The Spectrum Monitor®

Amateur, Shortwave, AM/FM/TV, WiFi, Scanning, Satellites, Vintage Radio and More

Volume 9 Number 2 February 2022

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Cushcraft D4 rotatable dipole mounted in the author's attic space. OK, there's no rotating this dipole so who will hear these signals and will the foil-back insulating panels block the signals? (K4FMH photo)

Stealth DX with a Cushcraft D4 Dipole in Your Attic

By Frank M. Howell, PhD K4FMH

Like so many amateur operators who live in homeowner association (HOA) restricted neighborhoods, my attic space and a couple of spots outside my house that are covered by shrubbery contain my various antennas. My attic has been my main "antenna farm." While many attics may be smaller than mine, others might be much larger, some fit even for future completion as additional living space. If you have 36 linear feet of free space in your attic, the Cushcraft D4 Rotatable Dipole might be a very useful HF antenna for you as it is for me. The D4 covers 40-10 meters with a reasonable bandwidth in my installation and is accompanied in my attic by an MFJ 80/40-meter dipole which gives me coverage of most HF bands.

Now, I do not expect that anyone would have room to actually rotate it in the attic with its required turning radius, but the nulls are not sufficient in my experience to rule out its effective use. But check your bearings in an azimuthal map. In my case, my installation is broadside to Europe as well as New Zealand which I consider desired DX targets. Take a look at your attic space and measure carefully. Mine antenna even works from behind a dreaded foil-backed radiator barrier (though I don't dread the lower utility bills!). While common wisdom is that such a barrier represents a Faraday Cage (see next page for more on the Faraday Cage), my experience has been otherwise.

While the D4 will handle full power, it would not be wise to do so in most attic placements. It is lightweight at 13 pounds which I was able to handle without assistance throughout the process. It covers 40, 20, 15 and 10-meters with a "typical" SWR of 1.2:1 on each of these bands and a bandwidth of 350 kHz or greater, except on 40-meters where the rating is only 125 kHz. I note that while the manufacturer's specifications state a typical SWR of 1.2:1, the narrative in the manual itself suggests 1.5 is the rating. This is an inconsistency within the manual itself.

But how would the D4 perform among HVAC and other things in the attic that prevent HF antennas from performing according to the rosy specifications that most manufacturers give on the box? As Cushcraft warns in the manual: "Location of the antenna is very important. Surrounding objects such as trees, power lines, other antennas, etc. will seriously reduce efficiency."

A Faraday Cage is an enclosure used to block electromagnetic fields. A Faraday shield may be formed by a continuous covering of conductive material, or in the case of a Faraday Cage, by a mesh of such materials. Faraday cages are named after scientist Michael Faraday, who invented them in 1836. (Wikipedia.org)

The conventional wisdom trades on a partial set of facts from Faraday's work, owing to the extreme implementation of his principle. Note the following narrative:

"Faraday cages cannot block stable or slowly varying magnetic fields, such as the Earth's magnetic field (a compass will still work inside). To a large degree, though, they shield the interior from external electromagnetic radiation if the conductor is thick enough and any holes are significantly smaller than the wavelength of the radiation… The reception or transmission of radio waves, a form of electromagnetic radiation, to or from an antenna within a Faraday cage is heavily attenuated or blocked by the cage; however, a Faraday cage has varied attenuation depending on wave form, frequency, or distance from receiver/transmitter, and receiver/transmitter power. Near-field, high-powered frequency transmissions like HF RFID are more likely to penetrate. Solid cages generally attenuate fields over a broader range of frequencies than mesh cages."

Foil-backed radiator barriers are not designed to repel or contain RF but, rather, keep heat from the sun's effect on the exterior roof singles from penetrating the attic space. Moreover, most such radiator barriers are not bonded but intentionally leave gaps between the plywood sheets to allow for expansion during the summer months. As a consequence, these "slots" may well allow for RF at certain wavelengths to pass.

Final Mount of Cushcraft D4 (note paracord string and capacity hats)

Assembling the Cushcraft D4

My attic has two main joists forming an L-shape. The longest one has about 16 feet of head room, more than I would guess the typical attic has but much more than is required for the Cushcraft D4 to be installed. In the longest run of the main roof joist, there are several cross-brace beams. My thought was to just invert the usual mast mount for the D4 rotating dipole, hanging it upside down from one of the crossbeam braces. I had to fabricate a simple mount to do so. This also gave me the ability to use the supplied paracord to keep the ends from drooping which helped in tuning.

