

RF calibration best practice guide: coaxial connectors

Application Note

Using coaxial connectors correctly is important, not only at radio and microwave frequencies, but also at dc and low frequency. Achieving measurements that are traceable to national and international standards may depend on several different calibration systems 'seeing' the same values for parameters presented by a device at its coaxial terminals. It is, therefore, important to prevent connectors from damaging the test equipment interfaces to which they are offered for calibration. Poor performance of many coaxial devices and cable assemblies can often be traced to non-compliance with the mechanical specification for each connector type. By following the guidance given in this best practice guide, it should be possible to maximize the lifetime of a connector. These guidelines also can help you reduce possible damage to your own and customers' equipment. The connectors used on Fluke instruments are supplied by quality connector manufacturers to provide optimum performance. They comply with the IEEE Standard 287, MIL-STD-348A (MIL STD 39012C) and the IEC STD 169 standards. The main body of the Type N connectors is made of stainless steel. They have hexagonal nuts to enable torque wrenches to be used for tightening.

Connector repeatability

Connector repeatability is a key contributor to a measurement system's performance. Connector repeatability can be impaired because of careless assembly, misalignment, using incorrect torque values, damage from

over-tightening, inappropriate handling, poor storage, and unclean working conditions. Permanent damage can be caused to the connectors, and possibly also to other connectors to which they are coupled. For example, the N-Type connectors in the Fluke 9640A RF Reference Source can be damaged if you attempt to connect the 50 Ω to a 75 Ω UUT connector. Because the center pin diameter is larger in the 50 Ω version, attempting to couple a 50 Ω male to a 75 Ω female will destroy the female contact. Connectors should **never** be rotated relative to one another when being connected and disconnected. Hold the connector body (or in the case of the 9640A, the leveling head), firmly, rotating only the collar. Take special care to avoid rubbing the mating plane surfaces against each other. Insufficient tightening torque can result in connector loosening due to cable movement. Awareness of the advantage of ensuring

good connector repeatability and its effect on the overall uncertainty of a measurement should encourage careful inspection, interface gauging and handling of coaxial connectors.

Connector torque

The table below shows the recommended tightening torque values provided by the connector manufacturer for the connectors and adapters supplied with the 9640A and 96XXCONN kit. The torque wrenches supplied by Fluke in the 96XXCONN kit are preset to the correct torque value. A gentle smooth pressure should be applied directly through the axis until the wrench "breaks" at the correct torque setting. No further pressure should be applied. It is not necessary to repeat the tightening process.



Adapters and torque wrench kit as supplied with 96XXCONN

Connector type	Size (mm)	Opening (mm)	Torque (N-m)	Torque (in-lbs)
N	7	20 mm	1 \pm 0.1	9 \pm 0.9 in-lb
SMA	3.5	8 mm	0.45 +0.15/ -0.10	4 +1.3/ -0.9 in-lb

All connectors have a specified maximum safety torque, usually 15 lbs-in (1.7 N-m) that should not be exceeded to prevent mechanical damage, such as connector buckling or distortion. With torque wrenches, it is possible to get substantially the wrong applied torque by using a twisting action. It is sometimes useful to use a small flat wrench on a connector body to prevent any rotation when making connection. Always make sure that the torque wrench is at the correct setting before use. There are some differences in the recommended torque settings used when making a permanent connection (within an instrument) rather than for metrology purposes. The torque wrench used should be routinely checked or calibrated. If it is an adjustable type wrench, it should be adjusted to the correct torque settings for the specific connector and clearly marked. When in doubt, use the connector manufacturer's guidance for the connector torque.

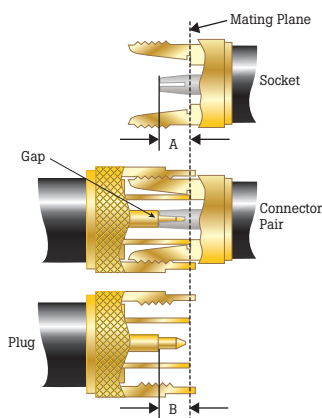
Connector gauging

Best practice requires that all coaxial connectors fitted on all equipment, cables and terminations should be gauged on a routine basis in order to detect any out-of-tolerance mechanical conditions that may impair the electrical performance or cause connector damage. It is particularly important when using coaxial cables that they are tested before use to ensure that the connector being fitted complies with the relevant mechanical specification limits.

