The SMA RF Connector and Associated Tools

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1. Introduction

This article briefly reviews the SMA connector and tools commonly used with it. The SMA designation denotes *Sub-Miniature version A* (there also are types SMB and SMC). When it was designed in the late 1950s (at Bendix Aviation), the SMA connector was truly subminiature compared to other RF connectors. It is a threaded connector commonly found then and now in microwave applications because of its wide frequency range, low cost and small size (figure 1). The specification for the SMA connector was formalized in military specification MIL C-39012 (*General Specification for Radio Frequency Coaxial Connectors*). Note: This specification may be obtained from the Keysight Technologies website but it requires an internet search engine to find.

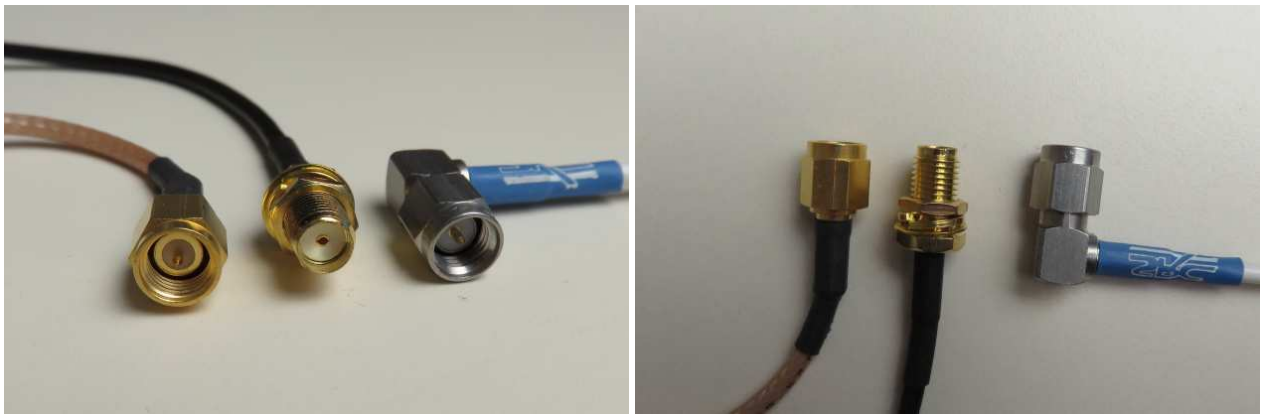

Figure 1 ~ Male and female SMA connectors. Left-to-right: Male, female, Right-angle male, all on small coaxial cable. The right-angle connector is stainless steel and the others are brass. The threads are 1/4 x 36 UNS and the hex body of the male connectors is 5/16 in. Images © 2015 W. Reeve

The SMA is a semi-precision connector that is almost identical to and mechanically compatible with the precision 3.5 mm RF connector. The SMA also may be mated to the 2.92 mm precision connector (see [Pino07]). Most SMA connectors available today have a frequency range from dc to 18 GHz but some can be used to 26 GHz. When used with flexible braid shielded cables, the upper frequency limit usually is 12 GHz. The SMA has 50 ohms impedance and is available in normal- and reverse-polarity configurations, but the reverse polarity version is not described the previously mentioned military specification. The hex body on the SMA male connector requires a 5/16 in or 8 mm wrench, and the female connector body is threaded 1/4-36 UNS (Unified Special).

The SMA's original design was based on using 0.141 in diameter semi-rigid cable in a system that, once assembled, was left alone except for occasional repair. The coaxial cable center conductor was used as the center contact in the male connector much like the familiar type F connector used in the CATV industry. However, this application can be problematic because of inadequate care and chamfering of the center conductor, which damages the mating connector center contact. Many modern SMA connectors use a separate center contact that is crimped or soldered to the cable center conductor, eliminating most of these problems at the expense of increased assembly time and higher cost.

Modern SMA connectors are used with small semi-rigid and formable coaxial cables with shield diameters that range from 0.020 to 0.141 in as well as small flexible braided shield cables with solid or stranded center conductors such as RG-316/U and RG-174/U. SMA connectors also are available for larger cables.

The SMA is rated for 500 mate/de-mate cycles when the connectors have a separate center contact and only 100 cycles without the contact, so test equipment with SMA connectors often use sacrificial SMA male-female adapters (figure 2). Couplers for joining cables with the same gender connector take on many forms (figure 3), and adapters are available to connect the SMA with many other types of RF connectors (figure 4).

