Ladder Line Myths

Ladder line is great - extremely low loss, even at high SWR. However, many hams refuse to use it because they are afflicted by common misconceptions:

1. "Ladder line radiates!" Baloney. Ladder line does not radiate any more than does coax, if terminated in a balanced antenna.
2. "I tried it once, and it messed up my TV, my computer, and filled the shack with RF!" The trick here is simply to make sure you use a length of ladder line that is **not** a multiple of a half-wavelength on any band. Lengths like 43 and 86 feet work well. A resonant length of ladder line, just like the shield of coax, will pick up RF from the antenna and conduct it into the shack. The only difference is that the shield of the coax is grounded, and the ladder line is not, so it acts in common-mode to bring in and radiate induced RF. Again, simply avoid those resonant lengths.
3. "It's too hard to work with! You have to keep it away from metal!" Well, yes, a couple inches or so. The general rule is twice the width of the line. It's easy to make stand-offs from half-inch PVC pipe.
4. "It's too hard to bring into the shack!" Baloney! There are many waterproof ways to bring ladder line into any shack. One is shown below.
5. "I can't buy a lightening arrestor for ladder line!" So just **make** them yourself, as shown below.
6. "It flops around in the wind, and it breaks too easy!" (a) Windowed line should be twisted about a turn every two feet to prevent wind-induced oscillations. (b) Make a good feedpoint connection, with proper strain-relief. It doesn't hurt to wrap it over the top of your feedpoint insulator and then secure it to itself with cable ties. Also, the 14-gage stranded stuff is **much** more reliable than the old, cheap 18-gage solid stuff.

If you run an all-band dipole (with a tuner in the shack), you need ladder line. Coax is **very** lossy when operated at high SWR. It's easy to lose 90% of your power in your coax when operating on bands where the non-resonant dipole presents a high feedpoint impedance to the feedline.

Ladder Line Types

No one seems to know what to call it: ladder line, windowed ladder line, windowed twin-lead, "true" ladder line, open ladder line, open feeders, etc. etc.

- Twin-lead is the 300-ohm TV antenna line. Don't mess with it.
- Ladder line is any kind of parallel feedline except twin-lead.
- Windowed ladder line is just that: 1-inch twin-lead with windows punched in it. Some call it window-line. I just call it ladder line.
- The "true" ladder line is best called "open wire feed-line," to distinguish it from window line. This is the type made from two parallel wires, separated by spreaders.

What to Get

Get the 14-gage stranded window line from Cable-Xperts or Wireman. Don't get that solid-wire crap that many ham stores sell.

Brew Your Own

The one problem with window line is that it tends to change characteristics when wet, and the longer the run, the more tinkering you'll have to do with your tuner as the weather changes. The solution for long runs is to make your own open-wire feeders. It isn't hard or complicated.

1. Get a 500-foot roll of #14 THHN or THWN insulated stranded ($20 at builder's supply). Pick a color that blends with the background. Get some pressure-treated 2x4s, 10-12 feet long, and plant them in the ground every 100 feet or so. To change directions, use a 4x4 in cement.
2. For spreaders, all you need is some kind of small, UV-resistant plastic tubing. Cut them 4 inches long, and make enough to put one every 5 feet or so. Use your table saw or table router to cut a notch in each end of each spreader, about 1/8th by 1/8th.
3. String up two strands of the wire, appropriate length between trees. Pull them even. Insert a notched spreader every few feet. Inject a dab of hot-melt glue in each end of each one to secure it to the wires.
4. Congratulations - you just made modern, high-quality "true" open-wire ladder line, and you didn't even have to boil a bunch of wood dowels in paraffin!
5. Now attach it to your 2x4s with wire staples or electric fence insulators.

Note: Purists think you have to use "bare" wire - **baloney.** Why mess with wind static, rain static, and corrosion? The

same holds true for all wire antennas. **Never use uninsulated wire.**

One more thing to consider: Bending ladder line at sharp angles can cause problems on the higher bands. This is because the magnetic field around the line will interfere with itself at the bend. Or so say the books! I have never had any problems bending window line at 90-degree angles - and I've even fed a 2-meter beam with window line, bent 90 degrees, and it worked great! Ham radio abounds with techno-myths...

