Bob's TechTalk #8
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Coaxial Connectors:
(Part I of III)

'UHF' and 'N' Connectors

Introduction:
The antenna feed line is an important part of the amateur station. While twin lead offers low loss and high SWR handling capabilities, coax has become the feedline of choice for most hams because of its ease of installation, inherent self-shielding, weather resistance and low impedance. Therefore it is appropriate to spend a few Tech Talk sessions discussing the various types of coaxial cables and the connectors that are used with them. Since QST recently published an article on coaxial cable, let's start with the numerous types of connectors that are available and usable for ham radio installations.

Coax is not just used for the antenna feed; it is often used to interconnect equipment, as test leads for test equipment and also to internally connect signals from one part of a circuit to another in your equipment. If you build your own equipment you are probably no stranger to coax. Since coax has so many uses it is no wonder that there are so many different types of connectors available. Connector series that hams use or should be familiar with include the **UHF** Series, **"N"** Series, **BNC** Series, **RCA Phono** Series (Yes, these are used for RF by some low-cost manufacturers), **"F"** Series, **Mini-UHF** Series, **SMA** Series, **TNC** Series, **FME** Series and **MMCX/MCX** Series. There are many other connectors that are less common that will be mentioned in a future Tech Talk article including **1.6/5.6** Series, **SMB/SMC** Series, **"C"** Series, **"HN"** Series, and **APC 2.4/3.5/7** Series.

Depending on the part chosen, assembling the connector to the coax involves crimping, soldering and/or clamping. Usually the center contact is either soldered or crimped. The connector body is either soldered, crimped or clamped. Connectors are often listed by how they are assembled: (i.e. crimp – crimp, clamp – solder, solder – solder, etc.) Crimping requires rather expensive crimping tools. They are great if you are attaching many connectors, but are not cost-effective for most amateurs. The exceptions are the "F" and BNC connectors that have inexpensive crimping tools available. The more expensive crimping tools will do a much better job.

Before looking at specific types, lets look at the important properties of the typical coaxial connector. These properties will then be used to compare some of the more common types listed above. Each type has its advantages and disadvantages and the trick is to choose the connector that is most advantageous for the job at hand while minimizing the impact of the disadvantages. Here are the major coax connector properties:

Impedance: Coaxial connectors can be either constant impedance or non-constant impedance. Constant impedance connectors are carefully designed to have an impedance that is the same as the coaxial cable the connector is designed to work with (50 ohms and 70 ohms are common values.) The outside diameter of the inner conductor and the inside diameter of the outer conductor are chosen (in conjunction with the dielectric the connector uses) to appear as a length of coax at the proper impedance. Non-constant imped-

ance connectors exhibit an impedance "bump" at the point of the connector along a feedline.

Size: Depending upon your use, size can be important. Do you need a micro-miniature connector for a GPS receiver or are you connecting 7/8-inch cable to your antenna? Relative size will be given on a scale of 1 to 5, 5 being large.

Voltage/Power Handling: Are you handling a kilowatt or just a few milliwatts? If the connector cannot handle the voltage, arcing can result, leading to damage to feedline and possibly the equipment. This property is related to the connector dielectric and size.

Frequency Range: Most connectors are good down to DC. At higher frequencies they become lossy and no longer exhibit a desirable impedance. The maximum recommended frequency can vary from about 30 MHz to over 50 GHz.

Cost: The price of connectors varies greatly. Items that determine cost include materials used (precious metals) complexity of design and manufacture, the market, proprietary designs, greed, etc. Relative cost will be given on a scale of 1 to 5, 1 being least expensive and 5 being most expensive.

Weather Handling: For outdoor use it is important to keep water out of connectors and coax. Low-loss foam dielectric coaxial cable is very susceptible to moisture and a good weather resistant connector can help to keep moisture from entering the end of the cable.

The UHF Series connector:

Impedance: The UHF Series is non-constant impedance. Generally it is used with 50 and 72 ohm coaxial cable.

Size: Moderately large; 4 of 5.

Voltage/Power Handling: 500V peak. It can handle the legal amateur power limit below 100 MHz.

Frequency Range: Up to 300 MHz.

Cost: Typically 2 of 5. Many low-cost no-name types available. Amphenol also carries an RFX series of UHF connectors that are lower in cost with good quality. Often UHF connectors are available surplus.

Weather Handling: No inherent weather protection. Must be protected from the elements. Exposes coax dielectric to the environment.

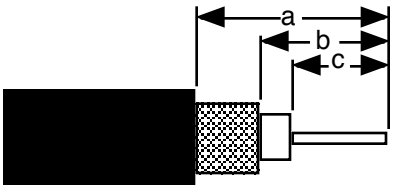
The UHF Series of connectors is the most common type used in ham equipment below 70 cm. E. Clark Quackenbush of Amphenol invented them for the radio industry in the 1930's. The military nomenclature of the standard plug is PL-259 and the chassis mounted receptacle is SO-239. The standard PL-259 is designed for RG-/U cables 8, 9, 11, 13, 63, 213 and other cable with an O.D. of 0.405" to 0.425". Two reducing adapters are available (military nomenclature UG-175 and UG-176) to fit RG-58/U (0.195") and RG-59U (.242") sized cable respectively. The UG-176 also works with RG-8X size coax. The UG-111/U is a solder plug for RG-59 that doesn't require a reducer. Crimp type connectors, right-angle plugs, hoods for the back of SO-239 receptacles (UG-106/U, UG-177/U), elbow adapters (UG-646/U), tee adapters (M358), male-to-male and female to female (PL-258, UG-363/U) adapters are also commonly available. "Between series" adapters are available for most other common connector series.