Figure 2 ~ Male-Female SMA adapters commonly used to protect test equipment connectors from wear and damage. When the adapter wears out it is simply replaced at much lower cost than the equipment connector. The upper adapter is stainless steel. Images © 2015 W. Reeve

Figure 3 ~ Variety of SMA couplers. The silver female-female coupler at lower-right is nickel plated brass and others are plain brass. The female-female coupler with knurled center grip is used only in quick-test applications where the connectors are not torqued. Images © 2015 W. Reeve

Figure 4 ~ Variety of SMA adapters. Shown here are type N to SMA and BNC to SMA and one TNC to SMA. Images © 2015 W. Reeve

2. Materials

SMA connector body materials can be brass, stainless steel or beryllium-copper. Brass connector bodies can be unplated, gold plated with thin nickel underplate or nickel plated. Female center contacts are gold plated beryllium-copper (a springy copper alloy) and male contact pins usually are gold plated brass. Crimp sleeves usually are plated copper. The insulator (dielectric) in SMA connectors is PTFE (polytetrafluoroethylene), commonly called *Teflon*, which is a trademark of Dupont. The military specification mentioned previously does not allow nickel plated connector bodies due to the problems of passive intermodulation (PIM) but commercial connectors often use nickel plating. Connector bodies meeting the military specification use silver plated brass but mating surfaces must not have silver plating. Connectors for special applications or environments may use different materials.

3. Connector Tools

After the connectors to be mated are physically aligned and the threads engaged by hand, it is convenient to use a tool to continue closing the connection before final torque is applied. A variety of tools for SMA connectors are available (figures 5 through 9). It is important that when connectors are mated only the male connector's hex shell is rotated; otherwise, the center contacts may be damaged by rotational forces or at least may wear out quicker. In cable-to-cable connections, a second wrench is necessary to hold the female connector.

Figure 5 ~ Combination wrenches for the SMA connector. Both 6-point and 12-point box ends are shown. All are 5/16 in or 8 mm except the 3rd wrench from the top, which is 5.5 mm. I ground down the open end so that it fits the narrow flats on an SMA female-female coupler. Also, I cut the box end of the 2nd wrench from the bottom to allow it to fit over RG-316/U and RG-174/U coaxial cable pigtails. These types of wrenches are never used for final tightening of an SMA connector, only to aid in closing the threads before applying a torque wrench. Image © 2015 W. Reeve

Figure 6 ~ Mini-Circuits HT-series "tight spot" SMA wrenches, one long (102 mm) and one short (63 mm). These finger wrenches are convenient where several SMA connectors are closely spaced. They appear to be made of an aluminum alloy and have been dark blue anodized. Both have an open 5/16 in hex at the lower end for the SMA connector. There is an open slot for the coaxial cable from the lower end to knurled finger grips at the upper end. Between the two finger grips are flats for a 5/16 in or 8 mm open end wrench or torque wrench. Image © 2015 W. Reeve

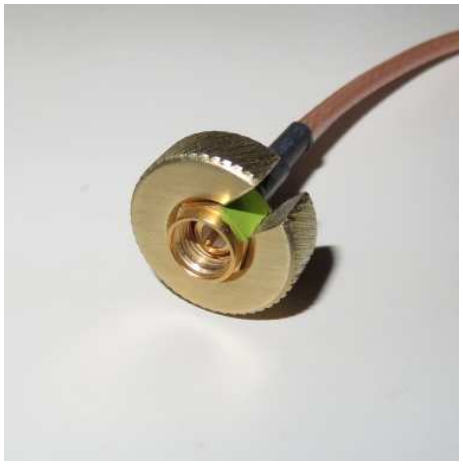

Figure 7 ~ Mathews Engineering "thumb wrench". The internal hex size is 5/16 in. Left: When received both were solid like the one on the left, but I cut a slot in one so that it would slide over a connecting cable. Each wrench came equipped with a set screw and L-wrench but I have not yet found a practical purpose for them except possibly for semi-permanent installation. The thumb wrenches are made of brass. Right: The thumb wrench in action. Images © 2015 W. Reeve

Figure 8 ~ Huber+Suhner 5/16 in click-type torque wrench. When the torque setting is reached, the handle clicks and breaks over a few degrees. This wrench is fixed at 0.45 N-m (4 lb-in) but may be adjusted over a small range with a screw on the handle end. It has been marked with finger-nail polish to indicate the torque value (in lb-in) and connector material (B – brass). Image © 2015 W. Reeve

Figure 9 ~ AtlanTech RF 5/16 in break-type torque wrench, which is supplied in a wood case with calibration certificate. Setting is 0.56 N-m (5 lb-in). Image © 2015 W. Reeve

In quick-test applications, where measurement accuracy is not an overriding concern, the threads can be made finger tight for the test. For convenience, an open or box end wrench or wrenches may be used to make a connection snug depending on the physical layout of the connectors, cables and nearby obstructions. Otherwise, the final tightening must be made with a torque wrench. It is important that the initial turning with anything but a torque wrench is not made too tight. This requires very little practice.

3. Connector Torque

Like all coaxial RF connectors the SMA must be properly mated and torqued, and the proper torque cannot be applied without the proper tool. Published torque values vary considerably depending on vendor, and torque varies with material – brass connectors require lower torque than stainless steel (table 1). When mating the SMA to compatible connectors with different torque requirements, the lower torque normally is used. However, when mating the SMA to the precision 3.5 mm connector, the following applies {Keysight}:

- To connect an SMA male to a 3.5 mm female connector, use an SMA torque wrench.
- To connect a 3.5 mm male connector to a SMA female connector, use a 3.5 mm torque wrench.

