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Secrets of the Ubiquitous PL-259/SO-239 Plug and Jack (aka UHF Connector)

Don Dorward, VA3DDN

Sooner or later most Amateur Radio operators, will come across the "ubiquitous" PL-259 male plug for coaxial cable and/or its equally "ubiquitous" female version, dubbed the SO-239 jack.

There is also a female to female version, dubbed the SO-238, but that designation is never used. It is now mostly referred to as "the double female".

Figure 1 shows some typical "UHF" connectors. I have shown the common name for the various pieces which I will refer to in the text provided below.

Figure 1: Some typical UHF Connectors

If you have an HF transceiver or a 2m/70cm transceiver, the antenna jacks on the back are likely SO-239.

Unlike antenna connectors on small HTs, these rugged RF connectors can handle serious power. You will even find them used on linear HF amplifiers where they must handle 1,000 watts or more.

My purpose in this article is not to cover old ground – such as the origins of the connector and so on – since you can do this by simply searching online or picking up almost any version of the *ARRL Handbook for Radio Amateurs* (see the References at the end of this article).

Rather, I hope to pass on to you some of their lesser known characteristics I have learned from my years of personal experiences. You may find them to be of use and some may even help explain to you why something is not working.

A Connector Known by Many Names

The "UHF" connector is a popular name, in spite of the fact that it performs poorly at what we call UHF frequencies today.

PL-259/SO-239 is an old Army Signal Corps name which is probably the most used designation.

Navy #49190/49194, mainly for the record.

Manufacturers

The PL-259/SO-239 remains a very popular connector which is used in many pieces of Amateur Radio equipment. This may be surprising since the connector has some serious limitations, most of which are due to its relatively uncontrolled manufacturing history. It may be surprising to hear that none of the male and female connectors of this type that are offered for sale these days are made to a common standard, as you might have expected.

Amphenol (https://www.amphenol.com) is one of the largest manufacturers of interconnect products in the world. With its World Headquarters based in Wallingford, Connecticut, "the company designs, manufactures and markets electrical, electronic and fibreoptic connectors, coaxial and flat-ribbon cable, and interconnect systems."

There are many other fabrication sources for these connectors – particularly from offshore locations – and it sometimes appears that some manufacturers are attempting to make their own version of these connectors, which results in some really poorly made clones. Inconsistencies and variations may be present in the dimensions and/or the materials used.

The only features which seem to be consistently "right" are the thread for the outer shell and the size of the center pin.

This is definitely an example of situations in which the expressions "buyer beware" and "you get what you pay for" apply.

Standard or Base Specification

Amphenol does provide a few outline drawings of their own versions of these connectors and they are likely the most consistent relative to the original. However, there is no single accepted standard worldwide which governs the mechanical and electrical performance of these connectors.

Some Potential Issues

The following are several issues that may arise as a result of the lack of a standard:

1) The center contact of the female connector may rotate.

The center contact of the SO-239 connector is supposed to stay fixed in place, but it may sometimes rotate when you insert the PL-259 plug and twist it. This can be caused by the lack of effective "staking" of the center contact in the insulator when it is made, or over-heating during soldering or because of a very tight-fitting plug.

When the male plug is inserted, it is inevitable that you will always have to rotate the plug body a few degrees, to get the anti-rotation pips to line up with corresponding serrated detents on the female connector edge.

Some of the poorly made female connectors may only have four serrated detents, guaranteeing you will have to twist the plug and thereby increase the risk of rotating the SO-239 center connector.

Why is this a problem? If the solder connection on the other side of the SO-239 is connected to something flimsy, like a component or a wire lead, then you may actually break it off or cause other problems due to the rotation of the center connector. I have seen this occur on one of my antenna analyzers and even on a Daiwa CS-201 coaxial switch which had gone “intermittent” (see Figure 2). In the coaxial switch, the SO-239 has a silver contact that has rotated, resulting in intermittent contact. Note that the set screw shown on top ensures that the body of the SO-239 cannot move.