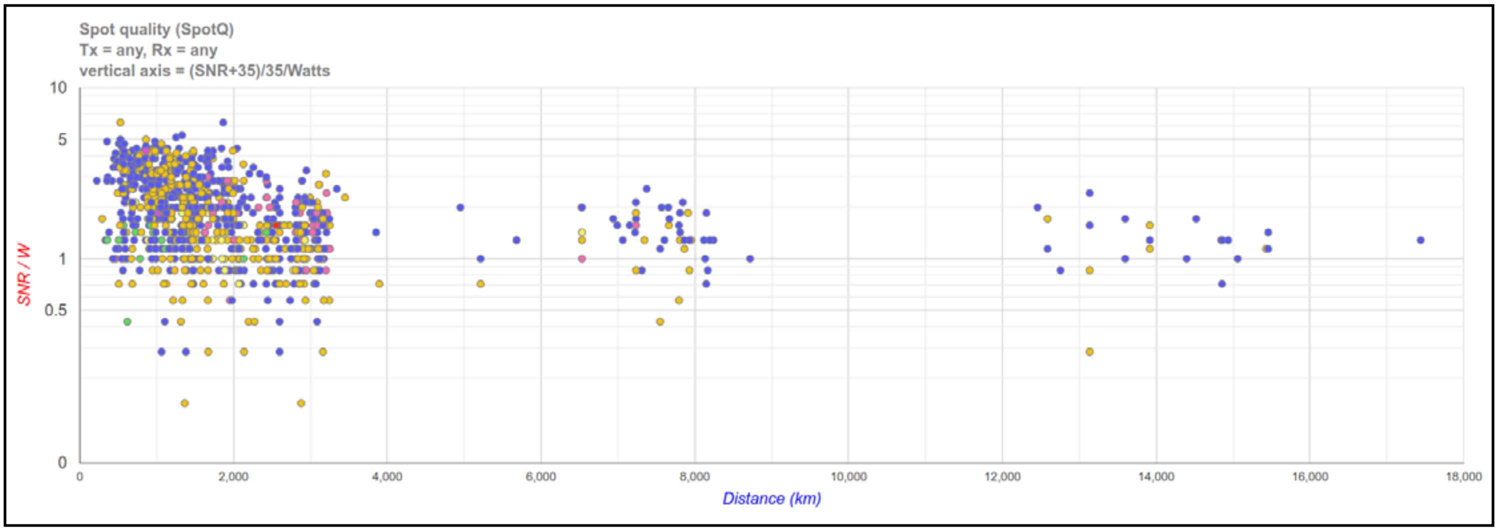
Every part was in the box as well as a few extras, a good manufacturing practice. Some were not needed because of using my fabricated mount. The instructions were very well written and illustrated but they must be followed carefully, step-by-step, to achieve the stated results.

The simple mount that I fabricated uses half-inch plywood, a 1.5-inch PVC pipe and U-bolts to hold the D4 in place. The photo above at right illustrates this (the wire dipoles were later moved). This mount works very well although readers need to assess their own attic space for workable alternatives. I connected the supplied paracord to a nearby crossbeam joist support to keep the dipole as straight as possible. This is illustrated in photo on the previous page. It is located 36 feet above ground at this spot—not uncommon for an outdoor dipole height. The antenna has spokes on each end which are capacity hats supplied in the D4 parts. As will be mentioned below, the reader will note in the photo on the previous page that the foil-backed radiator barrier plywood sheets are separated by slots with spacing clips.

The final mount also illustrates the anticipated dangers of an antenna mounted in an attic. This is where most of my home's HVAC, electrical, communications, and security system lives. Plus, the dreaded foil-backed radiator barrier on the underside of the roof! The key questions are how well does this pessimistic installation work in terms of tuning the antenna to the manufacturer's resonance specifications? Are HF phone contacts possible with the D4 installed in my attic?

Tuning the Cushcraft D4

Once the intended final mount was in place, I used both my MFJ-269 and Rig Expert AA-55 Zoom antenna analyzers to adjust the aluminum tubing held in place with metal hose clamps. While I could have used a NanoVNA to simultaneously measure the key parameters, I used a conventional scalar antenna analyzer (Rig Expert AA-55 Zoom) to follow the manufacturer's suggested tune-up procedure. This involves adjusting each lower frequency segment of the dipole before the band trap to resonance before moving on to



WSPR Spot Quality vs. Distance in kilometers over a 24-hour period. (Courtesy of the author)

a higher band.

Each band was able to be tuned to an SWR of less than 2.7, higher than the manufacturer's specification but largely due to the 10-meter segment. This included a low of 1.19 on 40 meters, 1.30 on 20; 2.20 on 15, and 2.69 on 10 meters.

