Introducing an Improved Version of Transmission Line for Windows Software

A popular piece of ARRL software gets a makeover.

Joel R. Hallas, W1ZR

For many years, Transmission Line for Windows (TLW) has been one of the PC software programs provided on the CD-ROM that comes with The ARRL Antenna Book. The CD includes many useful antenna-related programs, as well as the contents of the book and EZNEC models of many of the antennas described in the book. In addition, a special version of EZNEC can run all of those models. The CD is such a valued resource that many argue that the price of the book is really for the CD, with the comprehensive book as a free bonus!

I can state that among all the programs and data on The Antenna Book CD, I find Transmission Line for Windows (TLW) to be the program that I use the most. TLW painlessly allows you to enter an impedance value that can be obtained from measurement, antenna modeling, or just inferred from an SWR or measurement or analysis of conditions at either end of a transmission line. The program then displays the complex impedance at the other end, along with and including the effects of line loss (see Figure 1) depending on your chosen feed line, length, and frequency. With the results TLW provides, you can design an antenna system or an antenna tuner. Not only that, TLW also painlessly designs an antenna tuner (your choice of topology) that will match the load to 50 Ω, calculates the tuner loss, and specifies the voltages and currents on all the components! (See Figure 2.)

The Need for an Update

The version of TLW that has been included in the recent edition of The ARRL Antenna Book was last updated in 2006 by the original programmer and (now retired) Antenna Book editor, R. Dean Straw, N6BV. The transmission lines it supported included 22 specific types of 50 Ω coaxial cable, five types of 75 Ω coaxial cable, one type of 93 Ω coaxial cable, and unspecified balanced transmission lines including 300 Ω twinlead, 450 Ω window line, and 600 Ω open-wire line. In addition to the built-in line models, there is a capability to specify a “user-defined transmission line,” in terms of characteristic impedance, velocity factor and attenuation characteristics versus frequency.

While this seems like a lot of choices, it came up a bit short on the increasingly popular balanced transmission lines, especially window line, which is available in multiple wire sizes and characteristics. The prior version only offered a generic “450 Ω window line” choice.

Of even more importance, ARRL International Member Steve Hunt, G3TXQ, performed an independent analysis that
indicated that the loss predicted for the balanced lines by TLM was optimistic. TLM predicted a loss that was even less than the loss contributed by the ac resistance of the copper itself.

The loss calculations in TLM are based on curve fitting to published data, which is a very reasonable approach for coaxial cables that are associated with detailed data determined by the manufacturers and included in their specifications. Unfortunately, that kind of precise data for balanced transmission lines is generally not available. Instead, the balanced transmission line data used by TLM was extracted from measurements reported in early ARRL publications that turned out to be somewhat inaccurate.

Dean Straw, N6BV, graciously agreed to reexamine the balanced line calculations with new measurements performed by the ARRL Laboratory. The Lab obtained multiple specific transmission lines from manufacturers and conducted tests in a carefully controlled environment. The test team was led by ARRL Laboratory Test Engineer Bob Allison, WB1GCM, and supported by Senior ARRL Lab Engineer Zack Lau, W1VT, and ARRL EMC Engineer Mike Gruber, W1MG. The results they obtained were consistent with Steve Hunt’s, G3TXQ, analysis, as well as some sample testing that he conducted independently.

With the new data in hand, Dean proceeded to update the software to our new version, which includes two specific 450 Ω types of window line — Wireman #551, composed of #18 AWG solid copper clad steel, and Wireman #554, composed of #14 AWG, 19 strand, copper clad steel conductors.

In addition, the 300 Ω twinlead is now specified as a tubular type composed of #20 AWG wire and the 600 Ω open-wire line is specified as having #12 AWG conductors.

### How Much of a Difference Are We Talking About?

The difference between the predicted window line attenuation from the earlier (2006) version of TLM and the newly released (2014) version of TLM obviously depends on which type of line you were actually using and the way you were using it. Tables 1 and 2 compare the earlier version’s results to the revised version’s results.

### Table 1

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for a number of representative cases. All data is for 100-foot lengths that can be scaled to different lengths if desired. Note that nominal “450 Ω” window line actually has characteristic impedance closer to 400 than 450 Ω. The “matched impedance” value of the model is about 405 Ω for the 2006 version and close to 403 Ω for the 2014 version. For the 10:1 SWR mismatched case, ½ of the model Z₀ was used as the terminating impedance. For comparison, the attenuation of traditional 600 Ω open wire line and popular RG-8X, 50 Ω coax is also shown. Note that the values for previously unspecified 600 Ω open wire line match those of the #12 AWG open wire line in the new version.

What This Means
First, we should reiterate that there has been no change to the way TLW handles coaxial cables. Because these have been based on solid data from manufacturers, they are as good as they have been in the past. With window line the story is a bit different, depending on your perspective. For a length of window line that is matched to its load, the difference comes down to tenths of a decibel in most cases. That may seem significant on a percentage basis, but not in terms of its effects on radio communications.

For mismatched window line, however, the difference is indeed significant. For many years ARRL publications have stated that mismatched window line exhibits less loss than matched coax. In light of this new information, it is now more accurate to say that mismatched window line has loss that is comparable to that of matched coax. This is probably not too dramatic a change, but those who use window line in the presence of SWR higher than 10:1 should probably reassess their options, including improved impedance matching and/or shifting to open-wire line.

Note that this change not only has impact on the results from TLW analysis, but also applies to the tabular and graphical data for balanced lines that has appeared in both The ARRL Antenna Book and The Radio Amateur’s Handbook for many years. Needless to say, the next editions will include corrected data.

On a personal note, for some years I have been successfully using a 135-foot centered Zepp as my main antenna on most bands. With the exception of an excursion to a 12:1 SWR on 40 meters, it has a 400 Ω SWR of less than 10:1 on all bands from 80 through 6 meters, and is much easier to deal with than 10 separate matched dipoles. I’m still happy with my decision.

The ARRL Offers Special Thanks
We are particularly appreciative of the efforts of Steve Hunt, G3TXQ, for bringing the balanced line attenuation disparity to our attention and especially for his patience in working with us on demonstrating the nature and extent of the problem. Our thanks to R. Dean Straw, N6BV, for his willingness to depart from his well-earned retirement in order to tackle this problem and execute a very positive solution in short order. Also, special thanks to the ARRL Lab team, who despite being fully booked, made extra efforts to obtain the data needed to allow this version to come to fruition.

Update Your Version of TLW
The files needed to update your recent (The ARRL Antenna Book, 20th edition or newer) version of TLW to the latest version are available to anyone who owns a CD from The ARRL Antenna Book. The TLW3V32A.zip file can be downloaded from the ARRL Product Notes web page, www.arrl.org/product-notes, and are also the QST in Depth section of the website at www.arrl.org/qst-in-depth. In order to provide all the features of the software, you will need to save the new version 3.24 “TLW3.exe” file to the same directory that held your earlier version in order that it has access to the various support files. Also included in the package is a revised set of documentation. If you haven’t tried it before, I hope you will find TLW as useful as I have.

Notes
1 The ARRL Antenna Book, 22nd Edition. Available from your ARRL dealer or the ARRL Bookstore, ARRL order no. 6948. Telephone 860-594-0355, or toll-free in the US 888-277-5289. www.arrl.org/shop; pubsales@arrl.org.
2 Several versions of EZNEC antenna modeling software are available for developer Roy Lewallen, N7EL, at www.ezneccom.com.