beginner's corner

BY WAYNE YOSHIDA,* KH6WZ

Wires and Cables

Over the years, I have had many conversations with hams (and their non-ham spouses) about "all those wires." While non-hams may think a wire is a wire is a wire, most hams know that this is not the case at all.

In its simplest sense, wires and cables transport electrical signals from a source to a destination. In ham radio stations and equipment, wires are used to route operating power from a source such as an electrical AC mains outlet or a battery to the radio gear. Wires are also used to transport radio signals from the radio to the antenna during transmit, and from the antenna to the radio during receive. Inside the radio, other signals are moved from place to place and can include data signals from a microprocessor. However, it all boils down to electrical signals moving from one place to another.

Wires for Antennas

When making antennas with insulated wire, you do not have to remove the insulation. I do not recall any antenna article that addressed this bare-wire versus insulated-wire question, so let's make a clarification here: When making antennas with wire, such as a dipole or inverted-Vee, you do not have to remove the insulation. If the antenna wire you are using is not insulated, you do not have to add any insulation. You can use No. 12 or smaller wire, in either stranded or solid copper. (You can use heavier, thicker gauge wire, but the weight may make the antenna difficult to support.)

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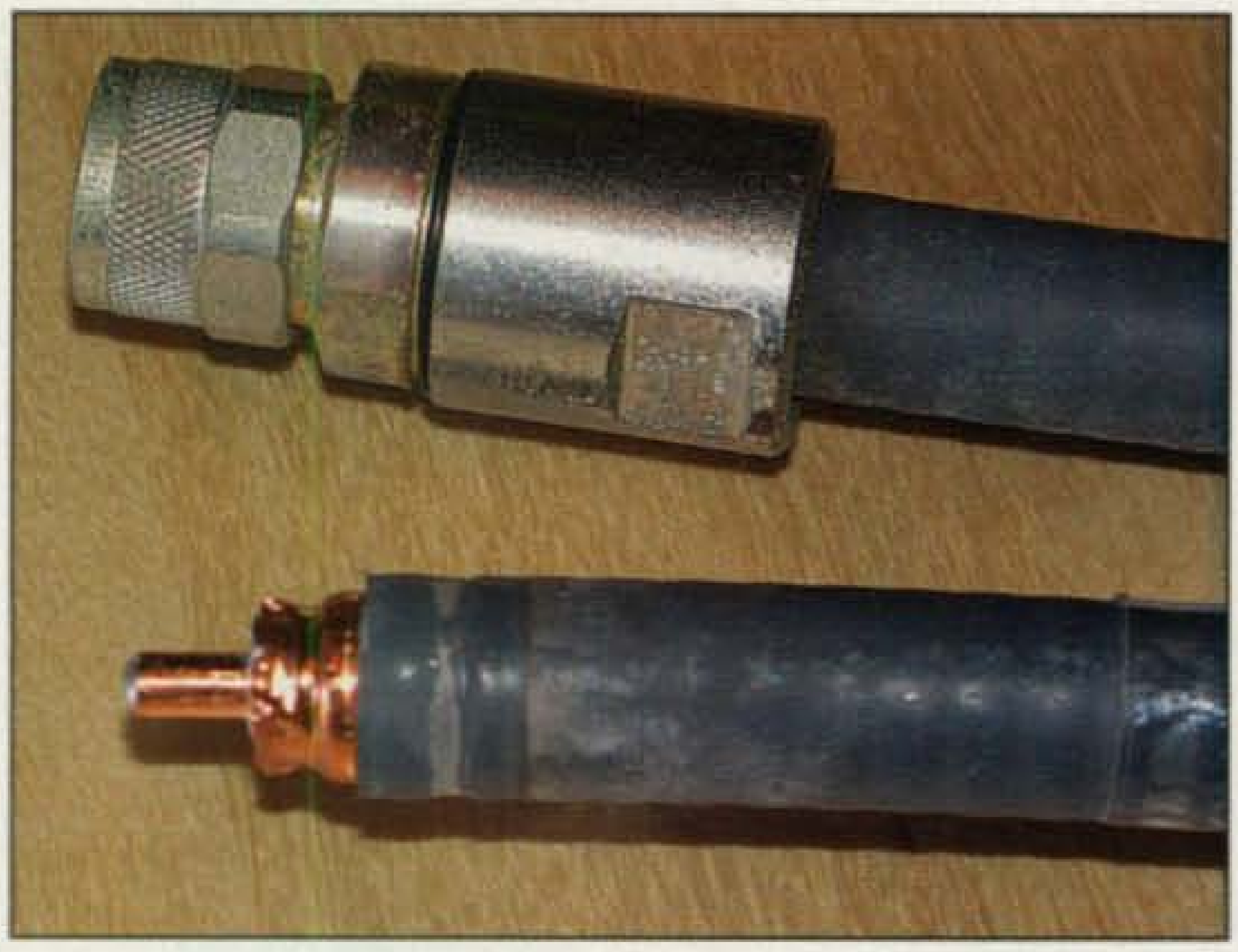

