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RF

By Zack Lau, W1VT

A 70-cm Power Divider

When stacking identical antennas, many textbook presentations suggest making a power divider out of 75-Ω coax. The math works out quite nicely—a λ/4 transforms the 50-Ω impedance of the antenna to Z_0^2 / Z_{load}, or 112.5 Ω. When two of these are parallel connected, the result is 56.25 Ω, about a 1.1:1 SWR. This is close enough for most people. I'm assuming a 50-Ω reference impedance throughout this article.

In practice, this doesn't work out so nicely on 70 cm. Here, the antennas are so large that a λ/4 just isn't long enough for proper spacing, so you need to consider a 3/4 or 5/4-λ line. Particularly since the velocity factor may shrink the electrical λ/2 to just λ/3 in actual physical spacing. However, errors in line length become more critical—a 1% change in physical length becomes a 3% or 5% change in effective electrical transformer length. One could add 50-Ω extensions, but who wants to go through the expense and reliability problems of additional connectors?

Attaching the proper connectors isn't trivial at higher frequencies and mixed impedances. Some 50 and 75-Ω connectors don't properly mate. If you are very unlucky, a fat, 50-Ω center pin will actually damage a 75-Ω socket. Almost as troublesome is a thin 75-Ω pin making intermittent contact with a 50-Ω socket. One solution is to dispense with the troublesome connectors altogether. Especially for temporary installations, like a weekend EME station designed for use only in good weather, it may make sense to just solder the coax directly together, without any coaxial connectors. The center conductors are soldered directly together. The shields can be connected with copper tape or plumbing hardware.[1]

The best solution I've seen is a power divider made out of square aluminum tubing and round brass tubing.[2] The square shape allows you to easily attach coaxial connectors—one-inch square tubing is readily available at hardware stores and is a good match for UG-58A N connectors. Square tub-

225 Main St
Newington, CT 06111-1494
zlau@arrl.org

[1]Notes appear on page 58.

ing is much easier to work with than round tubing, particularly when drilling holes in perfect alignment. Aluminum is a good choice for the outer conductor—lightweight, with excellent electrical conductivity, and it's easily worked with hand tools. The usual problem with aluminum—obtaining good soldered connections—isn't a problem since the connectors can be attached with screws. The center conductor of the custom coaxial line is a different story. I recommend attaching the center pins to the center conductor with solder. Set screws aren't really suitable in an environment where vibration and flexing might be expected. More importantly, you need to pick material dimensions that will result in the proper impedance match.

The formula for calculating the impedance of the λ/4 matching section is:

$$Z_o = \sqrt{Z_{in} \bullet Z_{out}} \qquad \text{(Eq 1)}$$

If two 50-Ω loads are placed in parallel, the resulting impedance is $\sqrt{50 \bullet 25} = 35.4\Omega$

The formula for the square coaxial line is

$$Z_o = 138 \log\left(\frac{1.08D}{a}\right) \qquad \text{(Eq 2)}$$

where D is the ID of the square tubing and a is the OD of the center conductor. Alternately,

$$a = \frac{1.08D}{\left(10^{\frac{Z_0}{138}}\right)} \qquad \text{(Eq 3)}$$

Thus, for one-inch-square thin-wall tubing with a wall thickness of 0.055 inches, one gets a tubing diameter of 0.53 inches, or 17/32. This may be an advantage of using brass—selections of brass tubing in 1/32-inch increments aren't unusual.[3]

If you use 1/2-inch tubing instead, the impedance is 39.3 Ω. This results in an impedance transformation from 25 to 61.8 Ω, an SWR of 1.23:1. This is a bit higher than the 1.02 predicted for the 17/32 tubing, but may be acceptable. I've measured 19 dB return loss for the 1/2-inch tubing and 30 dB return loss for the 17/32 tubing, which correspond to SWRs of 1.25:1 and 1.06:1. Accurately measuring a 1.02:1 SWR at 70 cm requires precision equipment—most people don't find it necessary to go through the trouble. An advantage of thin brass tubing is the ease of soldering—relatively little heat is needed to get the metal up to the proper temperature, especially since the square aluminum tube effectively shields the operation from drafts. In addition, the thin tubing puts less stress on the soldered joints than does heavier tubing.