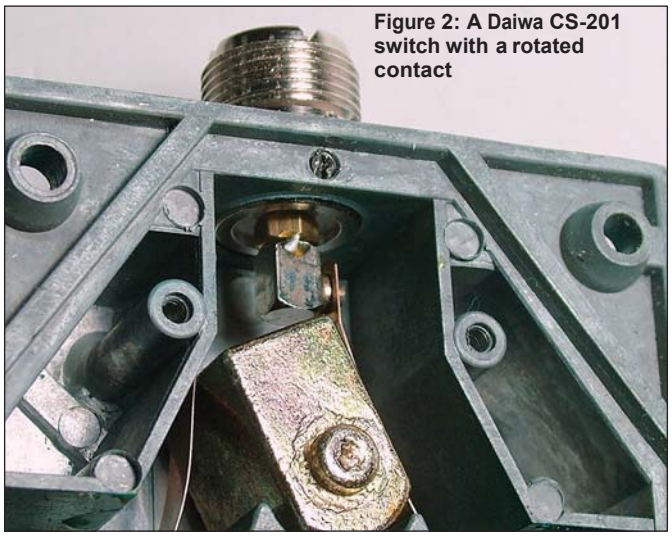

Figure 2: A Daiwa CS-201 switch with a rotated contact

2) Lack of resistance to weather and moisture

If they are used outside, these connectors will readily admit moisture. They must be weatherproofed in some way, such as by wrapping them with rubber tape, or they will quickly fail.

3) Differences in the center insulator

The older connectors, both male and female, used a version of bakelite, which is a thermosetting phenol formaldehyde resin, sometimes called phenolic. Usually brown or dark yellow in colour, these insulators seem to be quite resistant to melting from soldering heat and the center contact seems to be tightly held in place.

Newer, better quality connectors use polytetrafluoroethylene (PTFE), commonly known as Teflon, for the insulators. However, since there is no standard, it is difficult to determine what other plastic materials – such as acetal, nylon etc – may be used by low-cost manufacturers.

4) Short- and long-threaded shells

Depending on who made the connector, the overall length of the threaded shell can vary as shown in Figure 3. Problems can occur if you try to use a PL-259 with a long shell and mate it with a very short SO-239. Crimp versions tend to have shorter barrels and threads.

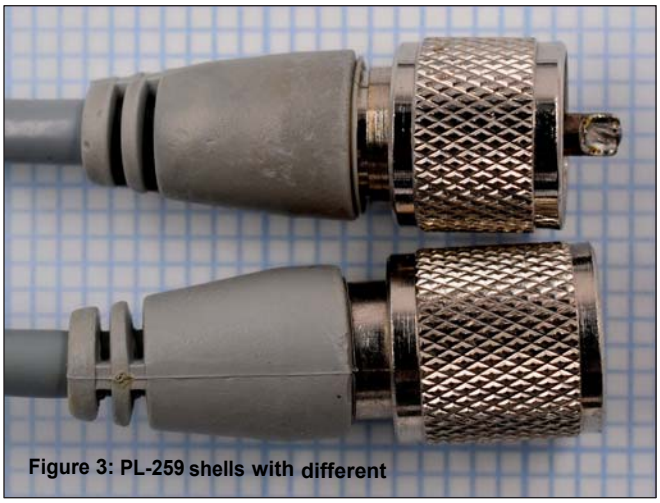

Figure 3: PL-259 shells with different

Figure 4 shows an SO-239 jack on the rear of a popular Daiwa wattmeter, which is rather short, having only about six threads. I know of an Amateur who encountered this and had low power out and a high standing wave ratio (SWR).

