By Paul Danzer, N1II

Open Wire Feed Line—A Second Look

Put up the longest dipole you can fit, feed it with open wire line, connect it to the balanced output of your tuner and—poof! Instant multiband antenna. Is life really that simple?

The answer is yes…this actually works. But there are a few things that should be considered before you dump that G5RV, cut down all your other antennas and replace them with just one dipole. A few practical considerations may change the way you build, tune or use a single, multiband dipole.

Open wire line has a very large advantage. By open wire line, we mean both commercial ladder line as well as two parallel wires with plastic or ceramic insulating bars. The *TLA* program, included on a disk with the 17th through the 19th editions of *The ARRL Antenna Book*[1] gives us a way to see the primary advantage of open wire line quickly and directly. (The 20th edition has a newer program, *TLW* for *Windows*.)

This program lets us pick a transmission line and impedances (and therefore the SWR on the line) and presents us with the losses on the line. The few numbers given here will be sufficient for an understanding of what's going on, even if you aren't mathematically inclined.

Open Wire Versus Coax

Using *TLA*, four sets of calculations were run. Each was for 100 feet of transmission line at 28 MHz. Ladder line, the 450 Ω variety, was connected to an imaginary perfectly matched antenna of some sort. The total transmission line loss was 0.201 dB, so small as to be silly. (A 3 dB loss would mean you have lost half of your power.) But, since we are interested in multiband operation, on other bands the antenna will be mismatched.

In order to use nice, round numbers, a new antenna was imagined that looked like 1000 Ω resistive and 1000 Ω inductive. All transmission lines will show an increased loss when the SWR is not 1:1, and in this case the additional loss was again only 0.270 dB—small enough to be ignored.

This was not true with coax…in this case 75 Ω, RG-59/U, and a perfect 75 Ω dipole. At 28 MHz the loss was about 2.01 dB. That's noticeable, but perhaps acceptable if you chose to use a lightweight, small-sized transmission line. But with the same 1000 Ω resistive and 1000 Ω inductive imaginary load, the additional transmission line loss *TLA* tells us is 6.797 dB. Wow—too much already!

That is why open wire line has been suggested many times for a multiband dipole. With a mismatch, the increased line loss does not amount to very much.

Figure 1—A few hours in the wind and you are no longer connected.

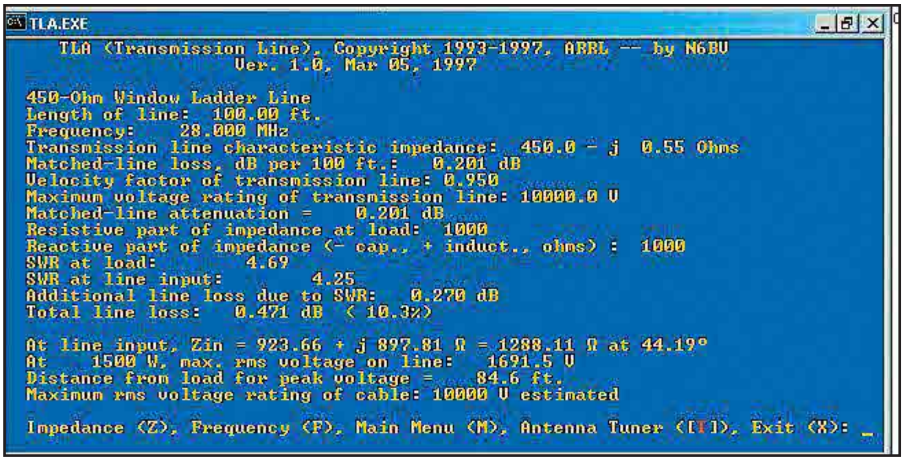

Figure 2—The *TLA* program output reveals losses and voltages.

[1]Notes appear on page 36.

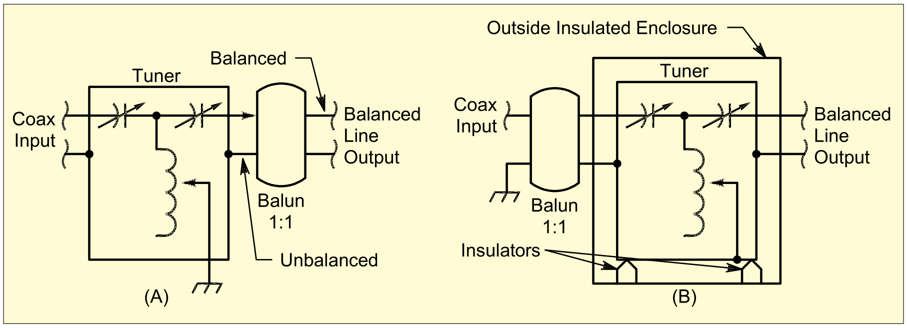

Figure 3—The A solution shows the conventional approach, and B the high-efficiency, practical approach.