Spacing and Impedance

Don't worry about it. A non-resonant antenna will present a feed point impedance of 10 to 5,000 ohms, with plus and minus reactance, at various frequencies - so who cares about the exact feed line impedance. Matching the antenna to the feed line simply has nothing to do with efficiency (unless your using coax).

Anything from 1 to 6 inches is acceptable spacing. 1-inch #14 line is 370 ohms. 1-inch #18 line is 450. 6-inch #12 is about 600. It just isn't at all critical - and don't let any geezer or guru tell you different! The spacing should not be over 1 percent of the wavelength, and that's the only real consideration with ladder line.

Length

As mentioned above, parallel feeders can pick up RF from the antenna and transport it into the shack as common-mode current (this simply means the two wires acting as one). The way to avoid this is to simply avoid resonant lengths of ladder line, and, if possible, bring the line away from the feedpoint perpendicular to the antenna (90 degrees) for a far as practical. Setting your bend-point will also help you take up slack when using a non-resonant length, without having to cut off the excess.

In other words, measure your total run, then increase that to the next available "good" (non-resonant) number, then route the line to take up the slack. A 300-foot open-reel tape measure is handy, and Harbor Freight has them for well under $30.

Lengths to avoid (in feet): 32, 65, 96, 130, and 260 - and multiples of any of those.Don't let them make you buy 100 feet when you know that'll be too close to 96! Make them sell you 110 feet, for example.

Good lengths: Somewhere around 40, 80, 110, etc. Say you saw it here. If in doubt, consult the ARRL Antenna Book.

Feed-Throughs and Lightening Arrestors

How to make your own spark-gap shunt ("lightning impulse arrestor"), waterproof ladder line feed-through, and quick-disconnect for (hopefully) improved lightning safety, using common hardware. Or, how to possibly avoid the "billion-amp arc in the shack" scenario.

Disclaimer: All disclaimers apply. No guarantees. I am not an engineer nor expert in the field of lightening protection. I assume absolutely no liability for your use of this material. These ideas have not been tested. Use at your own risk! The actual effectiveness of these measures cannot be quantified. Lightning is dangerous, destructive, deadly, and unpredictable, due to rapid release of incredible power, and extremely wide range of variability.

My HF antenna is a 160 meter dipole, fed with 14-gauge windowed ladder line. This arrangement should make a nice lightning collector, so I took special precautions on the entry path of the ladder line.

In figure 1, notice the PVC standoff (one of two), made of half-inch PVC, about six inches long, attached to the trailer with aluminum angle. The ladder line proceeds down to the arc-shunt assembly, which is mounted directly on the ground rod. It then proceeds up to brass feed-through assemblies (Fig. 2). Once inside, it plugs into the tuner with banana jacks (Fig. 3), for quick disconnection.

The ladder line is kept separate from all the other cables, which enter via a 1½-inch PVC nipple and coupling (inside) through the floor. The coupling is packed with paper towels (and a little boric acid powder) to keep out bugs. The arrangement provides a good seal that can be easily removed and replaced to allow passage of PL-259s intact.

Ladder-Line Arc-Shunts

I constructed the shunts as follows: Using a piece of 1/8th-by-1 inch aluminum flat or angle stock, cut to about four inches long, drill three holes. Enlarge the two outer holes until you can force-thread two spark plugs into them. Use new, non-resistor-type plugs. Run a 1/4 x 4-inch bolt down through the center hole and place a nut underneath. Now grind a couple of flats on the last inch of the bolt, so it will clamp easily in your ground rod clamp.

Attach the ladder line as follows: Measure and strip the incoming line and jumper lead. Crimp and solder uninsulated ring lugs. Apply a little grease and then place them under the spark plugs' caps. Tighten securely with pliers, but be careful not to twist off the small stud on the plugs! Seal the tops off with silicone caulk or Coax-Seal. Be sure to insulate

all connections, particularly if you have curious children around, to prevent RF burns.

Note: A gap of .025 will not arc RF at 100 watts on any band. Higher power may require a wider gap, so watch your SWR meter carefully the first time you QRO on each band.

If you want the lightening arrestors to arc at a lower voltage, you'll need to obtain a couple of gas-filled arc shunts (commonly used in coaxial arrestors), or obtain commercial MOVs rated for RF service.

