A Novel Approach to Using Window Line

Routing 450 Ω window line through inexpensive polyethylene foam tubing enables its use in places once reserved for coax.

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It was obvious from the start that a recent antenna project would have to be fed by low-loss window line, but there was no stealthy way to do so while avoiding often-heard window-line taboos such as laying the line on the ground. After some thought and experimentation, I found that routing 450 Ω window line through widely available polyethylene foam tubing used for hot water pipe insulation would allow it to be used in places once thought to be the sole domain of coax cable.

Coax, which was first widely used by the military during World War II, became available to Amateur Radio operators for pennies on the dollar soon after the war.[1] Hams, eager to get back on the air, quickly forgot open-wire line once they were exposed to coax, which had few of open-wire line's usage restrictions. Despite open-wire line's low loss advantage over coax, it soon succumbed to a popular negative mythology that it could not be used near solid material, especially metals, or that you could not run it through a stucco wall or over a metal window frame. This article will demonstrate that these restrictions are easily overcome with a novel approach.

Deployment

As you can see in Figure 1, the method is really very simple: encase the open line in the gray polyethylene foam tubing used for insulating ¾-inch hot water pipe. The tubing is inexpensive and widely available in 6-foot lengths at local hardware stores. For longer runs, join the segments with three wraps of 2-inch waterproof tape, also sold at hardware stores. Long lengths can be purchased in coils from industrial and building suppliers.

The line easily slips through the tubing, which now takes on the role of a linear stand-off insulator. Further, the closed foam protects the line from moisture, a potential enemy of window line. In its protective shroud, the window line can now be deployed much like coax.

In practice, you only need to encase the line for those portions of the run that lie directly on the ground or right against an object — open-air runs require no protection. Where rigidity or mechanical protection is important, give the foam-encased line additional enclosure in 2-inch ABS DWV pipe.

Figure 2 shows the four test conditions that were considered — the first three are common window-line blunders, with the fourth as a control. First, I made measurements with the foam-encased window line laid on dry concrete, wet garden soil, an aluminum patio roof, and, finally, in free air a few feet above my concrete walkway.

Measuring Line Loss

In the radio community, a common technique for measuring transmission line loss is to run an S_{11} dB return loss measurement sweep with a vector network analyzer (VNA). I used an SDR-Kits VNWA-3e, set for 2 – 30 MHz. I included a phase measurement of the reflected signal as well. Figure 3 shows the curves from 18 – 22 MHz for the four situations. We'll see in a moment why I zeroed in on this smaller range.

Return loss measurements are made from one end of a line with the other end open. The resulting infinite mismatch at the open end forces the test signal to totally reflect and to make two passes of the line. The loss then is half the measured total.

The reason I selected 19.8 MHz is because of the sudden 180-degree jump you can see in the phase trace in Figure 3. It indicates the lowest half-wavelength resonance of my test line. This is important because at other frequencies, the loss measurement is a combination of real loss (what we're interested in) and reactive (mismatch) loss. Only near the λ/2 frequency do we measure only real loss. The slope of the curves is caused by the reactive components.

You can make similar measurements with an MFJ-259B antenna analyzer (on the coax-loss setting) by manually recording the loss one frequency at a time. The lowest λ/2 frequency is found by sweeping the frequency upward to locate the first major SWR dip.

Test Results

Figure 3 is a graph from my data. To ensure consistency, I made four separate test runs, repositioning the lines

Figure 1 — Routing 450 Ω window line (sometimes called "ladder line") through polyethylene foam pipe insulation provides enough physical isolation from nearby objects to ensure minimal changes in the line's characteristics.

Figure 2 — Test conditions (from left to right): on dry concrete, on wet garden soil, on an aluminum patio roof, and, as a control, suspended a few feet above a concrete walkway.

each time, but always in the same conditions. As I expected, there was variation between runs. Soil and concrete caused the most deviation, but the variations are small — 15 percent at the most, and certainly not the giant jumps hams expected.

I suspect the reason for the surprisingly small loss in these adverse situations may be because the bulk of line's field does not extend more than an inch or so from the line. Most of the field exists between the conductors.

Amazingly, there was actually less loss on metal compared with all four runs. I'm not positive why, but it at least suggests that metal window frames, chicken wire in stucco house walls, or even a hole through the metal skin of an RV or mobile home aren't nearly as much of a concern as many hams think.

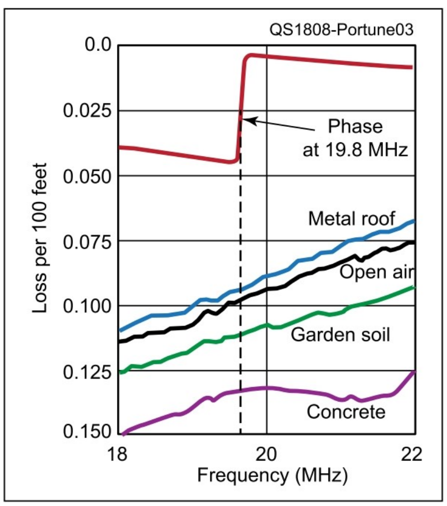

Figure 3 — Test results: loss in dB per 100 feet from 18 MHz to 22 MHz.

