Feed Lines, Decibels, and Dollars

Take care when selecting a feed line for your station. The right choice may result in considerable savings, in more ways than one!

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Hams love to boast about their transceivers or antennas, but you rarely hear them extolling the virtues of their feed lines. This lack of attention is surprising when you consider that feed lines are solely responsible for transferring precious RF energy from your radio equipment to your antenna. Without feed lines, radio communication is next to impossible.

The type of feed line that gets the most attention is *coaxial cable*, or simply *coax*. Coaxial cables come in a variety of designs, but what they all have in common is a wire in the center of the cable, surrounded by another conductor that is acting as a shield. Between the center wire and the shield, you'll find an insulating material (the dielectric). Sometimes the insulator is a type of plastic, but it can also be nothing but air.

Coax is popular because most types are quite easy to work with. You can install coaxial cable just about anywhere, twisting and turning as necessary to fit the available space. You can even put coax under the soil, if it is rated for "direct burial."

Less well known are the *parallel-conductor* feed lines. These are made of two wires in parallel that are separated by an insulating material (see Figure 1). There are three common varieties, the most popular of which is *window line*, which uses a plastic insulator that is perforated with window-like openings. Hams often refer to it as *ladder line*, but that's inaccurate. True ladder line — the second variety of parallel-conductor feed line — uses insulators that look like ladder rungs, hence the name.

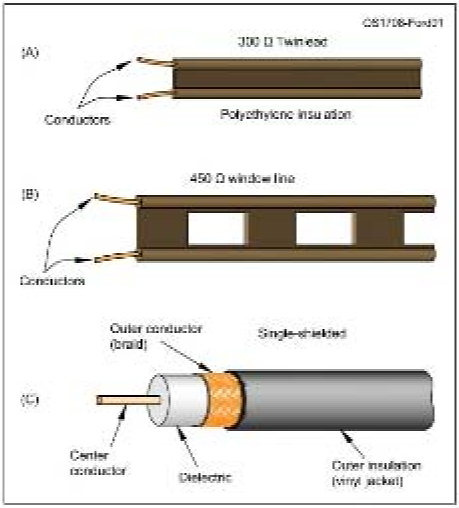

Figure 1 — Two examples of parallel feed lines and an example of coaxial cable. At (A) 300 Ω twinlead; at (B) 450 Ω window line and, at (C), coaxial cable.

The third variety is *twinlead*, in which the parallel wires are separated along their entire lengths by a solid insulator.

Every feed line, regardless of how it is constructed, has a *characteristic impedance* expressed in *ohms (Ω)*. The types of coaxial cables most commonly used in Amateur Radio applications have impedances of 50 Ω. Among the parallel-conductor feed lines available in the marketplace, window line is typically 450 Ω, ladder line is often 600 Ω, and twinlead is usually 300 Ω.

Feed line impedance is important because it can have a major effect on how efficiently RF power is transferred from your radio to your antenna. Your transceiver, for instance, expects to work into a 50 Ω impedance. A feed line impedance other than 50 Ω will result in an elevated SWR, and your radio will respond by decreasing its output power. This doesn't mean you must always use a 50 Ω feed line, but if you install a feed line with an impedance other than 50 Ω, you'll need to convert the impedance accordingly. A common way to do this is with a device called an *antenna tuner* or *transmatch*.

Feed Lines and Loss

To get to the real meat of this discussion, we must deal with the mathematical concept of *decibels (dB)*. If you're not comfortable with decibels, fear not. For the purpose of this article, just keep in mind that rising dB figures translate to increasing feed line losses. Because decibels are based on a logarithmic scale, as the numbers ratchet upward, things get very bad, very quickly.

When you browse vendor websites and brochures, you'll see feed line loss expressed in *dB per 100 feet* at a given frequency. The literature also assumes that said cables are operating under *matched* conditions with SWRs at a flat 1:1.

Some vendors specify the loss at only one frequency, but it is important to note that as a signal increases in frequency, the feed line loss also increases. To complicate matters a bit further, feed line loss also increases with feed line *length*. So, you have two criteria to consider when shopping for cable: your operating frequency and amount of cable necessary to stretch from your radio to your antenna.