It may also be possible to find aluminum tubing with thicker walls, though the selection is often more limited than in the round-brass-tubing case. Nevertheless, I have made a power divider using 1/2-inch brass tubing and one-inch-square aluminum tubing with 80-mil-thick walls. The return loss measured 31 dB. At least 26 dB of return loss was measured on this divider between 410 and 473 MHz.

I strongly recommend using N connectors at 70 cm. UHF connectors aren't a good idea—they typically introduce a 1.5:1 SWR at 70 cm. While this might be tuned out with clever engineering, who needs the hassle? An obvious exception is the use of unusual or surplus cables—you may need to use whatever connector you can get.

The end caps for keeping water and bugs out are made from 3/8-inch sheet Lexan, a shatterproof plastic that is quite UV resistant. Thus, it isn't necessary to protect it from sunlight. The centers of the caps have tapped #8-32 holes—this allows me to remove the caps easily from the tubing by inserting screws and pulling them out. The

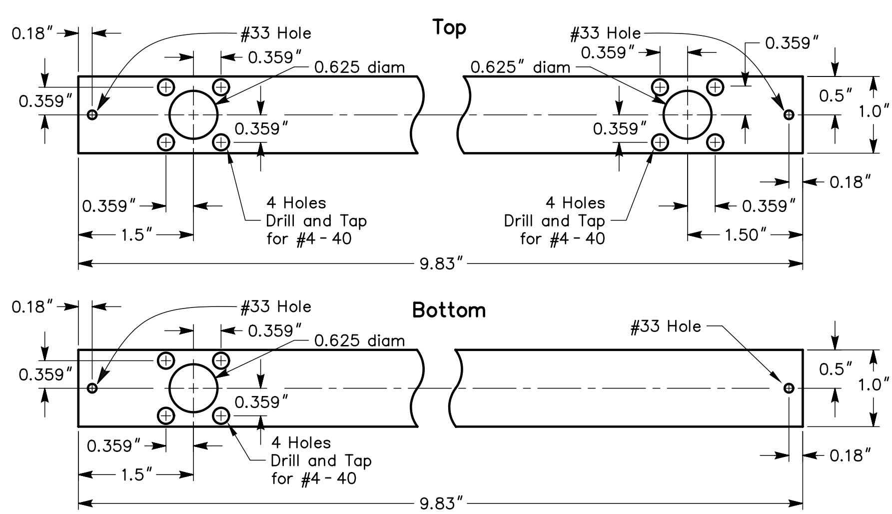

Fig 1—Drilling diagram for the square tubing.

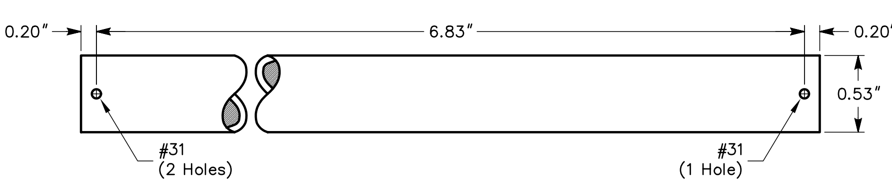

Fig 2—Drilling diagram for the brass center conductor.

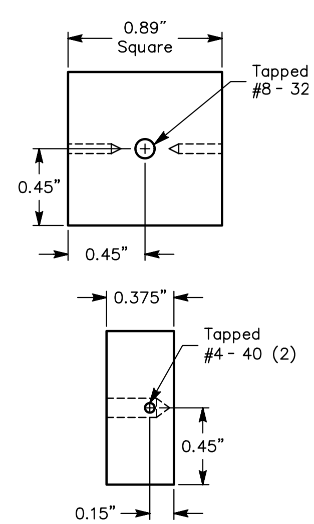

Fig 3—Lexan end plates.