Coaxial connectors should never be forced together when making a connection, because forcing often indicates incorrectness, damage or incompatibility. Gauge kits for checking the mechanical dimensions for all connector types are available from a variety of manufacturers. Type N connectors

with a knurled coupling system rarely need to be more than finger tight for routine electrical calibration purposes, and most of them function satisfactorily and give adequate repeatable results.

Certain dimensions (see the table below) are critical for the mechanical integrity, non-destructive mating and electrical performance of the connector. The diagram below shows that the Type N connector has the junction mating surface offset from the reference plane by 0.207 inches (5.258 millimeters). This is done in order to reduce mechanical damage or misalignment when making connections. Also, the inner inner female pin of the Type N socket connector is of the non-slotted type, to produce characteristic impedance that is independent of the mating pin.



Connector Type	Socket dimension A (inches)	Plug dimension B (inches)	Gap between the mated center contacts (inches)		
			min	nom	max
Precision N	0.207 ^{+0.000} _{-0.003}	0.208 ^{+0.003} _{0.000}	0.001	0.001	0.007

There are a number of different mechanical specifications for the type N connector and the user should be clear on the mechanical requirement needed for a particular application. For more details see the various specifications in the standards quoted at the beginning of this guide and the ANAMET Connector Guide¹. Again, when in doubt, use the connector manufacturer's guidance for the correct connector torque.

¹A further source of information on connectors is The ANAMET Connector Guide, which is available via the UK NPL website www.npl.co.uk

Connector cleaning

Connectors used on test equipment and measuring instruments need to be maintained in pristine condition to retain the best performance. Interconnecting cables should not be subjected to stress due to flexing or stretching. A connector can be damaged mechanically any time that a connection and disconnection is made. To ensure a long and reliable connector life and maintain good performance, connectors should be inspected regularly and carefully cleaned before use. Look for dents, raised edges, and scratches on the mating surfaces. Connectors that have dents on the mating surfaces usually also have raised edges around them and will make less than perfect contact. Raised edges on mating interfaces will make dents in other connectors to which they are mated. Small particles, usually of metal, are often found on the inside connector mating planes, threads, and on the dielectric. They should be carefully removed to prevent damage to the connector surfaces.

The items required for cleaning connectors include a source of low pressure compressed air (solvent free), special lint-free cleaning swabs, and isopropyl alcohol. An illuminated magnifier or eye glass is very useful, and small wooden cocktail sticks can be used to remove small particles. Only a small amount of isopropyl alcohol, applied using a swab, should be used to clean a connector. Connectors should not be immersed into baths for cleaning because the dielectric may be damaged or contaminated.

Adapters

Buffer adapters ("sacrificial connectors" or "connector savers") can be used to reduce possible damage to the 9640A RF Reference Source leveling head output connector, or connectors on similar devices. It should be remembered that use of buffer adapters may affect the performance of a measurement system. Adapters are often used to reduce wear on expensive or difficult-to-replace connectors on measuring instruments. High quality connector

adapters are available from Fluke.

The importance of interconnections in measurement work should never be underestimated. Replacing a connector may significantly reduce the uncertainty contribution in a measurement process. When choosing a connector, careful consideration must be given to select the correct connector for the measurement task. In modern RF instruments, such as signal generators and spectrum analyzers, the coaxial connector socket on the front panel is often an integral part of a complex subassembly and any damage to this connector may result in a very expensive repair.

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Printed in U.S.A. 3/2013 2649664B_EN

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The 9640A system includes a 50 Ohm or optional 75 Ohm precision leveling head. The head delivers fully floating signals directly to the UUT to ensure the accuracy and integrity of the reference source output signals at the device under test input.