Photo 1–A very low-loss coax-cable type is called hardline. In this cable, the outer shield is made of solid copper, rather than woven wire braid. This type of cable is used on VHF-and-above frequencies and is particularly useful when long runs are needed.

Hardware and home-center-type stores carry insulated bell wire (usually in small gauges, from 18 to 26) as well as insulated house wire (usually with a designation called THHN and in larger, heavier 10- or 12-gauge sizes) both of which are suitable for wire antennas.

I use plastic-coated, No. 12 gauge solid-copper wire for just about all of my dipoles and inverted-Vees, mostly because I have hundreds of feet of this type of wire stored in my garage. (I found a "good deal" several years ago when a local electrician friend decided to clean out his workshop.) No. 14 can also be used, and the antenna would also be a little lighter in weight. Take a look at the wire antenna books sold in the CQ Bookstore for more details.

Coax is a two-syllable word in the ham radio world. It is short for "coaxial cable." Coax consists of a center conductor with a layer of insulation, followed by a woven braid or a solid shield (the shield forms the second conductor of the cable), and finally an outer insulating jacket.

There are many types of coax suitable for ham radio antenna installations, including many types with specialized jackets or construction and materials. The impedance for radio transmitting and receiving is 50 ohms. Since there are so many cable types from which to choose, *your* best source for help would be your favorite ham radio equipment dealer. If such a dealership is not conveniently located, you may want to ask your fellow ham club members for coax-cable advice.

The most common cable types for two-way radio applications are RG-58, RG-8X, RG-213 and RG-8. Generally speaking, the larger the diameter, the better the cable, with some exceptions, such as UT-141, a small-diameter, solid-copper-jacket coax used in the microwave frequency ranges.

A very low-loss cable type is "hardline," in which the outer shield is not a braid, but solid (or corrugated) aluminum tubing. Thus the cable is "hard," as opposed to a traditional cable with a soft and flexible braided wire shield. Hardline cable is usually used in VHF-and-above applications, such as a repeater installation (see photo 1).

Several types of outer jacket materials are available for most coax types, depending on where the cable is to be used. If the coax is to be buried, a jacket made of polyethylene (PE) should be used, and if the cable will run mostly outdoors, a UV-resistant jacket should be used, such as polyvinyl chloride (PVC).

According to Belden Technical Bulletin T/8-6

Connector	Upper Frequency Limit
PL-259	144 MHz
BNC	4 GHz
SMA	25 GHz
N	11 GHz normal, 18 GHz precision

Table I– Various coax-connector types and applications.

