# Ham 171 - Triad antenna background

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**Mission:** *Establish reliable, lowest technical common denominator communications, locally & regionally, in a HOA.*

**Trade-offs.** When designing an antenna, or any system, there are always trade-offs to evaluate. For engineering-type problems, it is the trade-off between performance, time, and cost. You can maximize two, but not all three. For antennas, 3-D trade-offs are altitude, length, and depth. Most antennas now must be neighborhood friendly. So, our goal is to mount near the ground having a footprint smaller than the size of a short human with hands on hips for 40-meters and much smaller for higher frequencies.

**Boundary Conditions.** All physical systems have a range of operations where they work reasonably well, then performance tapers off near the edges. Free-space, which is away from the limits, has less disturbance. Near the boundary, conditions are changing. Because of the transition, the most opportunity for improvement is in this region, called the reactive field. The most well-defined boundary is the earth (dirt, ground).

**What is earth?** That is not rhetorical for electro-magnetic signals and circuits. A common perception presumes earth is the equilibrium point, where everything magically is referenced and little happens. Those who have worked with corrosion and cathodic protection well know, the earth has myriad currents and potential differences. Soil conditions and conductivity vary widely.

Energy transfer, including electro-magnetic, has three modes. *Conduction* is by direct contact, like a wire. *Convection* is by fluid currents moving from one region to another. *Radiation* is waves which require no contact or circulation movement.

The earth provides all three modes of electro-magnetic energy transfer, where air only has one, radiation. So, which would be *more efficient*? The conductivity of earth is orders of magnitude better than space.

Because of that, Tesla, a contemporary of Hertz and Marconi in 1890s, proposed using the earth to carry radio signals, rather than space. He patented and demonstrated limited implementations, but like many projects, lack of financing ended the experiments. [1] Although not invoking his design, it is instructive to know some of the earth-coupled reasoning for the minuscule Triad antenna.

**Quarter wave**. Commonly, antennas use elements (radiator and counterpoise) that are a quarter-wave (λ/4) long. Certainly not a requirement, but this dimension provides minimum voltage with maximum current at the source or connection and corresponding maximum voltage and minimum current at the quarter wave point. Whether the element is constructed in a straight line, zig-zag, or wound into a single-layer inductor, the length is still nominally the same.

**Conventional configuration.** Hertz originally built a dipole with two matching elements, one for the radiator and one for the return side. Next, Marconi built a single element vertical monopole with an earth return. Variations of his monopole consists of up to 120 radials extending from the feed-point for medium wave broadcast. Traditional iterations have three or four radials which are elevated, may or may not be grounded, and may be horizontal or drooped. The elements are typically about a quarter-wave long. Conspicuously missing among the antenna designs is a triad.

The target altitude of conventional antennas above earth is also quarter-wave. For High Frequency (HF) in the 80-meter to 10-meter wavelengths, these dimensions are huge and prohibitive in many neighborhoods.

**Constraints.** Several constraints can dramatically reduce the size and improve the effectiveness of the small antenna. No one constraint is magic, all antennas must use similar circuit elements and are restricted by geometry to a few shapes. Nevertheless, the combination has produced an *incredibly small footprint, near the dirt, and astoundingly effective antenna* from five miles to across the continent on 6, 10, 15, 20, 40, and 80-meters.

1. The preferred configuration is Triad, with a vertical and two drooped counterpoises. Many shapes, including inverted-vee, were evaluated, but provide little incremental benefit.
2. Elements are single-layered coiled inductors, quarter-wavelength with a tuning rod for adjustable reactance.

*Fig. 1. Triad antenna, 40-m radiator*

3. For single band, use a single radiator, rated for the operating band.
4. Use two counterpoise elements. Two is as effective as more elements and has numerous performance and construction benefits including omnidirectional. Moxon demonstrated the feasibility of two-elements over 40-years ago. [2]
5. Counterpoise elements can be shortened to one-third of the conventional quarter-wave (i.e. λ/12). For example, a 10-m element can be used as 30, 20, 15, 12, and 10-m counterpoise. Extensive modeling and tests have proven the viability as shown in the figures.
6. Dual band is realized by mounting both band radiators in parallel, separated about 5-cm (2-in). Then apply one counterpoise for each band.
7. Operate the antenna in the reactive field close to the ground for effective earth energy coupling and radiation pattern.
8. Mount the antenna at as low altitude as necessary. The lowest is with the counterpoise physically touching the ground. Up to attic height of 5-meters (15-feet) is still effective.
9. Adjust the shape to fit within the available space.
10. Tunable counterpoises perform compensation for altitude and changes in shape.
11. Add four to seven Mix31 ferrite beads to block the coax from being part of the counterpoise, and to reduce noise.