Since the UHF connector is in such common use, it is available from many sources and in many non-standard configurations. Quality can vary extensively – lower quality is usually evident in the dielectric used, the plating and the machining. Low-loss RG-8/U type coaxial cables such as Times Microwave LMR-400 and Belden 9913 coax have a larger diameter inner conductor than standard RG-8/U. Many newer PL-259 style connectors have a center pin with a larger diameter opening to accommodate this (such as Cable X-Perts' 401TS PL-259.) These connectors fit standard RG-8/U cable too. Some UHF connectors boast of a gold plated center pin. While this is fine, it isn't really an advantage over the standard silver pin if the connector is not to be regularly disconnected and reconnected.

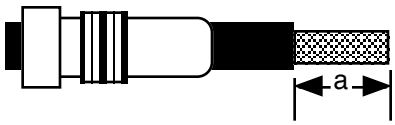
UHF Connectors - Table 1

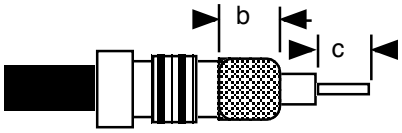
Part #	Conn Type	Cable (RG-/U)	Strip Dim, Inches a	b	c
83-1SP/SP-1050*	PL-259 Plug	8, 9, 11, 213, 214	1.25	0.687	0.625
401TS**	PL-259 Type	8, 9913, LMR-400	1.25	0.687	0.625
83-822*	PL-259 Plug	8, 9, 11, 213, 214	1.25	0.687	0.625
83-1SP-15RFX*	PL-259 Type	8, 9, 11, 213, 214	1.13	0.689	0.625
UG-175/U***	Reducer	58	0.750	0.375	0.625
83-168-RFX* ***	Reducer	58	0.689	0.375	0.551
UG-176/U***	Reducer	8X, 59	0.750	0.375	0.625
83-185-RFX* ***	Reducer	8X, 59	0.689	0.375	0.551

* Amphenol Part #, ** Cable X-perts Part #, *** Reducer used with PL-259's listed above.



UHF PL-259 Type





UHF with UG-175(6)/G Reducer
(Fold braid back over reducer)

UHF Strip Dimensions

Some cautions: Japan has a UHF connector that has a slightly different thread size than the standard SO-239 (which has a 0.625-24NEF-2A thread.) This metric threaded connector is found on non-export Japanese ham equipment. A PL-259 will fit on this connector, but will only thread on for a few turns leaving the shield connection loose and creating an undesirable condition. MCM sells a UHF bulkhead connector (#27-220) with the proper thread that replaces the most common of these bastard connectors.

You install a PL-259 connector by first stripping the cable to the correct dimensions. Some connector dimensions are given in Table one. Dimensions are available from the manufacturer (check his web page) or the place that supplied the connector. While you can often "eyeball" the dimensions on soldered plugs, crimp connectors are more critical. When cutting and stripping coax, all cuts must be sharp and square. Do not nick the braid, the center conductor or the dielectric. Next, slide on the coupling ring. Be sure it is facing the correct way. Use tape to hold it on the cable away from the end where you're working. Tin the center conductor and exposed shield; be careful not to melt the cable dielectric. Thread the connector body onto the outer insulation of the cable until it bottoms. The braid should be visible through the holes in the connector body and the inner

conductor visible in the connector tip. Solder the assembly to the braid through the four holes. A high-wattage soldering gun works well here. The trick is to heat the connector quickly enough to solder the braid without melting the dielectric (Here's where one learns to appreciate the "N" series connector!) Finally, solder the center conductor by flowing solder into the end of the pin. Trim any excess center conductor that is sticking out past the end of the pin. (There shouldn't be any if you measured properly.)

If you're using a reducing adapter for smaller diameter coax, slide the adapter on along with the coupling ring. After trimming the outer insulation, slide the adapter forward and fold the braid back over the end of the adapter. Trim it to 3/8 inch and tin it lightly. Screw the plug onto the adapter and solder the braid through the holes. Solder the center pin and screw on the coupling ring.

When soldering coax to an SO-239 chassis mounted receptacle the cable can often be connected by soldering the inner conductor of the cable directly to the center solder cup of the connector and the braid to a solder lug mounted to one of the connector mounting screws. At higher frequencies and for better shielding a hood should be used. Assembly instructions for hoods are available on the Amphenol web site.

The "N" Series Connector:

Impedance: The "N" Series is constant impedance and is available in 50-ohm and 70-ohm impedance. **Caution:** the 50-ohm and 70 ohm connectors DO NOT mate with each other!