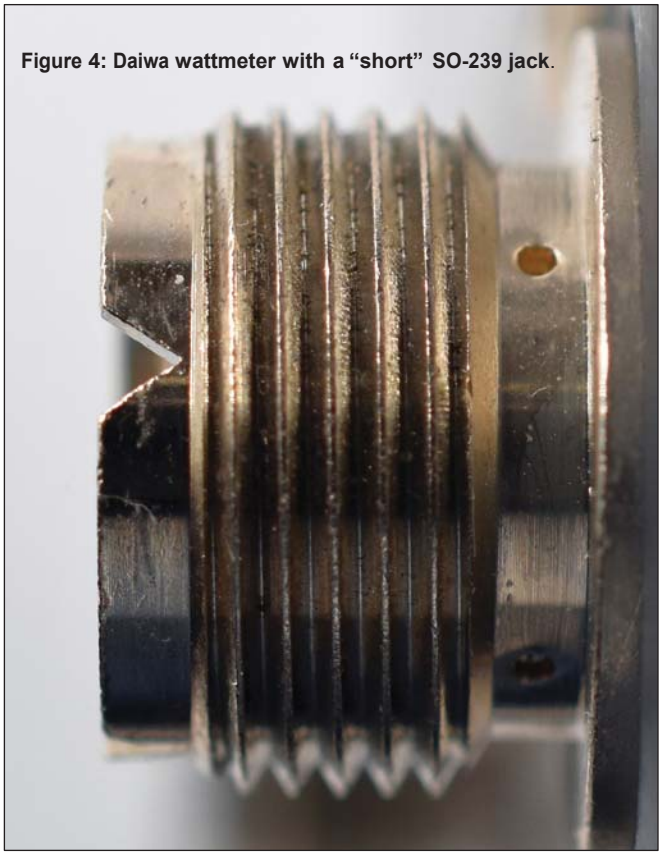

Figure 4: Daiwa wattmeter with a “short” SO-239 jack.

Remember, that the function of the shell of a PL-259 is to pull the two main connector parts together (the plug and the jack) and establish a low resistance butt contact! In this case that won’t happen because the leading edge of the shell bottoms out on the jack before the trailing edge can pull the plug into close contact. In fact, the plug may actually be loose, resulting in intermittent or no connections.

5) Various platings and materials are used

Better quality connectors are made of brass and use silver plating, for the shell, plug body and center pins.

Don’t be fooled by fake gold center pins.

You may also see some versions which are zinc die cast, with nickel plating and these may not be suitable for high power use at VHF or higher due to high skin effect increasing losses.

6) Female impedance “bump”

Nominally 50 ohms, the impedance of the PL-259/SO-239 connectors is non-constant with frequency. The main issue is with the SO-239 female, which presents an impedance of only 35 ohms over a distance of about ½ inch.

Improvements

1) Crimp-on versions seem to have taken over the market. They are much easier to install as the only thing needing soldering is the center connector pin. The issues mentioned previously can also apply to the crimp on versions.

2) Impedance bump mitigation is the intent of several SO-239's that I have seen. One was on a Daiwa wattmeter as shown in Figure 5.

Figure 6 shows a similar approach on a short female to female SO-239 I recently purchased. Here the dielectric is "cored-out" away from the center pin. The object is to trade plastic dielectric for air, which is higher.

Figure 5: The end of a wattmeter connector with the previously solid plastic dielectric "honeycombed" in the area of the center conductor.

Figure 6: An SO-239 female to female connector with a "cored-out" dielectric.

Some information resources:

Amphenol UHF Connector series: https://www.amphenolrf.com/connectors/uhf-connectors.html

"Installing Crimp Connectors", February 2019 QST, American Radio Relay League (ARRL) https://tinyurl.com/y6es8xmq

"Connectors for (Almost) All Occasions. Part 2", American Radio Relay League (ARRL), https://www.arrl.org/files/file/Technology/tis/info/pdf/9105034.pdf

Update June 13, 2021

I have become aware of a 7th “issue” to add to my list. This occurs when there is a loose fit between the male PL-259 plug center pin and the quadfurcated female center connector SO-239 socket.

Other amateurs have told me that they have experienced intermittent or even completely open connections, usually due to worn or damaged female contacts. The often used female to female “joiner” (SO-238), seems particularly prone to this.

I have found that a simple test is to fit a 5/32” (0.156”) diameter drill bit into the female contact. If it feels loose, then you may have found your problem.

73

VA3DDN

Note: This article was also published in the RSGB Radcom June 2021, p82.