Let's look at a few examples. To start, we'll assume the SWR is 1:1 at the antenna feed point. Raising the SWR adds to the feed line loss, but we'll take a swing at that curve ball in a moment.

For now, imagine a 100-foot run of good old RG-58 coax between your radio and a magical antenna that offers a 1:1 SWR on any frequency from dc to daylight. (These unicorns actually exist. They are pieces of test equipment known as *dummy antennas* or *dummy loads*, and as antennas, they work about as well as their names imply!) If you feed 100 W of RF into the RG-58 at 7 MHz, you'll suffer a loss of just over 1 dB. This equates to about 75 W at the antenna. That's not a bad loss figure, and it's entirely acceptable.

Keeping the feed line the same, let's switch your transceiver to 10 meters. At 28 MHz, that RG-58 coax is now losing about 2.8 dB, and the power at the antenna has dropped to approximately 52 W. That's a loss sufficient to make most hams wince. Losing 25 W is one thing, but 48 W?

Time for the curve ball. Let's add a 3:1 SWR at the station end of the coax. Thanks to the loss caused by the elevated SWR at 28 MHz, you can kiss an additional 6 W of RF power goodbye (not to mention the fact that your transceiver will probably balk at the elevated SWR and reduce your output anyway).

Table 1
Matched Loss in dB Per 100 Feet for Several Popular Feed Lines

	Frequency (MHz)		
Feed Line	7	28	440
RG-58	1.3	2.8	13.9
RG-8X	0.8	1.9	9.0
LMR-400	0.3	0.66	2.8
Window line (450 Ω)	0.14	0.3	1.5

Why stop there? Let's go for maximum misery by swapping out the HF rig and substituting a 440 MHz transceiver. We can return to a 1:1 SWR while we're at it. At 440 MHz, the loss in 100 feet of RG-58 can now be properly labeled "horrendous" at a bit under 14 dB. With 100 W of 440 MHz energy at the feed line input, you can count yourself lucky to see a mere 4 W at the antenna.

Let me repeat that RF loss in any *matched* feed line is largely a function of frequency and length. So, let's take a pair of cable cutters to our hapless RG-58 and reduce it to just 25 feet in length while leaving our 440 MHz transceiver and magical antenna in place. The result is a 3.5 dB loss and about 45 W at the antenna. While this isn't exactly delightful, at least it is no longer horrendous.

Okay, press the RESET button on our hypothetical example and go back to 7 MHz. This time, however, we'll replace the RG-58 with 100 feet of LMR-400, a popular type of low-loss coax. Now see what happens…

7 MHz = 0.3 dB loss; 93 W at the antenna

28 MHz = 0.7 dB loss; 85 W at the antenna

440 MHz = 2.8 dB loss; 52 W at the antenna

The loss at 440 MHz is higher than many would prefer, but it is still a far cry from the 14 dB loss we encountered with 100 feet of RG-58.

Feed Line Shopping

The point of this discussion is to vividly illustrate that loss is an important factor to consider when shopping for feed lines. In Table 1, I've listed the typical RF losses for several types of feed lines at the frequencies discussed in our examples.

As a rule of thumb, select the feed line that gives you the lowest acceptable loss at the *highest* frequency you intend to operate. You'll note in Table 1 that windowed line offers superior loss performance compared to the other feed lines, but recall that its impedance is 450 Ω. As we discussed, this means the addition of an impedance matching network between the line and your radio. At HF, this is the common approach, but at VHF and UHF frequencies it becomes a challenge.

I should also mention that antenna tuners and other matching networks have losses, too. When a tuner is reviewed in *QST*, we measure the losses and publish results in the data tables. The losses usually aren't great, but it pays to browse the reviews anyway.

Don't become obsessed with saving every fraction of a dB. I once knew an amateur who insisted on purchasing 100 feet of LMR-400 coax for an antenna that he only intended to use on 160 meters. When I tried to convince him that an investment in 100 feet of LMR-400 wasn't worth saving an extra 0.3 dB at 1.8 MHz compared to the same length of less expensive RG-58 coax, he was skeptical. He just couldn't embrace the idea that there was such a thing as "acceptable loss." For him, feed line loss was to be minimized at all cost — *literally*.

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