NOTE: No arrestor will protect your radio! All are meant to arc at a much higher voltage than your radio can stand. Always disconnect during storms! The arrestors shown here are meant to keep the disconnected jumper from arcing inside the house - **not** to protect the radio!

Figure 1 (Ooooo lookie! RF can change directions 180 degrees!)

Watertight Entry Assemblies

This assumes your rig is near a window, and you know how to replace a window pane with plastic. I used a window because my trailer-home has metal siding. If your walls are nonmetallic, you can, of course, go through with long threaded brass rods. This may be easier than replacing a windowpane with polycarbonate.

Remove and disassemble the windowpane. Measure the glass, then discard and replace with polycarbonate of the same thickness. Many hardware stores carry small pieces, and one shouldn't cost over a few dollars. Cut the new plastic pane to the exact dimensions of the removed glass. Reassemble the window.

Plastic sheet is best cut with a circular, table, or radial-arm saw, using an 80-tooth finish blade (hollow-ground or carbide -- do not use a "set-tooth" blade) and cool with a little trickle of water. Don't use a jigsaw, as they just make too much heat. Apply masking tape to avoid scratches during cutting. You may be able to find a store with a commercial panel cutter that will do this for you, and save all the mess and trouble. Take exact dimensions.

Note: It is possible, with a special bit, to drill glass. **Don't!** If a big storm comes along and a tree limb falls on your ladder line, it'll probably rip out the window glass - not exactly desirable, particularly during a storm...

Fabricate the feed-through assemblies using 10-32 brass hardware as shown in Figure 2. You'll need (2) 10-32 x 1½ screws, 10 nuts, 4 brass washers, and 4 flat rubber sink faucet washers (as seals). Drill the two holes through the window, spaced the same width as your ladder line. Attach the ladder line on each end using soldered ring lugs. Split the rings open with wire cutters, place over the outside end of screws, then close the rings and tighten the nuts. Cover outside connections with Coax-Seal (see mine corroding?).

If you'd rather go through a wall (nonmetallic houses), get the appropriate lengths of small brass all-thread rod, and the same length of Tygon tubing (the thick-walled variety) to slip over and insulate the rods. Then get the appropriate extra-long drill bit (carbide-tipped for brick, if needed). Don't drill into a pipe or electrical wire! Drill the holes through the wall and insert the Tygon-insulated rods. Put double nuts and washers on each end. Caulk the outside entry points. Apply

ring-lugs to the feedline and jumper. Grease the rings. Install and tighten. Waterproof the outside ends with silicone caulk or Coax-Seal. You'll then have a permanent ladder line entry that'll last as long as your house.

Figure 2

The Quick-Disconnect Jumper

The short jumper on the inside goes from the feed-through bolts to the balanced output of the antenna tuner. Solder banana jacks onto the line and just plug them in. When thunder is heard, jerk them out and bend the line well away from equipment. This is a lot faster and neater than using the cross-bores in the binding posts, and will encourage you to disconnect at every sound of thunder. However, the bananas might not handle the high current of QRO operation. Since I run barefoot, this is not a problem. A good old-fashioned double-pole knife switch is an even better option - and they look so cool!

