W1GHZ

MICROWAVELENGTHS

Microwave Plumbing

For the most popular microwave bands, 10 GHz and lower, waveguides are too bulky and difficult to use inside our equipment. RF connections are made with coaxial cable, but ordinary coax, with braided shield, is lossy and the familiar PL-259 coax connectors have poor performance.

The cable of choice is semirigid 50 Ω coax, which has a copper tube for the outer conductor, Teflon dielectric for lower loss, and a solid copper inner conductor, usually silver-plated. This construction seems like it would be quite difficult to bend, but at the smaller diameters used in microwave work, it can be bent with care to a desired shape. The most common size is 0.141 inches in diameter, sometimes designated RG-402. Another frequently used size is 0.085 inches in diameter, favored for tighter bends, but with higher losses. Other sizes are available, both larger and smaller, but are not often seen. Impedances other than 50 Ω occasionally appear as well.

SMA connectors are a good match for semi-rigid cable. Connectors designed for the cable are readily available, affordable, and have excellent performance at microwave frequencies. Mating chassis-mount and PC-mount connectors and adaptors to other connector types are all readily available. Even better, short cable assemblies with an SMA connector on each are ubiquitous at microwave swap sessions and flea markets.

Whenever I see them for $1 or less, I buy a handful — it takes a bunch to interconnect a microwave transverter or to set up test equipment. A selection is shown in Figure 1. When shopping, look inside the connectors and choose clean ones. Some of the cables have gold, silver, or tin plating on the outside for solderability or looks, but it isn't important, since no RF travels on the outside.

Surplus cable assemblies only come in two lengths: too long and too short. And they are usually pre-bent, in the wrong place. Often, we choose to make do, adding additional bends and tolerating extra length and loss. But sometimes we don't have the space or can't tolerate the extra loss, and need to make one the right length and shape. This is how I do it.

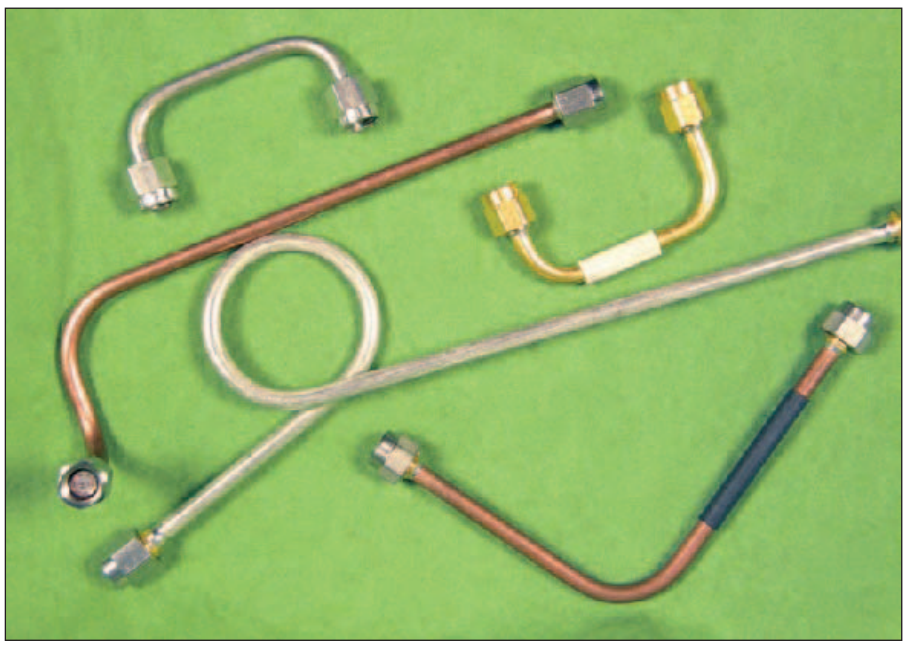

Figure 1 — Surplus semirigid cable assemblies come in all shapes and sizes.

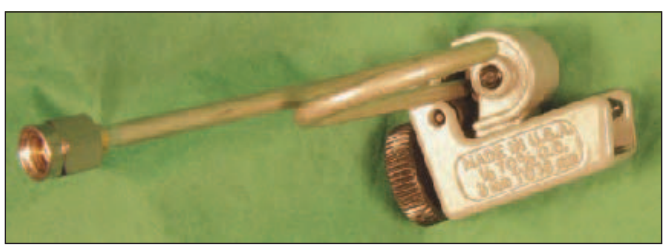

Figure 2 — Score the outer tubing with a miniature tubing cutter.

