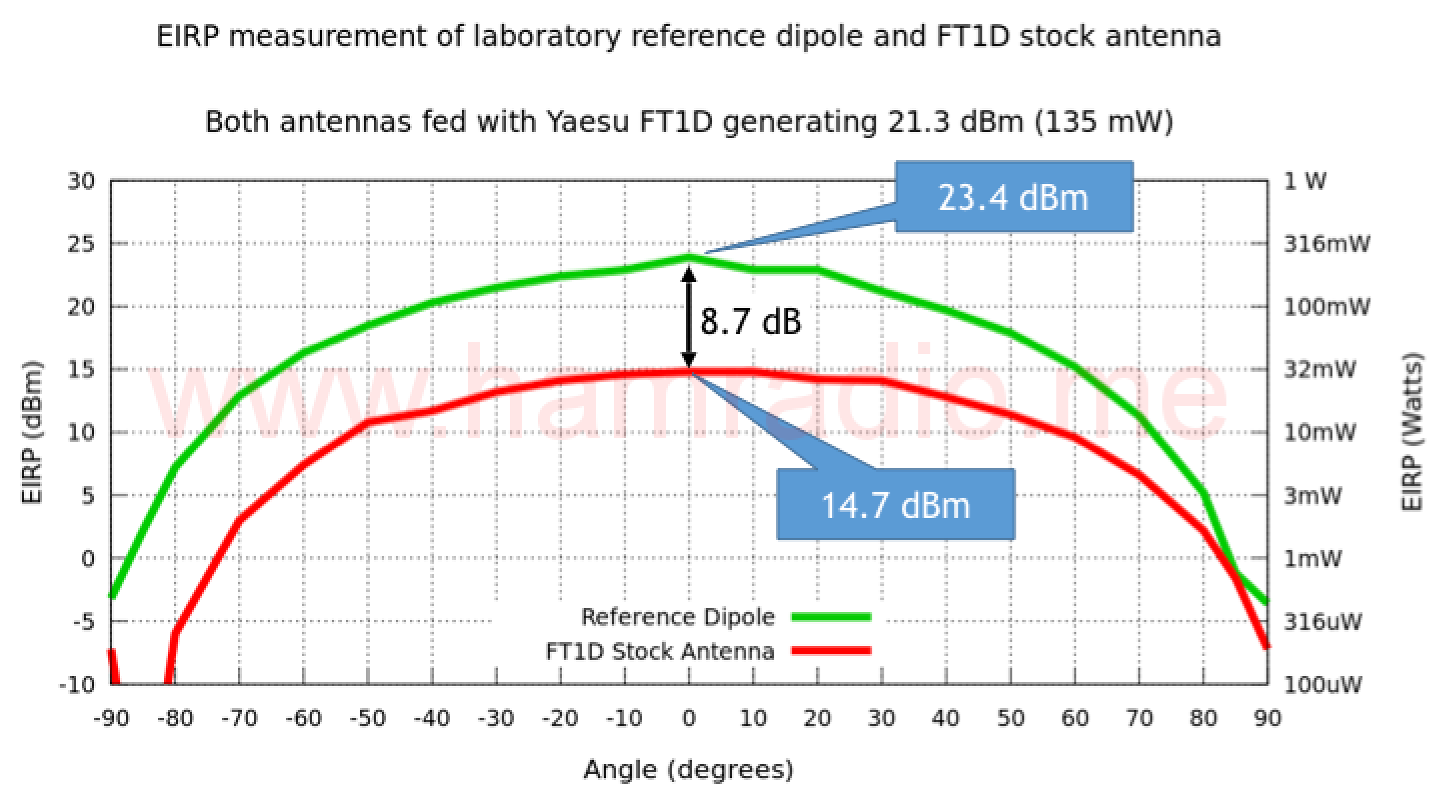
Laboratory Reference Dipole

- FT1D TX power used was 21.3 dBm (135 mW); Dipole gain = 2.15 dBi
  - Expected EIRP = 21.3 dBm + 2.15 dBi = 23.5 dBm
- Actual measured EIRP:



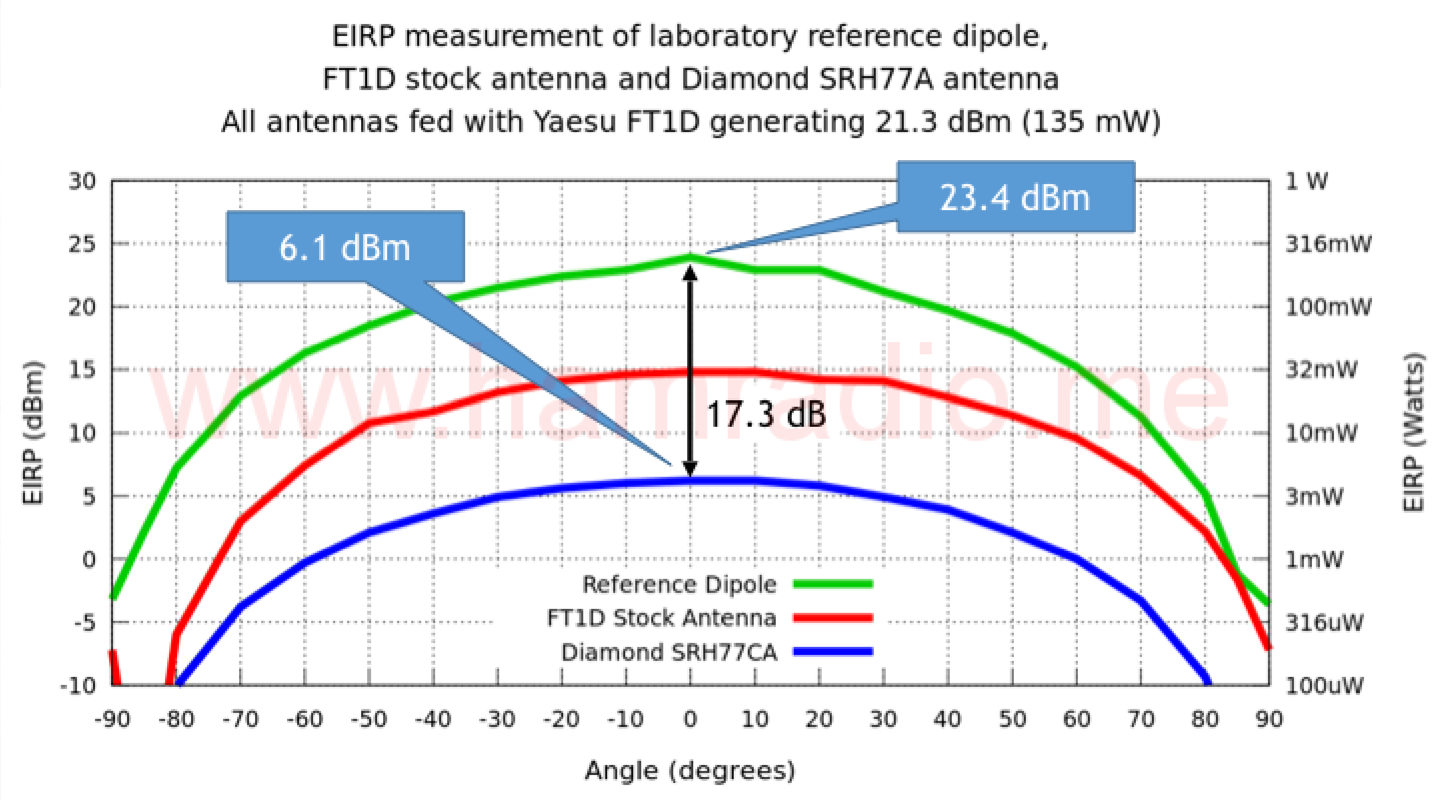
Yaesu FT1D Stock Antenna

- At almost 9 dB below the reference dipole, it can be seen that smaller antennas mean lower efficiency and less signal:



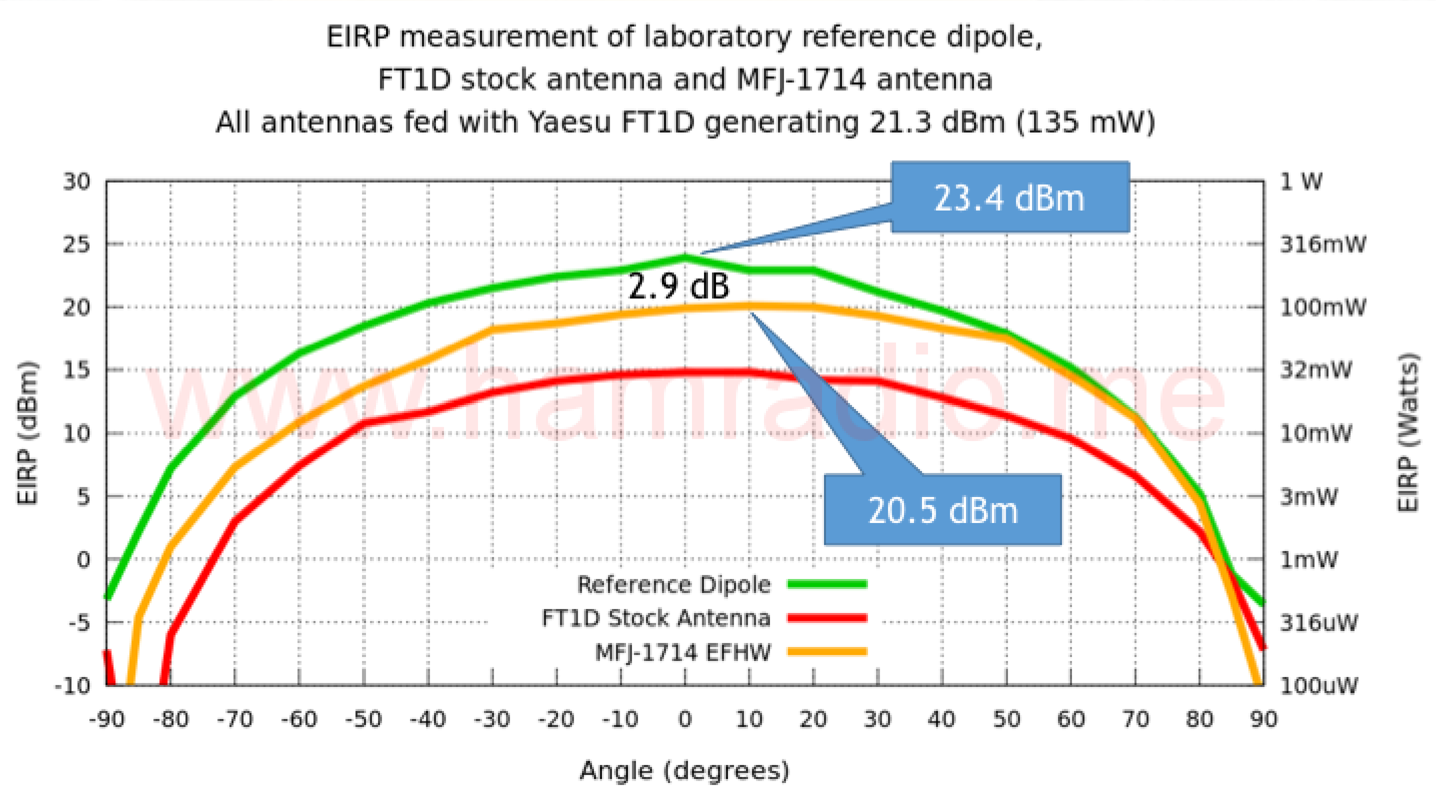
Diamond SRH77CA ¼ Wave Whip

- An obvious aftermarket antenna to test is the ¼ wave whip
  - The popular Diamond SRH77CA was chosen for this test
- The test results were pathetic, with a decline in gain of 17.3 dB relative to the dipole
  - The antenna seems to ‘crave’ the missing ¼ wave section
    - Holding the body of the FT1D improved reception of a distant repeater, versus setting the HT on a wood table
  - Diamond lists its gain as +6 dB, but relative to what, a dummy load?