The bandwidth on each band varied from the specifications. It was higher on 40-metes but lower on the others. I may spend some more time on tuning 10-meters as propagation improves. I suspect that the capacity hats at each end might be adjusted around the dipole itself to reduce any influence of capacitance loading with the foil-backed radiator barrier. All bands were easily matched using an MFJ 994B ATU to an SWR of 1.5 or lower.

Testing on HF

To see how the attic-mounted D4 fared inside the "Faraday Cage" that most attics are thought to be, especially with the foil-backed radiator barrier, I used a WSPR Beacon from QRP Labs (Ultimate 3S) operating on each band at 0.2 Watts of power. Running this low-power beacon over a 24-hour period gave me an indication of how well the radiator barrier could be penetrated as well as if there was any directional pattern in the fixed dipole. These data cover the period from 1 PM (Central Time) until 1 PM the next day beginning October 27, 2021. Key propagation indices were as follows: SSN = 27.8, SFI = 84.3, K = 0.667. There was a X1-class solar flare report on October 28, 2021, but *after* this WSPR observation period. Thus, these propagation indicators do not suggest any anomalies from the general time period for these WSPR results.

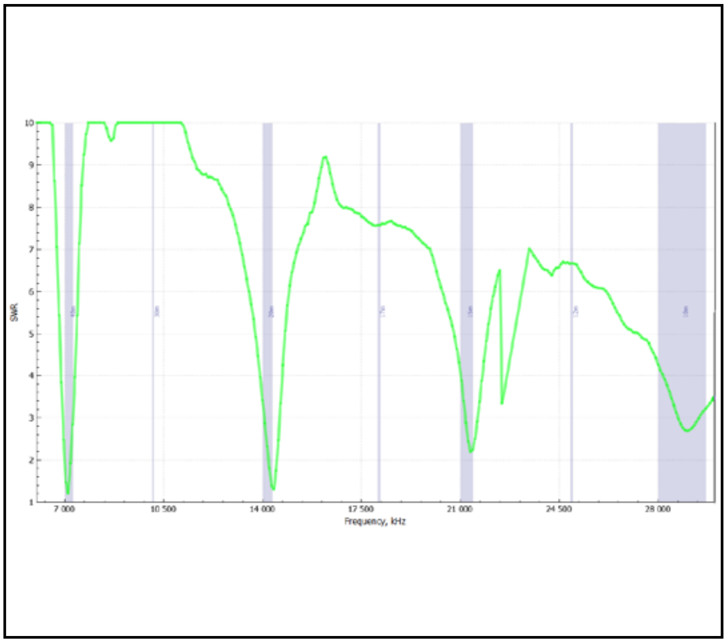
The graphic on the next page shows a composite of the four bands for this period of WSPR beacon reception. The Band Count legend shows that there were 930 spots in all. Bear in mind that due to corruption in the packets between received, a very small number of spots may contain erroneous information. In this case, there was one report on 160 meters and two "others" that fit this criterion, a very small percentage.

The WSPR spot results are very promising. The 40-meter band was heard all around the United States at various Signal-to-Noise Ratios (SNRs). Moreover, it reached Australia, Europe, South America, and the McMurdo Research Station on Ross Island in Antarctica! On 20-meters, it also reached McMurdo in Antarctica. Hawaii, Alaska, Iceland and Europe also reported successfully hearing this 0.2 watt WSPR beacon. There were only two spots on 15-meters, not entirely surprising during this period as the MUF never reached 21 MHz. There were 10-meter spots from my location in Mississippi to California, Montana and Western Canada.

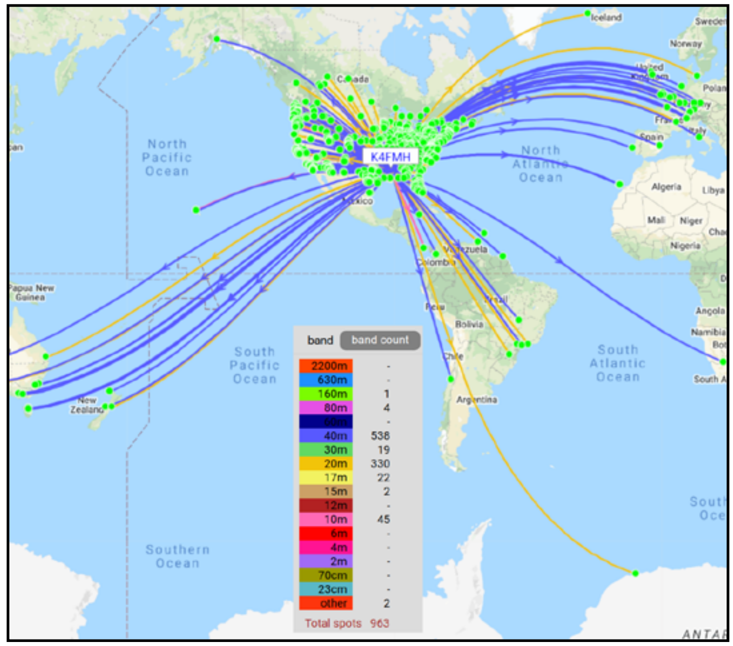
The "quality" of these WSPR spots, called Spot Quality in WSPR terminology, is displayed in the graphic above. As per Phil VK7JJ, "SpotQ is the relative Quality of a spot, i.e., how 'good' it is. The best spot is the spot that was received over the GREATEST distance at the LOWEST power and the BEST signal to noise ratio." This graph shows that the 24-hour WSPR spots contained in previous graphic had "good quality" over shorter distances in each band, maintaining that level on both the 40 and 20-meter bands out until 15,000 km or more. For the bands that the Cushcraft D4 is specified to cover, these results from inside an attic with a radiator barrier are positive.