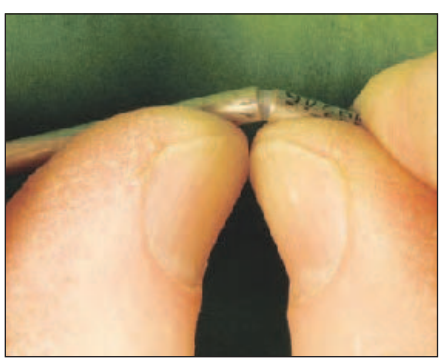

Figure 3 — Flex the cable with thumbs until the outer tubing snaps at the score line.

SMA Connector Assembly

To make things easier, I start with a cable assembly that is too long and make it into two shorter ones — that way, I only have to assemble one connector on each. For your first one, it might be a good idea to practice on the end of the less critical length first.

Some new connectors are needed — unsoldering used ones is difficult and not worth the effort. New connectors may be found surplus, but are also available from

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suppliers like Digi-Key (**www.digikey.com**) at quite reasonable prices. Either way, look at the data sheets on the Digi-Key Web site to get an idea of assembly dimensions for different styles.

Most SMA male cable connectors use the center conductor of the semirigid cable as the connector center pin, and make the end of the copper outer tube flush with the mating surface of the connector outer conductor. So the first operation is to cut the outer tube clean and square at the desired length, leaving about a ½ inch beyond the cut. I use a miniature tubing cutter to score the outer tube, as shown in Figure 2. The precision model at my local hardware store or from **www.smallparts.com** works really well — just a couple of times around scores the thin tube enough to snap the line with my thumb, as shown in Figure 3. The unwanted end of the tube can be wiggled off.

Figure 4 — Solder the connector body to the cable. Make sure to slide any necessary pieces on the cable first.

Figure 5 — Bending semirigid cable around a homemade bending jig.

Next, the Teflon dielectric is trimmed to length with a razor blade, being careful not to nick the center conductor. Some connector styles cut it flush with the outer conductor, while others leave a specified length protruding. Try and guess by the pictures on the data sheets.

The center conductor is cut to length to become the center pin. If the data sheets don't make the length clear, eyeball it from other SMA connectors. Filing a point on the end will make connections easier.

Before soldering, dry assembly is in order. Make sure everything fits together. Some styles require the threaded coupling nut to be slid on the cable before assembly, so that it can be added from the back after soldering.

When everything fits on the bench and in your mind, then put a small amount of rosin paste flux on the copper outer tube (I like Kester SP-44) and solder the connector on with a good-sized iron and a minimal amount of solder, as shown in Figure 4. After everything cools, clean up any excess flux.

The coupling nut may be loose, threaded in place, or held on with a snap ring, depending on the manufacturer. The rings just take some fiddling to get on. Once everything is in place, gently mate with a female SMA connector to check fit.

Figure 6 — Bending semirigid cable with a miniature tubing bender.

Bending Semi-Rigid Cable

Semi-rigid cable may be bent by hand, if the bend radius is fairly large. Just make a series of gentle bends with your thumbs. For tighter bends, perhaps any tighter than the size of a half-dollar, a bending tool is needed. The tool has a groove that the cable fits in to keep it round as it is bent so it isn't deformed, which would change the impedance. Professional tools are available, at a price, but aren't essential. Figure 5 shows a wooden bending jig that I made on a lathe, with a series of grooves for different bend radii, thumb operated. An inexpensive miniature tubing bender (Harbor Freight #94571; **www.harborfreight.com**) shown in Figure 6 also works, but only for one bend radius. Work slowly and don't force things.

Unbending existing bends in cable assemblies can be more difficult. Bending the cable work-hardens the copper, making it more brittle, so there is a danger of cracking the copper during additional bending. Work slowly, bending with your thumbs.

Connector Torque

In laboratories, SMA connectors are installed with a torque wrench set at 8 inch-pounds. The reason is to avoid damaging expensive precision connectors on test equipment, while making repeatable connections. Without a torque wrench, use one or two fingers on a small wrench until the connection is just snug. Before installing any SMA connector, inspect the mating surfaces to make sure they are clean, and wipe them clean with a cotton swab if needed.

However, equipment used for roving or up on a tower will soon have loose connections from vibration. I've seen many contacts missed because of loose connectors. So once you are finished testing and satisfied that everything is working, honk the connectors down! Before each roving season, I take all the covers off the equipment and make sure all connectors are tight.

Adapters

Sometimes it is necessary to connect to another type of connector, perhaps for test equipment, or because a surplus component came that way. Quality adapters from SMA connectors to other types may be found in surplus. Be wary of inexpensive imported adapters — some are made with inferior metals and dielectrics and are not suitable for microwave use.

Summary

Almost all microwave work requires some cabling — ready-to-operate transceivers aren't available. You might have noticed that all the work is done with thumbs, so even hams who are all thumbs can master SMA connectors and semirigid cable. QST