Table 1 ~ Common SMA connector torque values

Connector material	**Torque N-m (lb-in)**
Brass	0.34 to 0.56 (3 to 5)
Stainless steel	0.79 to 1.13 (7 to 10)

4. Using a torque wrench

A torque wrench is essential for proper joining of SMA connectors (figure 10). A new wrench costs at least 150 USD. Treat it well and it will last a lifetime. In industrial applications, torque wrenches are calibrated at least annually.

Floating female connector: Two wrenches are needed, the torque wrench and an open end wrench. After finger-tightening the male connector, place the open end wrench on the female connector flats or hex body. The dimensions of these flats depend on the manufacturer and usually are 1/4 in, 5.5 mm or 7/32 in. Place the torque wrench on the male connector hex body with the angle between the two wrenches ≤ 90°. Apply force with index finger and thumb to the end of the torque wrench handle until the wrench breaks or clicks. Do not move the wrench past the break-point.

Fixed female connector: Only the torque wrench is needed. After hand-tightening the male connector to a fixed female connector, place the torque wrench on the male connector hex body. Apply force with index finger and thumb to the end of the torque wrench handle until the wrench breaks or clicks. Do not move the wrench past the break-point.

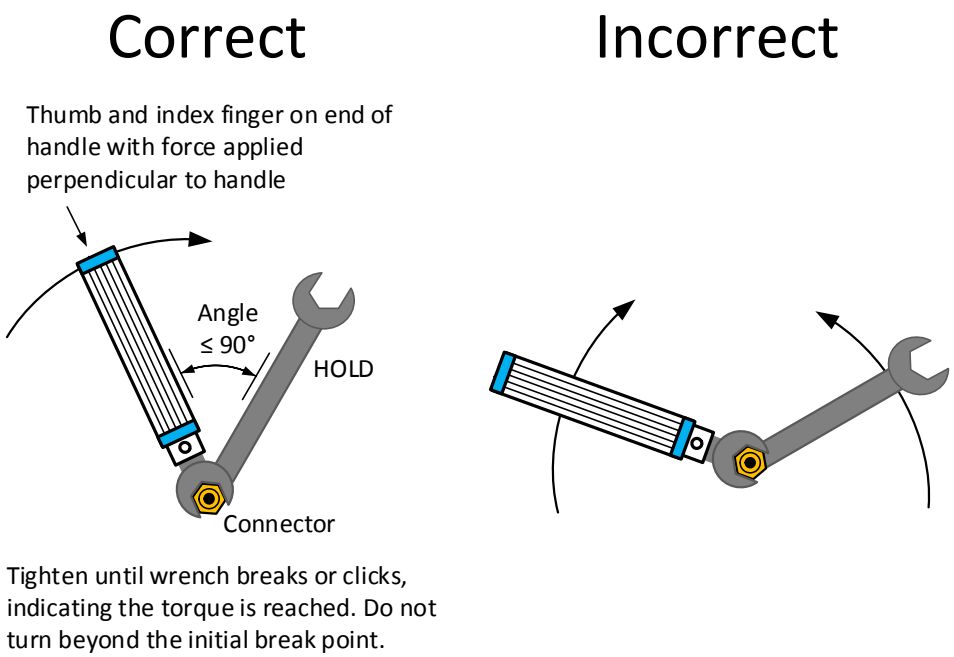

Figure 10 ~ Correct and incorrect methods for using a torque wrench. Never allow the center contact pin in the male connector or the female connector body to rotate. Only the hex shell on the male connector is turned. Image © 2015 W. Reeve.

5. Connector cleaning

SMA connectors that are used in test and measurement applications require regular cleaning. First, use clean, dry compressed air to blow off any loose particles. Canned air dusters are best; do not use a shop air compressor without a dehydrator and oil filter. Then use a swab that is small enough to clean all surfaces and corners of the connector; 2.5 mm foam and cotton swabs made for cleaning fiber optic connectors work well and usually are much cheaper than swabs specifically made for RF connectors.

Dip the swab in clean (uncontaminated), 91% or higher pure isopropyl alcohol (also called isopropanol) and carefully wipe the mating surfaces and the end of the center conductor. Avoid getting alcohol on the insulator or other non-metallic parts of the connector. Never apply any force to the male center conductor or contact. Wipe and clean the coupling threads. Finally, blow off the alcohol with clean, dry compressed air.

6. References and Further Reading

[Pino07] Pino, P., Intermateability of SMA, 3.5 mm and 2.92 mm Connectors, Microwave Journal, March 2007 (paper available at: https://www.gore.com/MungoBlobs/596/729/Intermateability-SMA-Connectors.pdf)

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