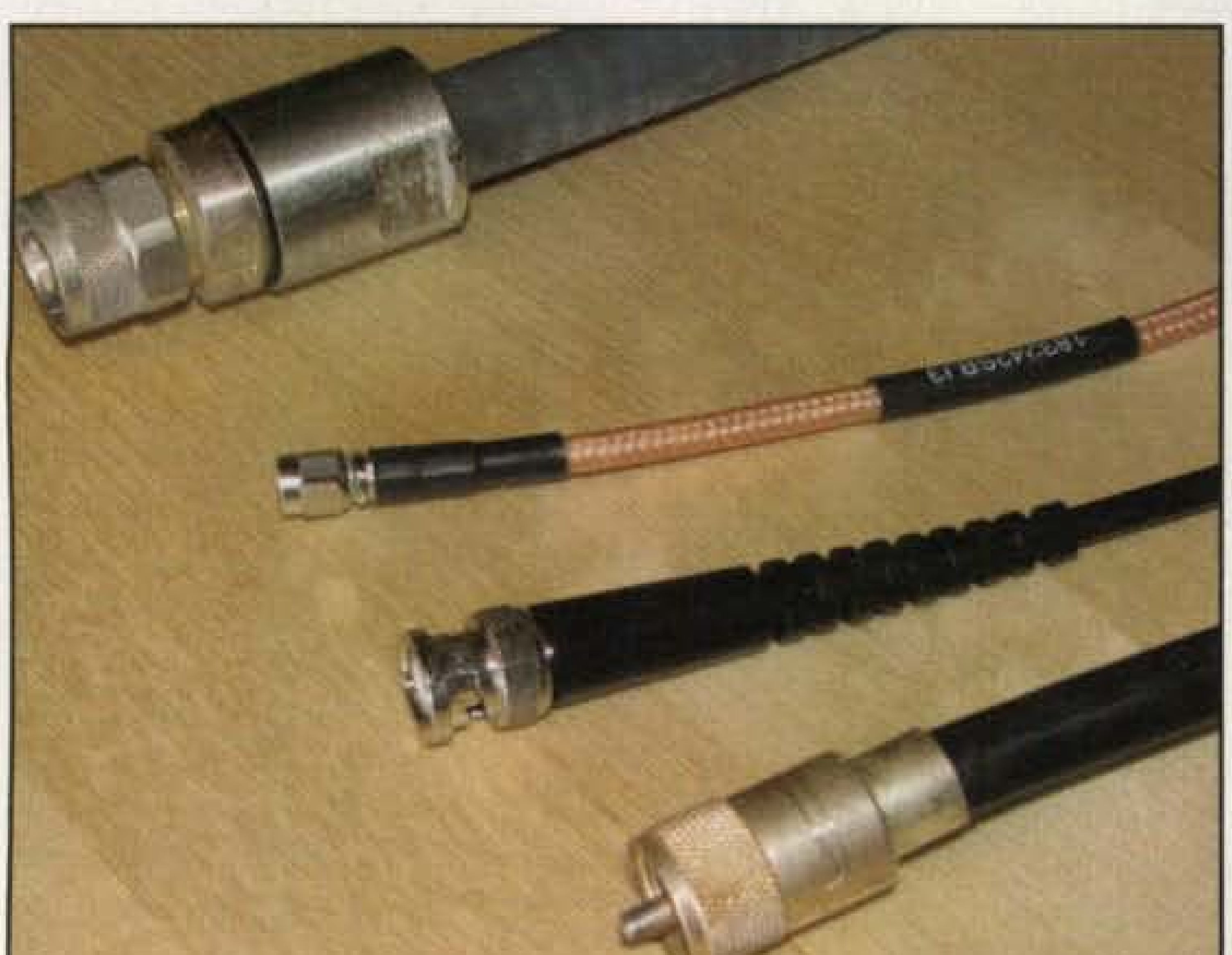

Photo 2– From bottom right to upper left, typical cables and connectors found on ham radio gear: PL-259 on RG-213, BNC on RG-58, SMA on some sort of very flexible cable, and Type N on 1/2-inch hardline.

Issue 5, "Underground Burial of Belden Cable," a high-density polyethylene jacket is particularly well-equipped for direct burial because it can stand up well to compressive forces, it is both non-porous and non-contaminating, and it provides complete protection against normal moisture and alkaline conditions.

It would be a good idea to spend a little extra and install an underground coax run inside a length of polyethylene water pipe or other suitable conduit to further protect the cable and to simplify replacement of the cable in the future. Use a large-diameter pipe so that if you decide to add another antenna, the new coax can be run inside the existing conduit.

References
Wire and Cable Information and Facts

Belden, Inc.: <http://www.belden.com/index.cfm>

Hardline coaxial cable—Andrew®, a CommScope Company, makes HELIAX® hardline cables:
<http://www.commscope.com/andrew/eng/index.html>

An online calculator for determining the voltage drop (loss) using power-supply voltage, wire size, and distance, from Current Solutions, Inc.:
<http://www.currentsolutions.com/knowledge/vdrop.htm>

A nice chart comparing wire sizes and voltage drop from Affordable Solar:
<http://www.affordable-solar.com/wire.charts.htm>

Connector, cable, and other useful information can be found at the Microwaves 101 website. Although this site is dedicated to the microwave-frequency ranges, it has some very useful information and interesting images on radio technology:
<http://www.microwaves101.com>