*Fig. 2. Measured SWR, left 80-m, right 10-m*

*Fig. 3. Tuned 10-m is flat*

*Fig. 4. Dual radiators widen bandwidth, 40-m*

*Fig. 5. 80-m strong, quiet. (MW photo)*

**Serendipity.** Several benefits arise from the Triad configuration. The closer an antenna is to dirt, the less noise it experiences. Therefore, signal to noise ratio improves. Lightning is a common issue for antennas. Low elevation allows the device to be below the cone of protection from taller structures. The Triad cost is only about $100.

**Key**. *Because the counterpoise design is to compensate for height and shape, all three elements interact and require adjustment. Adjust the radiator for frequency and the counterpoises for SWR.*

**Testing.** For these tests, we used commercially available short mobile antennas for the radiating element and both counterpoises. Whether a wrapped fiberglass or a bottom wound loading coil, the system works very well. We are experimenting with custom-wound antennas of much smaller dimensions with very promising results.

One notice is important. Since the antenna is so small and low, the user may be tempted to place it near the operating station and people. Evaluate the health effects using normal radiation protocol.

**Test measurements**. Figure 1 is a 40-m radiator with 20-m counterpoise. The 40-m element is 91-cm (36-in), while the counterpoises are 61-cm (24-in). Figure 2 left is 80-m (3.8 MHz) with a SWR of 1.35. Figure 2 right is 10-m with an even lower SWR of 1.12. The SWR indicates the Triad antenna matches very well. Figure 3 illustrates the wide bandwidth on 10-m. Figure 4 shows widening the band width by placing two radiators in parallel, but tuned slightly different, as recognized by the dips. Figure 5 shows 80-m is clean and quite with a strong S5 signal and a typically narrow bandwidth. Figure 6 illustrates net contacts locally and across states.

Tests employed an Icom IC-7300 transceivers with power limited to 100-Watts and a Rig-Expert Stick Pro.

**Results**. Although we designed, engineered, and developed the antenna, a team of seven Extra/General class amateur radio operators built, tested, gave feedback, and use the antennas as part of the research and for their routine HF communications. Capt. Mike Watson (USN), KJ5DRI, has done extensive experimenting with hundreds of contacts on Triad antennas from his fishbowl neighborhood location with surrounding hills. His Triad farm consists of dual band 6+10, 15+20, and 40+80 with a tee.

On 80-m and 40-m, conversations are routine with NVIS (near vertical incident skywave) net stations within 5-miles and out to 400 miles. Besides 20-m, other contacts include 15-m to New Hampshire. 10-m contacts include Grand Cayman, Virginia, and California. These are a few examples to show the system works exceptionally across the spectrum. Clearly the Triad is not conventional NVIS radiation, but communicates well with those type stations, through its effective earth-bound energy transfer.

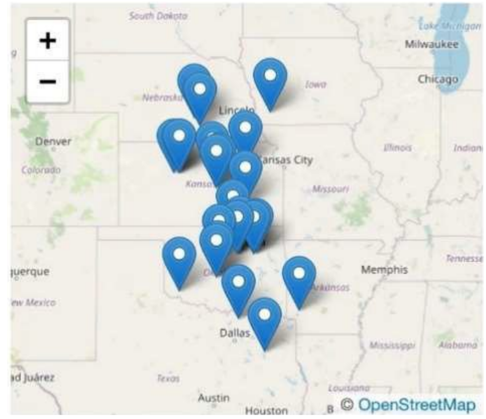


*Fig. 6. 40-m net contacts (MW photo)*

**References**


a. Nikola Tesla, "The True Wireless," Electrical Experimenter. May 1919. Reprint by BN Publishing.net.

b. Les Moxon, HF Antennas for All Locations. Bedford, MK, Great Britain: Radio Society of Great Britain, 1993.


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