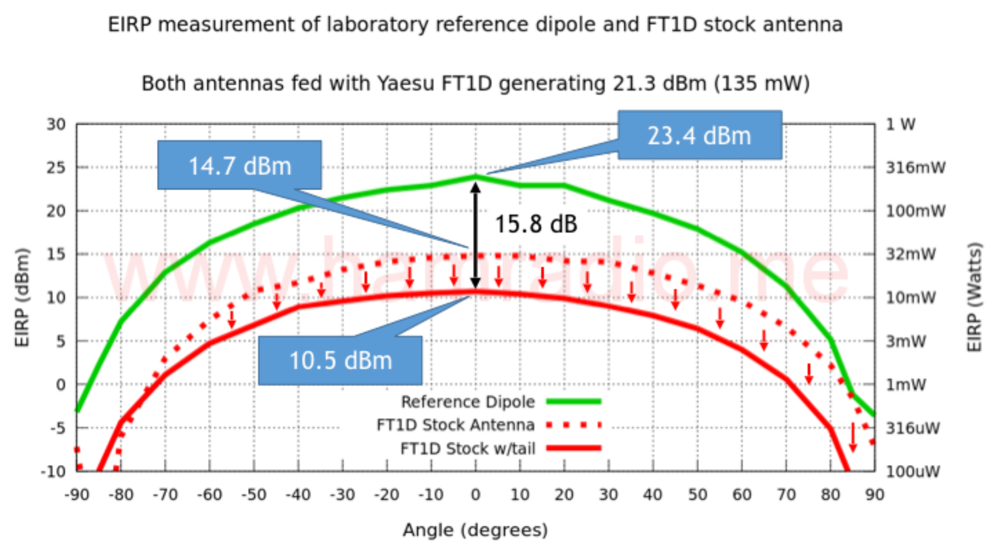


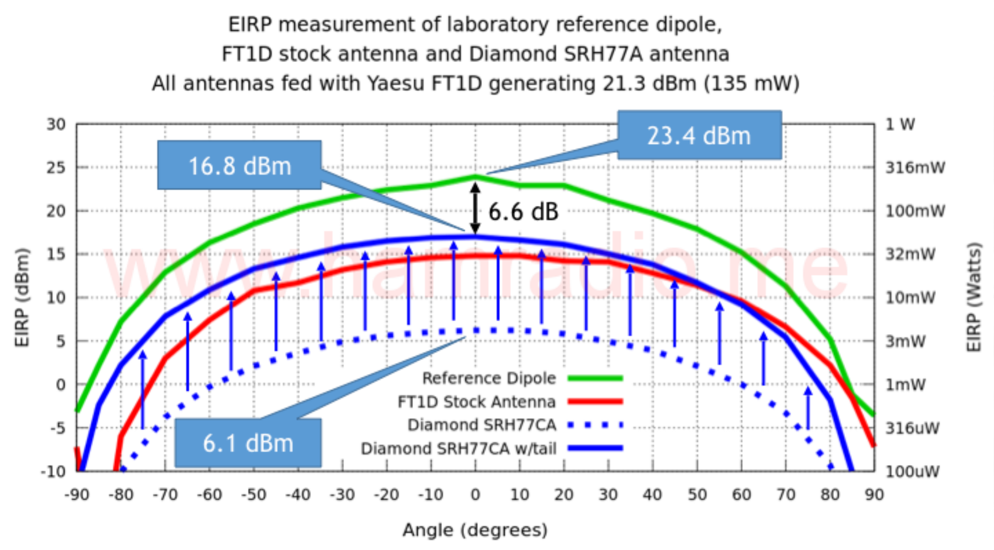
MFJ-1714 ½ Wave End-fed Dipole

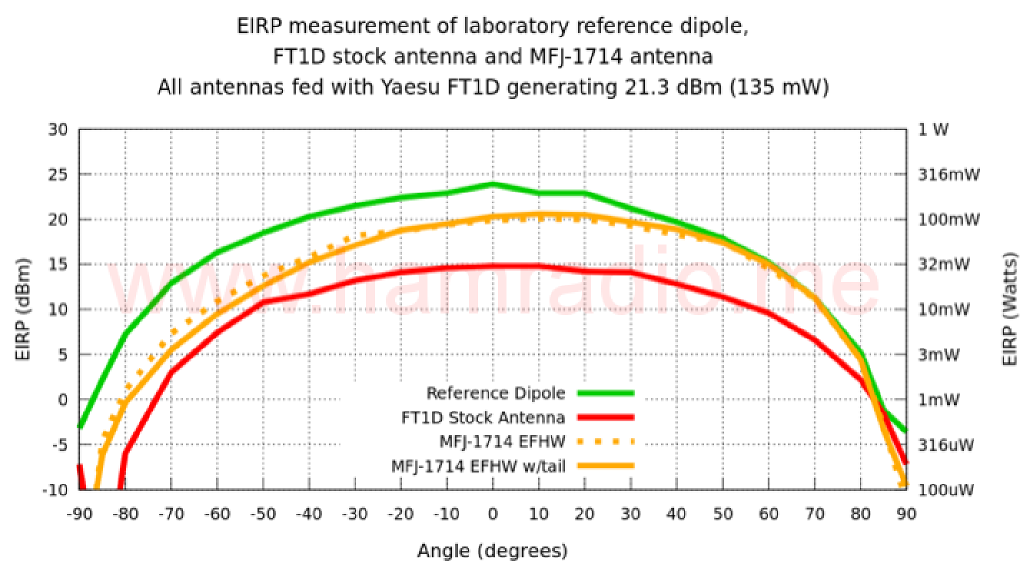
- The ½ wave antenna beats the FT1D stock antenna, but is it worth the trouble, given its size?