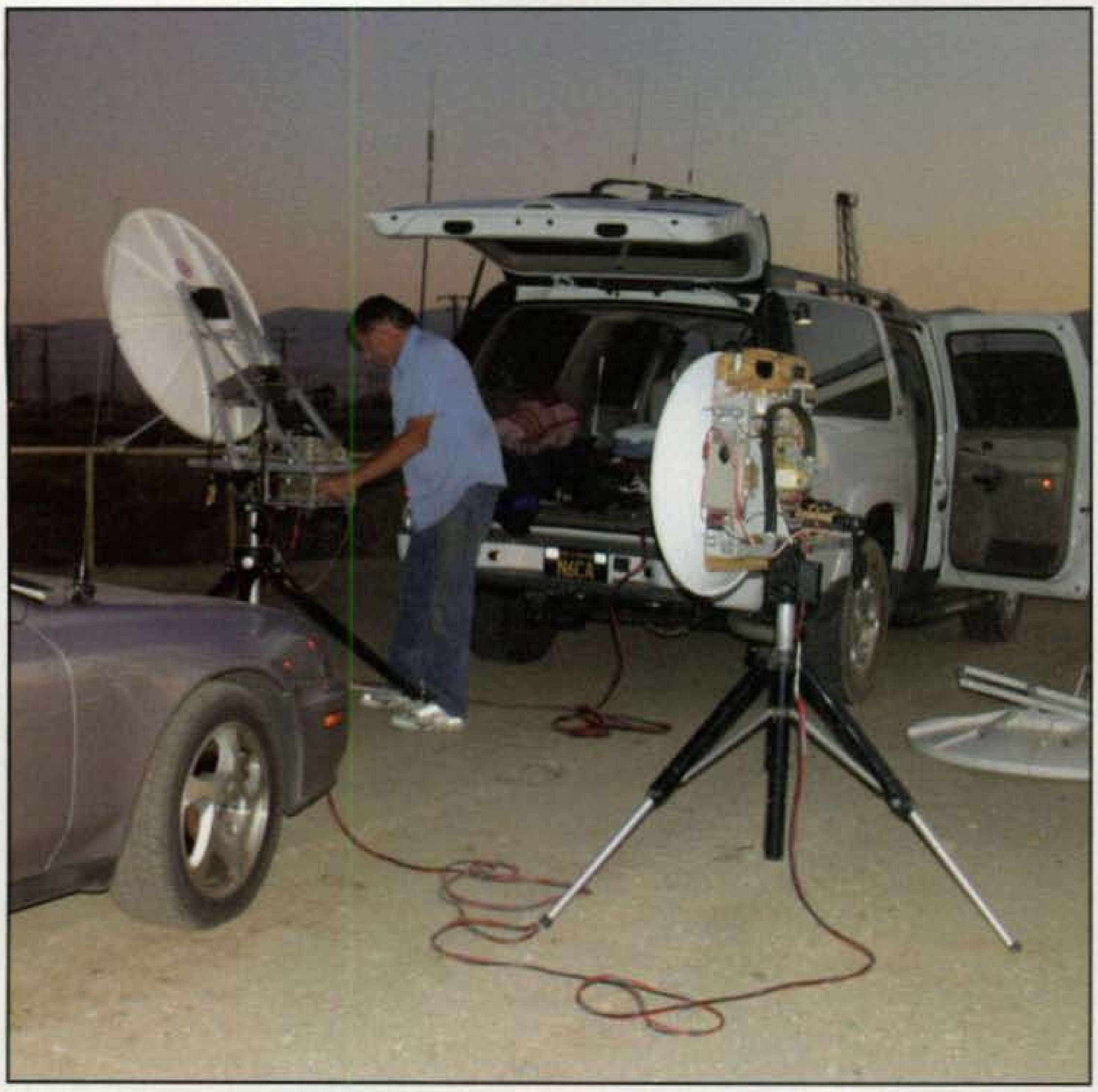

Photo 3– In this not-so-typical radio setup the rig is located far away from the power source (car battery). The voltage drop at the radio end of the long cable can be enough to cause the radio system to malfunction. Minimize this loss and maximize performance by using a cable made with thick wires.

Photo 4– A good source for flexible, large-gauge wire is your local electronics store that caters to car audio buffs. Other items, such as fuses and fuse holders, cable clamps, and other car audio supplies may also be available from shops like this.

The Belden information mentions one more important thing: In cold-weather areas, the conduit and cables should be run below the frost line to avoid damage from the expansion and contraction of the earth during freezing and thawing.

There may also be local laws or regulations regarding the use of buried wires, so you may want to check with the local building inspectors or do some research for any electrical codes for your area before considering burying any cables.