Size: Moderately large, 4 of 5. Slightly longer generally than the UHF connector - similar diameter. Available for large diameter cables.

Voltage/Power Handling:

The "N" connector is rated at 1,500V peak. It can handle the legal amateur power limit to above 500MHz.

Frequency Range: Up to 11,000 MHz. with a max. SWR of 1.3:1

Cost: Typically 3 of 5. Often they available surplus. Amphenol also carries an RFX series of "N" connectors that are lower in cost with good quality.

Weather Handling: When installed properly, "N" series connectors with gaskets are weatherproof.

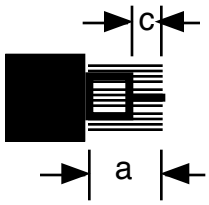
The "N" series of connectors was developed in the 1940's by Bell Labs (now Lucent). It was named for Paul Neill, and was the first connector to perform well at microwave frequencies.

The "N" series of connectors is found on higher quality UHF/SUHF amateur transmitters and antennas. At 11 GHz it boasts an SWR of only 1.3:1. The connector is a great performer at HF and VHF too, and is often found on commercial equipment designed for these frequencies. Properly installed, it is weatherproof and protects the coax dielectric from absorbing moisture that can ruin low-loss coax. Because of its weather resistance, it is ideal for outdoor

use, and since it exhibits a constant impedance it can be used to implement a low-loss splice in a run of coax. Often belittled by amateurs as being hard to install, it has not gained the popularity it should. Like the UHF series, the "N" series comes in numerous sizes and styles. It is available in clamp and crimp types. Since the braid is clamped to the connector body, only the center pin needs soldering, and heat damage to the dielectric is minimized. If you want to "move-up" the next time you install new coaxial feedline, you should consider using "N" connectors.

Part Number	Connector Type	Cable RG-/U	Strip Dim, Inches a	c
(Standard Clamp) UG-21/U			0.563	0.219
(Improved Clamp)			0.281	0.156
82-63, UG-23B/U	Straight Jack	8, 9, 213, 214		
82-67	Bulkhead Jack	8, 9, 213, 214		
82-209-1006	Straight Jack	9913		
(UG Clamp)			0.359	0.234
82-202 UG-21D/U	Cable Plug	8, 9, 213, 214		
82-202-1006	Cable Plug	9913		
82-312, UG-1185/U	Cable Plug	8, 9, 213, 214		
(Other)				
18750	Rt. Angle Plug	58, 141	0.484	0.234
34025	Cable Plug	58, 141	0.390	0.203
34025-RFX	Cable Plug	58, 141	0.354	0.177
35275	Bulkhead Jack	58, 141, 223	0.561	0.172

"N" Connectors – Table 2



"N" Strip Dimensions

Installing clamp-type "N" connectors can appear overwhelming to the unfamiliar amateur. Four different clamp styles exist: MIL-Clamp, Standard Clamp, Improved Clamp and Captivated Contact (C.C.). Recently many manufacturers have tried to simplify installation by combining styles. If you use older connectors you may still come across these names. Table two gives trimming dimensions for some of the more common "N" connectors; this table is just the tip of the iceberg. It would be wise to check with the manufacturer for the correct dimensions. "N" connectors also are available in many crimp-on styles.

To install an "N" connector, first place the nut, washer and gasket over the cable. The threads of the nut and the "V"-groove of the gasket should point towards the cable end where the connector will be installed. Then the outer jacket of the cable should be trimmed to the "a" dimension. Do not nick the braid. Next, comb out the braid so each strand is straight along the body of the coax towards the end. A good tool for this is a "solder helper" found in many Radio Shack soldering kits (such as 64-2802). Take your time combing out the braid, doing a small area at a time. It is not difficult, but if done too aggressively you can end up breaking off strands. Once the braid is combed out, move it out of the way and trim the dielectric to dimension "c". Carefully tin only the center conductor. Next, taper the combed braid slightly so it will fit through the center hole of the clamp, and slide the clamp onto the end of the cable; it only goes on one way (sharp edge of clamp towards the back.) It will stop against the cable jacket. Now, fold the combed braid back and over the clamp and trim it carefully so that it ends at the shoulder of the clamp. A pair of sharp scissors makes a good tool to trim the combed

braid. Solder on the center connector pin by flowing solder into the hole in the pin. The back edge of the pin should be flush with the dielectric. Finally, insert the cable into the connector body, make sure the gasket seats into the sharp end of the clamp and tighten the nut; the clamp will actually cut the gasket. Examine the connector; the pin should be seated so that its tip is recessed in the inner shield by about 0.05".

Some things to look out for: Though rare, there are 70-ohm "N" connectors. These do not mate with 50-ohm "N" connectors and damage to the center pin/socket can result. "N" connectors are now available that install like UHF connectors, with the solder holes for the braid. I suggest you avoid them.

Female "N" Chassis Mount Connector

Next month we'll look at the BNC and RCA Phono connectors, and maybe more.

73, from AF6C

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