From routinely checking a browser opened to the website wspr.rocks over several months, I've observed that Australia has heard my 40-meter beacon continually early in the morning before daybreak, sometimes until 9-10 AM local time. Moreover, Hawaii received this WSPR beacon very frequently on several bands, including 40, 20 and 10 meters when 10 meters has any openings at all. Fifteen meters has been sporadic, but spots reported do correlate with other beacons being heard on that band, too.

Once I completed the WSPR data collection, I used a QRP transceiver, the Xiegu X5105, at 5 watts on SSB for an afternoon stroll on 40-meters. I quickly received a 5-7 to 5-9 report over multiple transmissions to a couple of hams in a rag chew in North Texas. My receive noise was noticeable but low, at S3. Their report, however, of a 59 on my second



SWR Sweep Results Using Rig Expert AA-55 Zoom Antenna Analyzer and Antscope 2 Software



WSPR Beacon Spots Over 24-Hour Period Using Cushcraft D4 Antenna

transmission was surprising in a most positive way. Since that date, I've worked V31XX in Belize on 40 meters and KF2GV in Upstate New York on 20 meters using the D4. While this is just a single contact, it confirmed that the Cushcraft D4 could indeed support HF contacts, including QRP in the afternoon on 40 meters.

Conclusion

What have I learned from this installation and evaluation? The conventional wisdom that attic-bound hams with a foil-backed radiator barrier are doomed to very poor to non-existent HF operations does not apply here. Hams who have at least 36 linear feet of attic space can mount, satisfactorily tune, and use the Cushcraft D4 dipole. Moreover, while this is the antenna I chose because of the space dimensions of both the antenna and my attic, there are likely a number of other HF antennas that would also work sufficiently to maintain an HF presence. While it is less than ideal, it does seem effective.

I cannot generalize from my attic to others. Attic construction can be very different. But with the 36-foot length and just a few vertical feet to accommodate the capacity hats on the D4 dipole, I suspect that the reader who has ruled out attic antennas should study the possibilities. What I have learned is to just not believe the conventional wisdom posted in the various forums, websites and email listservs that an attic with a foil-backed radiator barrier "must" be a Faraday Cage without first testing yours. I've shown evidence that mine is simply not one. The radiator barrier might be an attenuator of an unknown degree, as the Faraday Cage sidebar describes, but that is clearly not a full blackout of RF on transmit or receive in my case. In fact, the quality of WSPR spots suggests that 1,000 kilometers or more is possible with "good" quality spotting on both 40 and 20-meters.

My neighborhood's utilities are all underground so that helps my RF noise level, a common problem with attic antennas. My ongoing task now is ferreting out the existing noise and reducing it by using ferrites and other tools as suggested in various sources such as The ARRL RFI Book. But the key message from my case study is to simply do the work to experiment and try. I've given the reader one example of what is at least a modest success story. Kirk Kleinschmidt's "Stealth Antenna Radio: Operate from Anywhere" is a must-read companion to also jostle the imagination. But I grew up on a farm. I'm going to plant more antennas to see what else can also work. Cycle 25 awaits!

The Cushcraft D4 is available from DX Engineering, among other outlets, for $600.

Cushcraft D4 Manufacturer Specifications (Courtesy of Cushcraft)

	D4
Frequency	28, 21, 14, 7
SWR 1.2:1 Typical. 2:1 Bandwith KHz	>350
Power Rating Watts PEP (CW	1500 (500)
Length ft (m)	35.8 (10.92)
Mast Size, in (cm)	1.5-2 (3.8-5)
Wind Load, ft2 (m2)	1.3 (.12)
Weight, lb (kg)	13(6)

TSM