Loss is Bad; Gain is Good

In the financial world, losses are bad and gains are good. The same is true in the electronics world. For wire and cable, losses and gains are affected by voltages and current and resistance, the factors you learned about when studying Ohm's Law and Watt's Law. Note that wires really do not have gain, but let's think about maximizing performance by reducing loss as much as possible. Of course, if one thinks in terms of wire antennas, it is possible that wires contribute to antenna system gain, since wire is used for the antenna elements, and the antenna elements can improve or increase antenna gain when compared to a simple one-element antenna (dipole).

In practical terms, we should minimize loss as much as possible when dealing with wires and cables. For antenna work, there are two major contributors to losses in the feedline.

The first is cable construction, and suitability of the cable to the frequency for which it will be used. This translates into a simple rule: You get what you pay for when buying feedline cable. Perhaps a better way to think about this is the fact that cable price increases as the frequency for which it is designed increases. The second factor is cable length. All coax-cable specifications include loss information per length, usually per 100 feet.

Related to antenna cable loss is the connector type and its suitability for the operating frequency. The most common connector for many ham stations is the PL-259. This connector can be used from about 2 MHz to 144 MHz, and is sometimes used at 450 MHz. One main reason the PL-259 is so ubiquitous is that it is fairly easy to install and use. Other connector types and their typical frequency ratings are shown in Table I and also in photo 2.

Most ham equipment dealers have varying lengths and types of coax cable as well as a selection of connectors. Almost all of these dealers also carry pre-made coax-cable assemblies with the connectors already installed, a great time saver.

Wires for Power

In power-supply situations, losses can be avoided by increasing cable diameter, or gauge. The fatter the wire, the smaller the loss. By the same token, cable losses are minimized when the cables are kept as short as possible. Now for most home and mobile station installations, the power cord supplied with the radio is usually adequate for almost all installations. The loss for such short lengths should not be an issue.

However, what if you are not doing a "typical installation," like we sometimes do in an emergency situation when we must remove the radio from its normal position and use it in the field? Or perhaps the installation is going to be in a boat, on the bridge, and the battery and electrical system are located many feet away?

In photo 3 the radio equipment is not mounted within the vehicle, but instead is connected to the power source (vehicle battery) via a cord about 20 or 30 feet long. The power cable is very long because the power must move from the car battery under the hood to the radio system located away from the vehicle.

Let's see what happens when we power 12-VDC radios with a long and lossy cord, and see what we can do to optimize performance, or at least minimize power loss and voltage drop at the radio end of the wires.

Most ham equipment operates at 12 VDC, which is actually 13.8 V to accommodate an automotive electrical system with the alternator running at highway speeds. High-transmit-power radios draw from 15 to 20 amps or more, and this is where the losses come into play. If the power-supply wires are "thin," the voltage drop caused by the cable length may be enough to cause improper operation of the radio.

Using the online voltage-drop calculator mentioned in the "References" section, a run of No. 14 wire, 30 feet long, connected to the car battery (assuming 13 V), powering a rig that pulls 14 amps will have a voltage drop of 1.05 V. This means that the cable will have 11.95 V at the "radio end."

Although this seems to be a very tiny amount of voltage drop, it may be enough to cause a radio to malfunction. As the battery begins to discharge—say to 10 V—the voltage drop is the same, but the voltage going to the radio drops to 8.95 V. This may explain why many battery-operated stations seem to lose performance after a long weekend of operating. The combination of cable loss and battery state of charge (or in this case "discharge") will likely cause a radio setup to malfunction.

Now keeping everything the same, but changing the wire gauge to No. 8 wire, we see that the voltage drop becomes much less than 1 volt, 0.260 V, so the radio will get 12.74 V to operate.

A good source for large-diameter power wires is your neighborhood electronics parts store or a stereo shop that caters to the car audio crowd (see photo 4). A wide range of colors and sizes of wire is available. I like the No. 8 or No. 4 wire for long DC cable runs. The car audio power wire is also very flexible, so it can be routed and handled easily.

Of course, using very heavy power wires is not going to totally prevent this from happening, nor will it magically increase operating time of a battery operated system. However, if losses are kept to a minimum, operating time can be maximized per outing.

In summary, wires and cables can be a way to improve station performance by minimizing loss, from top to bottom, or from the antenna system to the power supply.

73, Wayne, KH6WZ