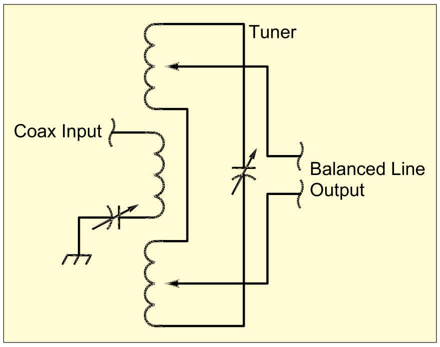

Figure 4—This tuner design predates coaxial cable, but is still practical for balanced line today.

A 100 Foot Test Dipole

To see what the results with a real antenna would be, a 100 foot long dipole, 40 feet in the air, was analyzed using *EZNEC* (to find its input impedance) and *TLA* (to find the transmission line losses and voltages). When fed with 600 Ω open-wire line, the dipole, as expected, was a reasonable choice for all bands except 160 meters, and perhaps a bit questionable for 80 meters.

Frequency (MHz)	*Complex Impedance Z_{in} (Ω)*	*Voltage (V)*	*Total Loss, Including that due to SWR (dB)*	*Additional Loss due to SWR Alone (dB)*	*SWR at Input of 600 Ω Line*
1.82	3.5963 –*j*1694.1	3700	7.66	7.64	39.71
3.6	20.156 – *j*466.45	1550	0.769	0.737	7.13
7.1	413.41 + *j*1155.7	650	0.154	0.107	9.15
10.1	2551.4 – *j*2804.4	750	0.259	0.202	9.15
14.1	106.41 – *j*181.65	600	0.221	0.152	5.90
18.1	1168 + *j*1674	600	0.249	0.170	5.97
21.1	567.29 – *j*1630.7	750	0.424	0.338	8.85
24.9	144.27 + *j*151.09	500	0.212	0.117	4.25
28.1	1498.1 + *j*1610.1	550	0.276	0.175	5.27

As you can see, the total loss for this feed line was less than 1 dB for all bands, except 160 meters. With 100 W delivered to the feed line, the voltage seen (only the peak value is shown here) is a bit high on 80 meters, but it goes out of sight on 160. As expected, with open-wire feed line, the additional losses due to SWR remain remarkably low for SWR values up to 9:1. Only on 160, where the SWR climbs to almost 40:1, do the additional losses due to SWR become important.

Don't let numbers like *j*1630.7 and 3.5963 throw you. The number of significant figures shown here are artifacts of the computer calculation, and the actual accuracy is nowhere as precise as shown. If you use another simulation program, or make other assumptions, you own figures may vary from this table by 20% or more.

There are, however, a few problems with this approach.

Problem #1: Mechanical

Before you even start, consider how you are going to connect the open-wire line to the dipole. Ladder line is not much of a problem; there are commercial connectors available. For most other lines, you will have to fabricate a clamp. If you can imagine soldering the line to the dipole, as shown in Figure 1, also imagine the line breaking off after few months of flexing in the wind. It's a problem you should be aware of.[2]

Problem #2: How Damp is My Shack?

The *TLA* program output for mismatched 450 Ω line is shown in Figure 2. The fourth line from the bottom of the screen print is an indicator of another problem. Almost 1700 V_{rms} is floating around. This voltage jumps, in the practical case, when you try to feed a short dipole, such as one cut for 80 meters, on a lower frequency band, such as 160 meters. Keep your fire extinguisher handy!

Problem #3: Baluns Work, But Only Sometimes

Most commercial and homebrew tuners consist of a T or other configuration that is essentially an unbalanced input to unbalanced output. Simple and straightforward.

Many years ago, in school, I was taught an interesting concept: "For every complex problem, there is invariably a very simple solution and invariably that simple solution is absolutely wrong!"[3] Taking the unbalanced (coax) output of a rig, putting it through a tuner, and then to a balun to take advantage of the low loss of a balanced open wire transmission system is a very simple solution, but it does not take into account the balun.

Strangely enough, the balun problem has been known "forever," and until only recently it has been ignored. In the 10th edition (1964) of *The ARRL Antenna Book*, the following was printed on this topic:

> The principles on which balun coils operate should make it obvious that the s.w.r. on the transmission line to the antenna must be close to 1 to 1. If it is not, the input impedance of each bifilar winding will depend on its electrical characteristics and the input impedance of the main transmission line…and the transformation ratio likewise will vary over wide limits.