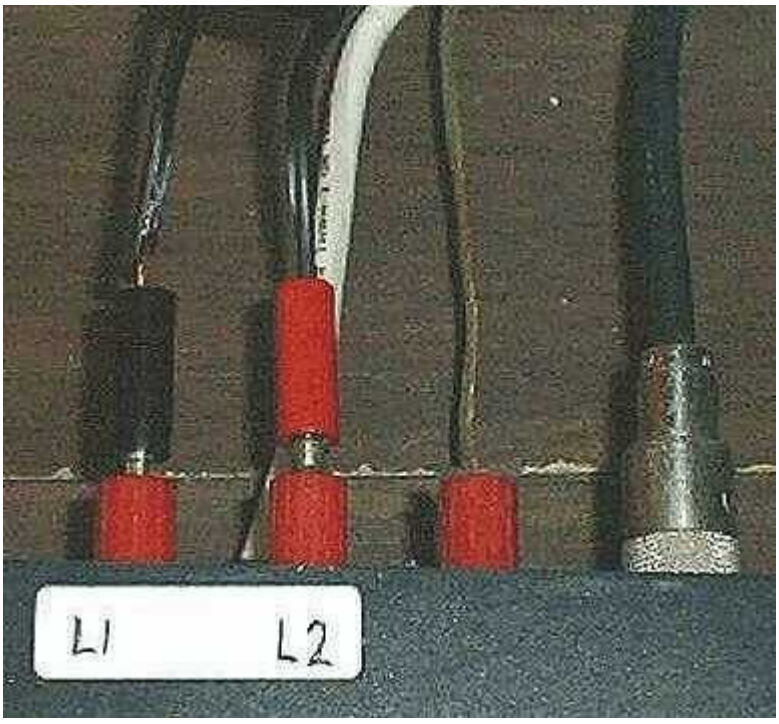

Figure 3

How Does it Work?

I have not had a direct lightning strike. The spark plugs should arc across the .025 gaps and shunt inductive impulses (nearby strikes) to ground, and they probably have done so on many occasions. In a direct strike, the arc current will probably ramp up until it vaporizes the ladder line, which being swagged from the tower, should fall open and might interrupt that leg of the pulse. The tower, about 50 feet away and also grounded, should then ramp up current until it is

destroyed or the charge is dissipated. In other words, three successive failure modes are designed to interrupt part of the strike and channel the vast majority of it to ground, away from the operating position. Well, in theory! I do not hope to ever test that scenario. Still, it's probably better that no planning at all. Remember that, once a lightning arc starts, it converts the air into plasma, which is highly conductive, and nothing will open the arc until the energy dissipates to the point that the power flow will no longer support the plasma state, at which point it converts back to regular gas. (Plasma is simply gas that is so hot that the electrons are stripped from the nuclei. With most of the electrons being free, it becomes a highly conductive gas).

Note that an inductive impulse that would arc the plugs will still damage the radio if the feedline remains connected. Spark "arrestors" are not a replacement for disconnected feedlines! All spark-gap shunts work because the feedline is disconnected, providing a much wider gap (several inches) than the small gap of the device, thus forcing an arc at that path of lower resistance, before the voltage can climb higher. I assume that the plugs should arc at about 10-15 kV, since they do so in engines. That will still ruin your radio if connected.

Possible Improvements

If I did it over, I'd plant a 4x4 post several feet (maybe 8-10) from the house, bring the ladder line down it, and place the arrestor assembly there, with its own ground rod. This would carry a large, direct-strike pulse to ground at a greater distance from the house. The jumper would then cross to the operating position, suspended near the ground. This would be a tripping and mowing hazard, but would probably (in theory) shunt the arc to ground at a distance sufficient to keep it from vaporizing the side of the house.

Another idea I have not yet tried is to run the ladder line underground, by twisting it, wrapping it in bubble wrap, and stuffing it into six-inch PVC sewer pipe. It should work, if the line is well balanced and kept centered in the pipe. This would be done to provide an easy full-stroke arc path to ground starting at some distance from the house, say, 20 feet. The pipe would have to be totally waterproof on both ends. Why not just use coax? Too lossy at high SWR's! We non-resonant antenna users benefit greatly from ladder line, in spite of its drawbacks. The most important consideration is to try to keep it from becoming the path for a fat, billion-amp arc right into your operating position!

If you want to get fancy, mount the spark plugs in a piece of brass or copper bussbar and then braze it directly to the top of the ground rod. If dampness or snow becomes a problem, just push 3-inch lengths of old garden hose up onto the threads of the plugs. Keep weeds and grass trimmed below. Making a plastic housing from a food container would be easy, but I have not found it to be necessary.

Are these ideas totally safe? No. Are they better than nothing? Probably, but that is just an untested assumption. The best lightning protection measure would probably be to design an entry point which opens with a window, so that you can just open the window and toss the whole feedline about 25 feet away from the house. My designs are probably a reasonable compromise between safety and convenience.

A Little More on Entries

A lot of hams seem to miss the KISS principle. You can take a 1-by-4, cut to the width of your window, paint it with exterior house paint, wrap its edges with foam weather stripping, put it in a window and close the window on it. Then cut a length of parting stop (door molding) to use as a jamb-stick to lock the window down against it. Then you can drill it to your heart's content and bring in all kinds of cables - all without drilling your house. Works great for renters.