  - FT1D's stock antenna looks pretty good at this point
    - It and the MFJ-1714 put the Diamond SRH77CA to shame



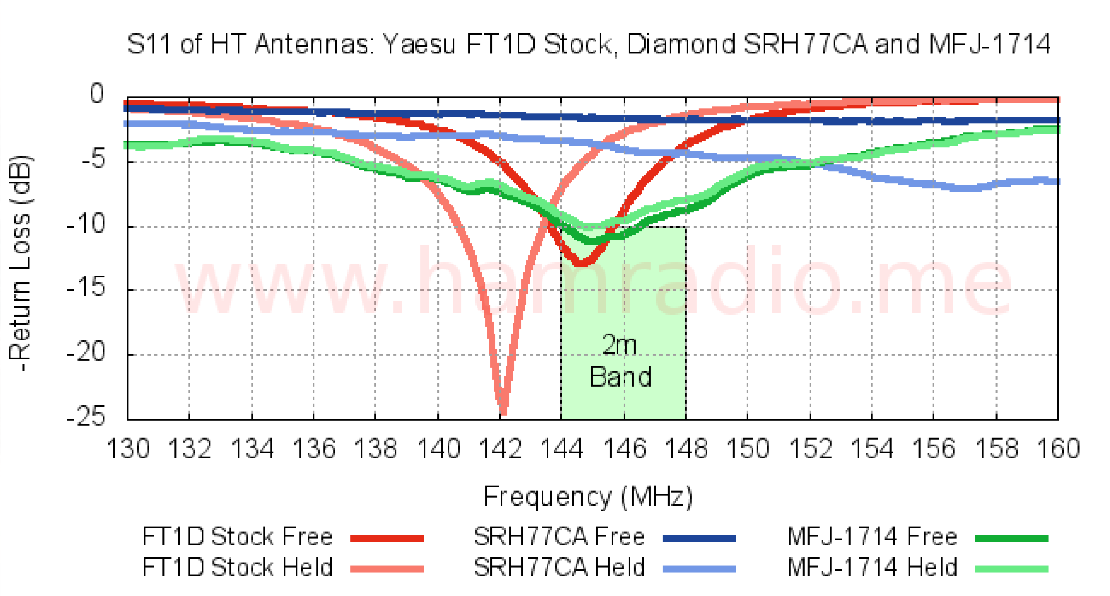
Results with ¼ Wave HT “Tiger Tails”:

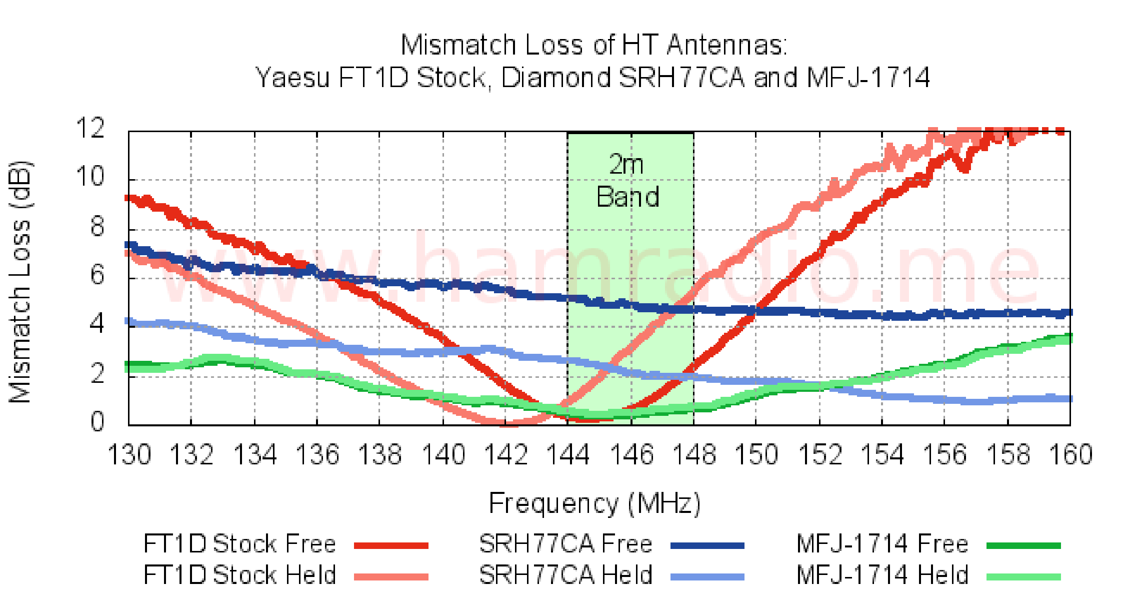






Loss Factors

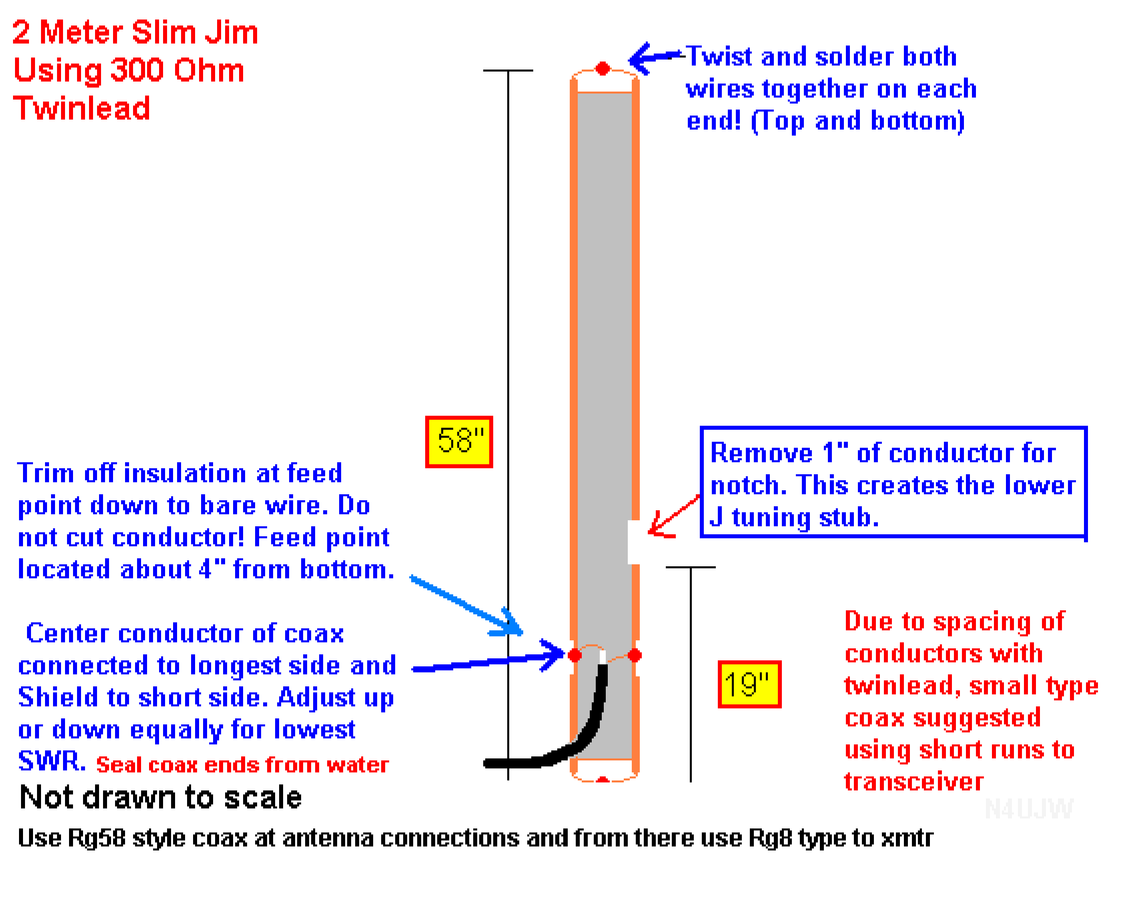




- Observations:
  - HT antennas live a tough life electrically
  - The best performer tested was the cumbersome MFJ-1714
    - Passable return loss across the band
    - Good resistance to variations in performance due to counterpoise effect
  - The FT1D’s stock antenna is a surprisingly good performer for its size
  - The Diamond SRH77CA is a pathetic performer
    - It gained 10 dB in performance with a Tiger Tail, putting it in the range of the FT1D’s much smaller Rubber Ducky without a Tiger Tail
    - Mismatch loss is high, likely due to transmitter foldback from its high SWR