Fig 4—The parts ready for assembly. *Do not* solder the connectors to the center conductor before assembly! Secure one connector at each end to the square tube. Then fit and solder the center conductor to the center pins of the mounted connectors. Install the remaining connector and solder its center pin to the center conductor. Press the Lexan end plates in position and secure them with #4-40 machine screws.

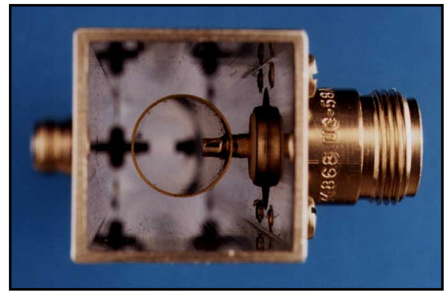

Fig 5—An end view of the completed assembly from the single-connector end. The near, single connector is at the right side of the square tube. One of the connector pair at the opposite end appears smaller and out of focus at the left side of the square tube. Notice how the N connector's center pin penetrates and supports the round center conductor.

holes don't go all the way through the plastic—though this would eliminate the possibility of the caps being attached backwards. A single cap installed backwards can be pushed out with a long stick. The caps are tapped with #4-40 threads so they can be securely attached to the aluminum tubing with stainless-steel screws and lockwashers. The aluminum tubing acts like a waveguide below cutoff. It yields about 30 dB/inch of attenuation. Thus, the end caps won't have much effect unless they get close to the connectors.

Construction

I made the divider about three inches longer than the calculated length of the matching section, so there is plenty of space for the end caps without intruding on the fields of the matching section. After squaring up the ends of the aluminum tubing, I carefully marked off the connector spacing and then the mounting holes for the three UG-58A connectors. Fig 1 is a drilling guide for the square aluminum tubing. It may be necessary to adjust the dimensions slightly to center the connectors, to compensate for slightly thicker or narrower tubing. For instance, with 1.02-inch-square tubing the centerline is 0.51 inches from either edge, not 0.50 inches.

I tried drilling the 5/8-inch holes with a 1/2-inch drill and then a Unibit step drill, but the step drill was too long to enlarge the hole without creating one on the opposite wall. A 5/8-inch Greenlee hole punch was used to finish the job, but these specialty tools are getting pricey. They list for $25.50 in the Mouser Electronics catalog.[4]

Fig 2 shows the drilling guide for the brass center conductor. Drill through both sides of the tubing on one end to accommodate the pair of connectors, while making just one hole on the other end. If the holes fit snugly over the center pins, this will ease center-conductor alignment by holding the tubing in place until it can be soldered.

The center conductor must be accurately centered—unless you wish to lower the impedance of the matching section. I used a 0.2-inch flat-bladed screwdriver tip as a gauge to judge how well the tubing is centered. It's much easier to see how well the tubing is centered when a reference is placed next to it.

Notes

[1]T. Pettis, KL7WE, "Hy-brid Hi-Power," *Proceedings of the 22nd Conference of the Central States VHF Society*, (Newington, Connecticut: ARRL, 1988), pp 149-151.

[2]"World Above 50 MHz," *QST*, Oct 1973, p 97 presents Don Hilliard, W0PW's two and four-port 50-Ω power dividers for 144, 220 and 432 MHz amateur bands.

[3]Small Parts, PO Box 4650, Miami Lakes, FL 33014-9727; 1-800-220-4242; http://www.smallparts.com; smlparts@smallparts.com; has such a selection from 1/16 to 21/32-inch OD.

[4]Mouser Electronics, 958 N Main St, Mansfield, TX 7063-4827; 1-800-346-6873; http://www.mouser.com.