Translated, this means that if the balun is not operated under matched conditions, it does not operate as the simple unbalanced to balun device you might imagine. Moreover, from a practical point of view, the balun core will get hot. This means that some of the power you thought you were sending to the antenna is actually going to raise the temperature of your tuner and your shack. There are easier ways to heat the radio room!

What are the Solutions?

Figure 3 shows one neat and perhaps elegant solution. The normal, but not desirable approach is shown in Figure 3A. But, if you reverse the flow, and put the balun first, then the tuner can operate as 50 Ω in and whatever is needed out, while the balun stays as 1:1.

This is the approach shown in Figure 3B. A practical, elegant high power tuner with this configuration designed by Dean Straw, N6BV, was included in the 1998 through 2002 editions of *The ARRL Handbook for Radio Amateurs*.[4] It was put together to squeeze every last watt out of the tuner. Any reasonable tuner, however, mounted on insulators, within a second enclosure, can be used in this mode. Each knob shaft would have to be extended with an insulated section, and a good quality 1:1 unbalanced to balanced balun used between the rig and tuner.

A second solution dates back to the 1930s, and is shown in Figure 4. The small winding is called a "link," and the configuration is referred to as "link coupled." The unbalanced input for the rig goes to the link, and the balanced transmission lines tapped off symmetrically from the tuned circuit. The link could be fixed and adjusted with a small variable capacitor as shown, or it could actually be moved mechanically in and out of the main inductor to achieve a match.

Open Wire Lines—Not a Bad Idea

As long as your open wire feed system is really matched, and the balun is used under reasonable SWR conditions, open wire does allow you to use one dipole on many bands with reasonable transmission line efficiency. Unfortunately, it is not as simple as connecting the line to the two terminals marked "balanced" on the back of your tuner. But with a little care, one dipole will serve all.

Notes

[1]Available from your local dealer or the ARRL Bookstore. Order no. 9043. Telephone toll-free in the US 888-277-5289 or 860-594-0355, fax 860-594-0303; **www.arrl.org/shop/**; **pubsales@arrl.org**.

[2]One solution to the breakage problem is to strain relieve the ladder line by passing the conductors through the insulator holes first and then looping and soldering them to the antenna wires. This has worked for the editor for many years.—*Ed.*

[3]Attributable to H. L. Mencken: "...there is always a well-known solution to every human problem—neat, plausible, and wrong."—*Ed.*

[4]It is also included in the current (20th edition) of *The ARRL Antenna Book* on p 25-15.

Paul Danzer, N1II, has been a licensed ham for over 50 years. Paul has both Bachelor's and Master's degrees in EE, and after many years as an electronic engineer, he now teaches at Housatonic Community College in Connecticut. When he was on the ARRL HQ staff, Paul wrote and edited ARRL books. He is also an ARRL Technical Advisor. He can be reached at 2 Dawn Rd, Norwalk, CT 06851; **p.danzer@ieee.org**.

NEW BOOKS

TIPS TO THE TOP FROM DX PROS

◊ The new book *Tips To The Top From DX Pros* describes dozens of DX success factors and operating tips collected in a survey of 100 outstanding DXers. Written by Devere "Dee" Logan, W1HEO, a veteran DXer and DXCC Honor Roll member, the 32-page book contains details of a survey of leading DX operators listed in the DXCC Honor Roll, Worked All Zones and CQ DX rankings, plus a number of key DXpedit-ioners. The 10 chapters include suggestions for equipment, antennas, pileup strategies, locating the DX, getting the QSL, tips for reaching the top and more. *Tips To The Top From DX Pros* is available for $9 plus $1.50 shipping and handling (check or money order only—payable to D.E. Logan) from D.E. Logan Public Relations, 9901 Cypress Circle, Mentor, OH 44060.

STRAYS

BYRON LICHTENWALNER, W3WKR

Byron Lichtenwalner, W3WKR, of Stroudsburg, Pennsylvania, searches the bands from this impressive station. It features an ICOM IC-765, PK900 TNC, Alpha amplifier, IBM PC running *Writelog* and a Mosley PRO-57B at 65 feet on a crankup tower.

LARRY ROBBINS, W3CEI

***SKN aficionado:* When Larry Robbins, W3CEI, of Middletown, Pennsylvania, sent us this photo of his straight key collection (and Heath SB-313 receiver and Knight T150A transmitter), he included a note that said, "I am looking forward to a 24 hour swing cycle of brass type music, hand-crafted with care and skill." The results of the 2004 running of Straight Key Night appear on page 110 of this issue.**