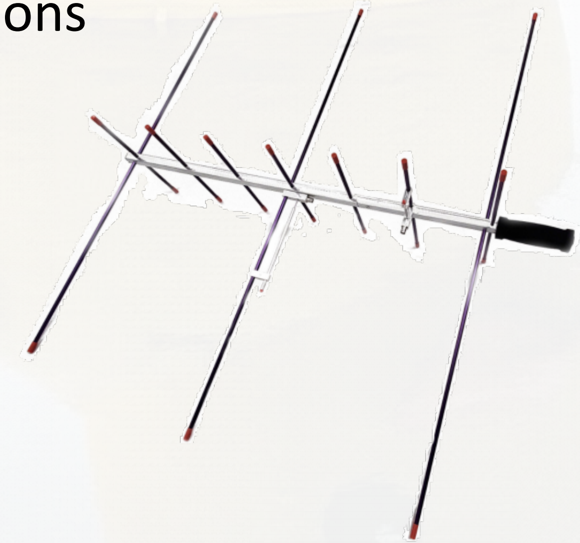
Using an External Antenna with Your HT

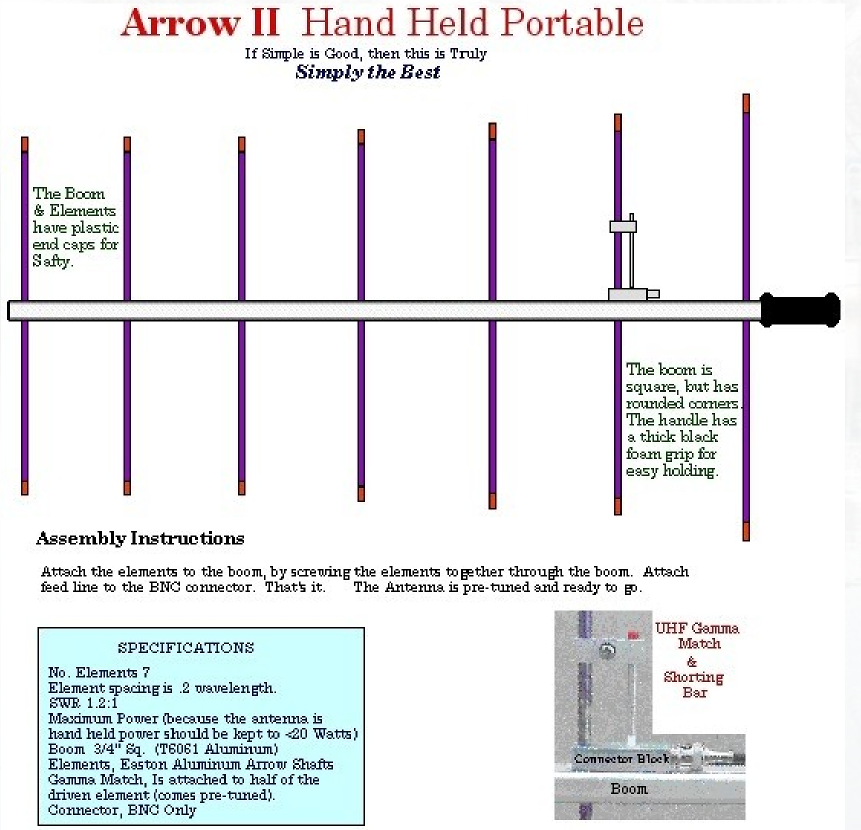
- The "Slim Jim"
  - Essentially a flexible J-pole antenna which can be rolled up
    - Use thin coax such as RG58 or even smaller coax to connect it to your HT
  - Can be suspended from a tree or other object or taped to a wooden dowel
  - Keep at least two feet away from metal objects
  - Easy to build and tune
  - Good emergency antenna for your "go bag" and car



Using an External Antenna with Your HT (cont.)

- An HT can be used with any external 2m/70cm antenna with an adapter to connect it to the HT's antenna port
- To really extend the range to a distant repeater, use a directional antenna such as the hand-pointed Arrow Antenna
  - 2m monobander and 2m/70cm dual band versions
  - 3-element to 7-element versions
  - LEO satellite version





How Good/Bad are Your HT Antennas?

- EIRP measurements are the most informative and require a sophisticated measuring environment unavailable to most amateurs
- SWR measurements are helpful to characterize relative performance differences between different HT antennas on the same HT
  - VSWR meter should permit the antenna to be close to the body of the HT for the most meaningful measurements
  - Surecom SW-33 Plus is small and inexpensive
    - About 4” long and around $45
    - Weighs 5.65 ounces
    - Measures up to 100W forward power
    - Measures 1:1 to 19.99:1 SWR
    - 125-525 MHz frequency range
    - Rechargeable Li-ion battery
  - NOTE: A dummy load will present a good SWR
    - Some Chinese HT antennas have a 50Ω resistor inside
    - Always measure a newly purchased antenna, especially ‘Nagoyas’

References

- 2 Meter Slim Jim Antenna Using 300 Ohm Twinlead
  - 2 Meter Slim Jim Antenna - 300 Ohm Twinlead Version (hamuniverse.com)
- The Survival Antenna (Kalispell Manufacturer – KF7AGO)
  - Survival Antenna - Portable HAM Radio Antenna > Store (thesurvivalantenna.com)
- N9TAX prebuilt Slim Jim antennas: Shop (n9taxlabs.com)
- Arrow II yagi antennas
  - Arrow Antennas II Yagi 2m 70cm Portable Handheld Satellite
- Surecom SW-33 Plus
  - SW-33 PLUS | SURECOM
  - Amazon.com: Mcbazel Surecom SW-33 Plus 100W 125-525 MHz Mini Digital VHF UHF Two-Way Radio Handheld Power & SWR Meter Black : Electronics
- BAOFENGTECH is the official U.S. distributor for Nagoya
  - Nagoya Antennas - BaoFeng Radios (baofengtech.com)

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