Impedance Matching

An impedance-matching balun (see Figure 4) between the VNA and the line was required for my tests. You can also see it in Figure 2. VNAs are commonly 50 Ω instruments, and window line is 450 Ω. I built a 9:1 (450 Ω to 50 Ω) Guanella current balun. The balun is comprised of three FT-240-61 ferrite toroids, each wound with 17 turns of dual #18 AWG speaker wire (i.e., bifilar winding). The three windings are interconnected as shown in Figure 4, with the left side of the **TOROID** block representing the start of the winding and the right side as the end. The red and green wires represent the same relative wires on each winding. Detailed instructions for making ferrite baluns are available in ARRL publications and on the internet.[2, 3]

Other Possible Applications

Another practical application for foam-encased line is to feed a beam antenna with the foam-encased line tie-wrapped directly to the leg of a fixed tower, or suspended for a crank-up tower. Then, if you ever want to use a tuner in your shack to switch your beam to a band for which it was not designed, the loss will be much less.

Other antennas that can profit from this approach are Windoms, Zepps, end-fed long wires, and off-center fed (OCF) dipoles. Also, aficionados of the 43-foot vertical should note that these are naturally non-50 Ω antennas, so feeding them with low-loss open line, an impedance-matching

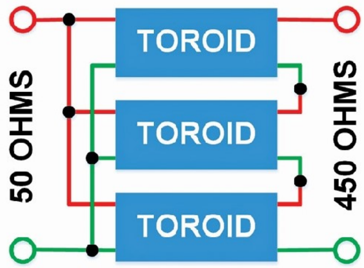

Figure 4 — The 9:1 Guanella current balun used during the tests. A similar balun is necessary to match 50 Ω radio equipment to the window line's 450 Ω characteristic impedance.

current balun, and a tuner in the shack is a very acceptable choice. This approach for an OCF dipole is much less lossy than running coax to a balun at the feed point.

Feeding an antenna with 450 Ω line that was designed by the manufacturer to be fed with 50 Ω coax is easily accomplished with two 9:1 baluns, one at each end of the 450 Ω line, with the first converting 50 Ω to 450 Ω and the second vice versa. However, it is more efficient to modify the antenna for direct 450 Ω feed. Antennas do not care how you feed them, as long as the feed point is matched. Gain and directivity remain essentially the same. You will still need a current balun at the rig. The balancing baluns found in many tuners, which are generally Ruthroff voltage baluns, are unsatisfactory.

A beam, for example, can be refitted with a 450 Ω delta or a gamma match. Other antenna designs, like the Hy-Gain R-series, may already have a matching balun at the base, which can be replaced with one for 450 Ω. The benefit is noteworthy.

Stealth and Ease

I ran these tests while building a CC&R-proof, 20-foot, off-center fed, coaxial, half-wavelength, no-radial, all-HF-band aluminum flagpole antenna, as shown in Figure 5. The local CC&R enforcers have no idea that it is an antenna. There are no visible loading coils, tuning stubs, or capacity hats. It's just a plain 2-inch aluminum pole with fiberglass insulators at the base and off-center feed point, and, of course, a flag and brass eagle.

Again, had I fed this non-50 Ω plain pole directly with coax, especially on 80 meters and 40 meters, the losses would have been considerable. But now, with a short run of foam-protected 450 Ω window line lying right on the ground next to my house and a tuner nearby in my shack, I get out well. I had originally been expecting to have to use an expensive remote auto tuner at the antenna's base.

Figure 5 — OCF 20-foot vertical stealth antenna that would have had unacceptably high losses if fed by coax.

Conclusion

These simple tests here have shown me that there are many practical possibilities for deploying window line in situations where coax was once thought to be the only player.

Please do not hesitate to let me know your experiences with this window line deployment method, or to share your ideas for topics you would like explored in the future at **jportune@aol.com**.

Notes

[1]G. McElroy, VE3PKD, "Opening Lines: A Short History of Coaxial Cable," *QST*, Aug. 2001, pp. 62 – 64.

[2]H.W. Silver, N0AX, "Coax to Open-Wire Balun," Hands-On Radio, *QST*, Dec. 2013, pp. 49 – 50.

[3]**www.k5wtr.com/k5wtr/manuals/ANTENNA%20&%20ROTORS/Balun_short_version.pdf**

Photos by the author.

John Portune, W6NBC, is an ARRL member and frequent contributor to *QST*. He has been licensed for 52 years and has held an Amateur Extra-class license since 1972. John has a BS in physics and also holds FCC Commercial General Radiotelephone Operator and FCC Radiotelegraph licenses. He retired as a broadcast television engineer and technical instructor at KNBC in Burbank, and then from Sony Electronics in San Jose, California. You can reach John via email at **jportune@aol.com**, or through his website at **www.w6nbc.com**.

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